On the Security and Privacy Risks of Browser Extensions

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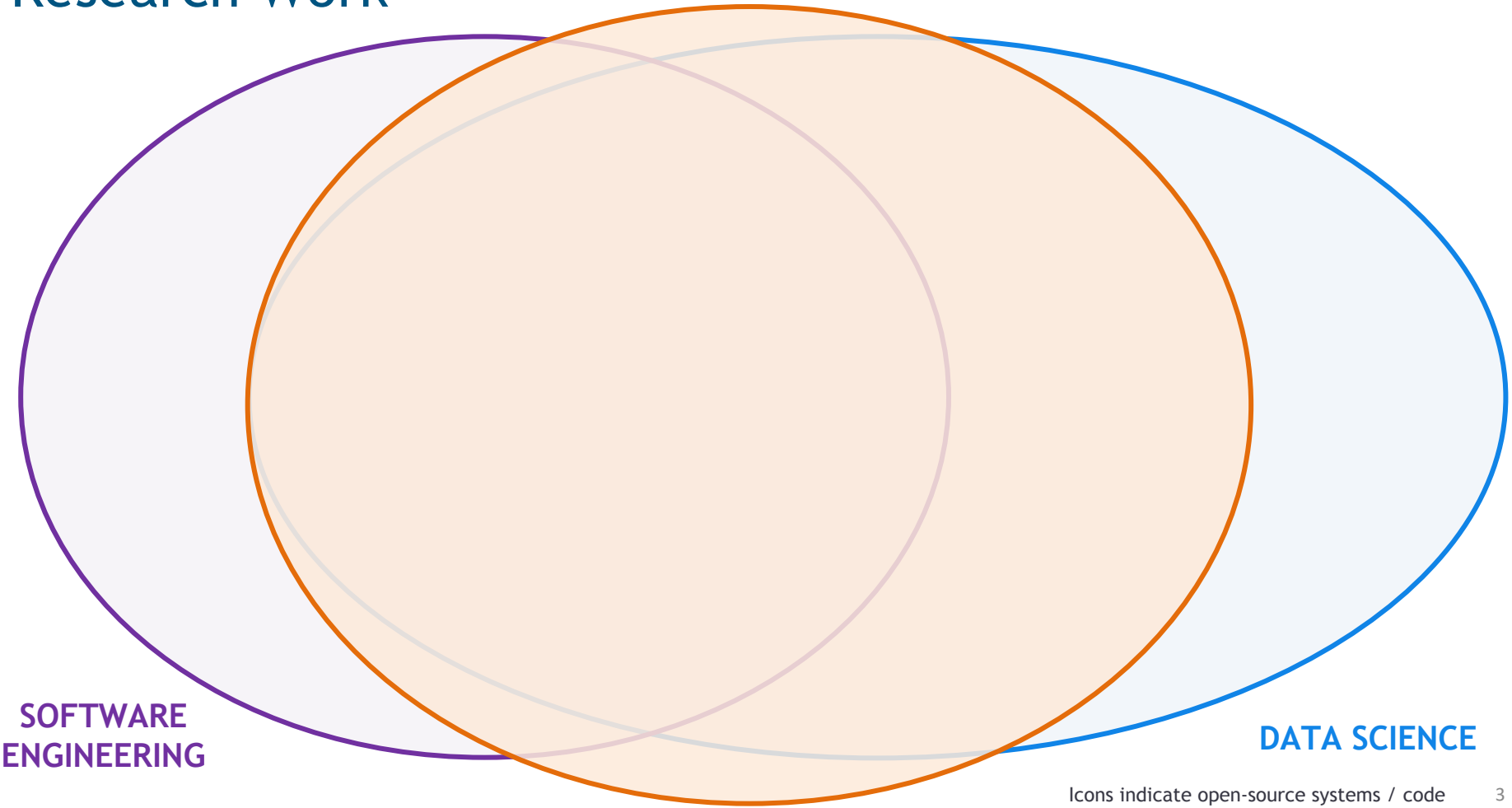
Tenured Researcher — Inria Centre at Université Côte d'Azur (since Dec 1, 2025)

Keynote at APVP 2026, June 3rd 2026

Dr.-Ing. Aurore (/ɔʀɔʀ/) FASS

- 🇫🇷 2017: Graduated from TELECOM Nancy (**FR**)
- 🇩🇪 2017—21: PhD Student + Postdoc at CISPA (**DE**)
- 🇺🇸 2021—23: Visiting Assistant Professor at Stanford (**US**)
- 🇩🇪 2023—25: Tenure-Track Faculty W2 at CISPA (**DE**)
- 🇫🇷 2025—: Tenured Researcher at Inria (**FR**)

Research Work



Icons indicate open-source systems / code

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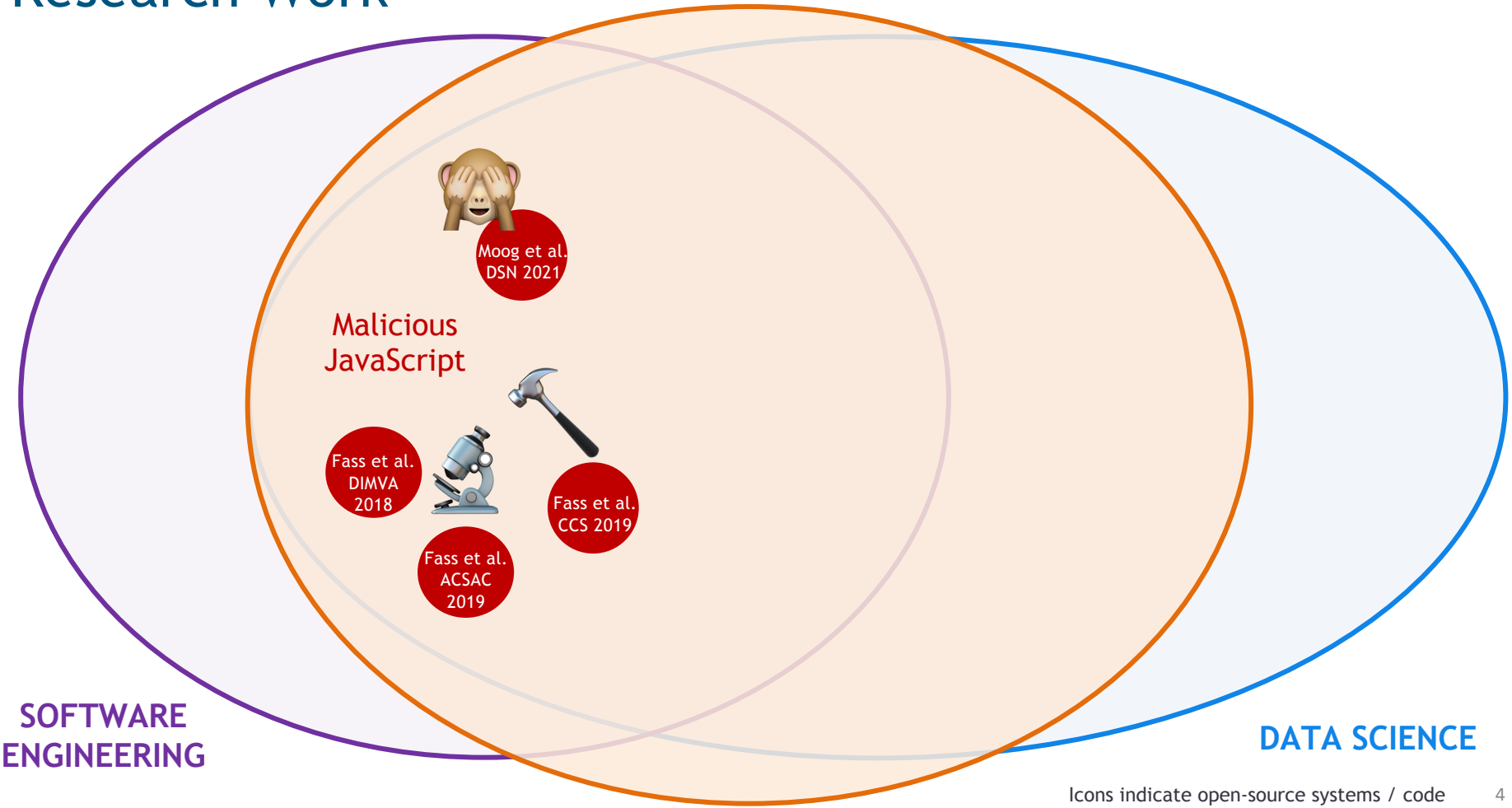

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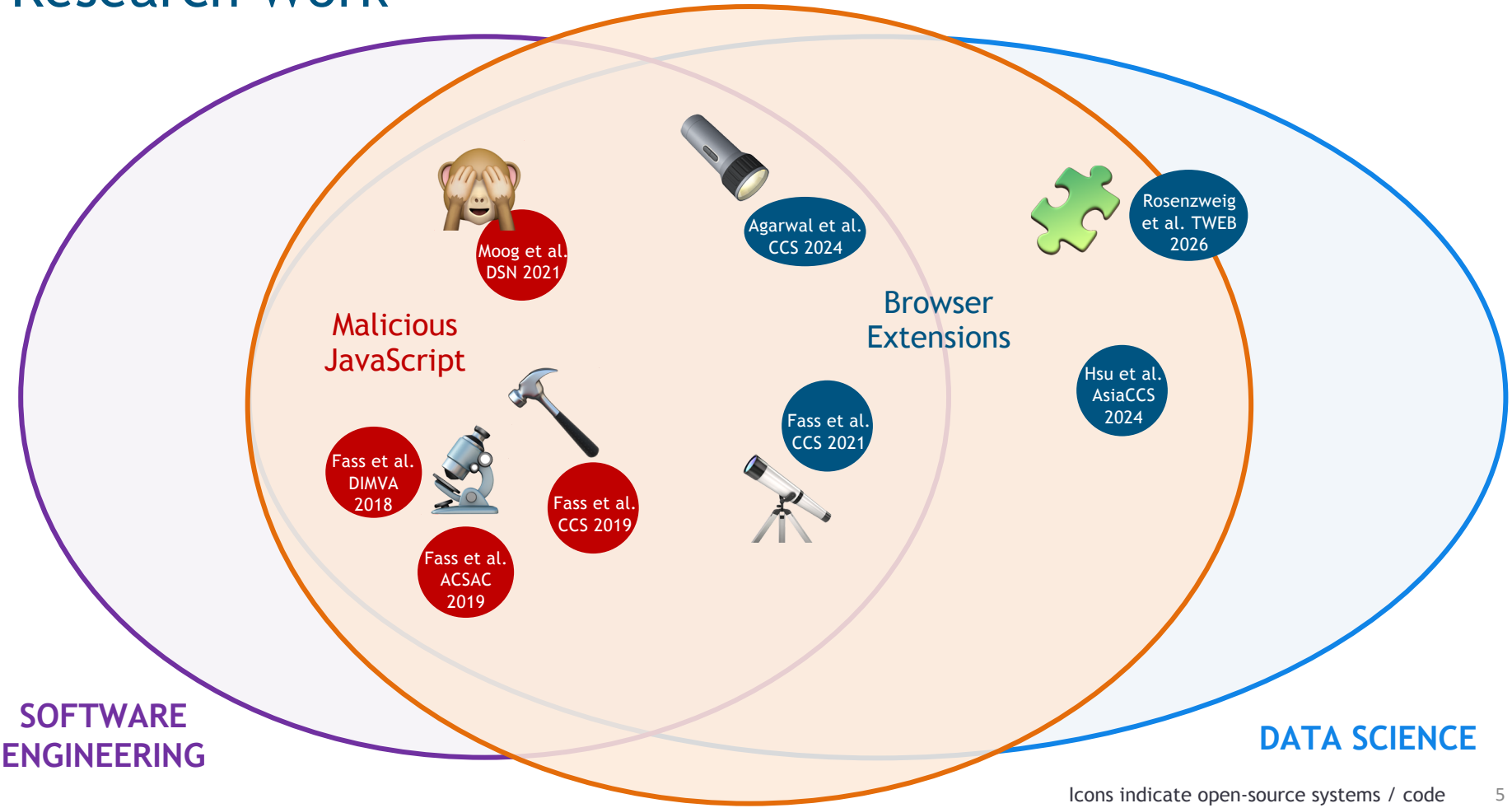

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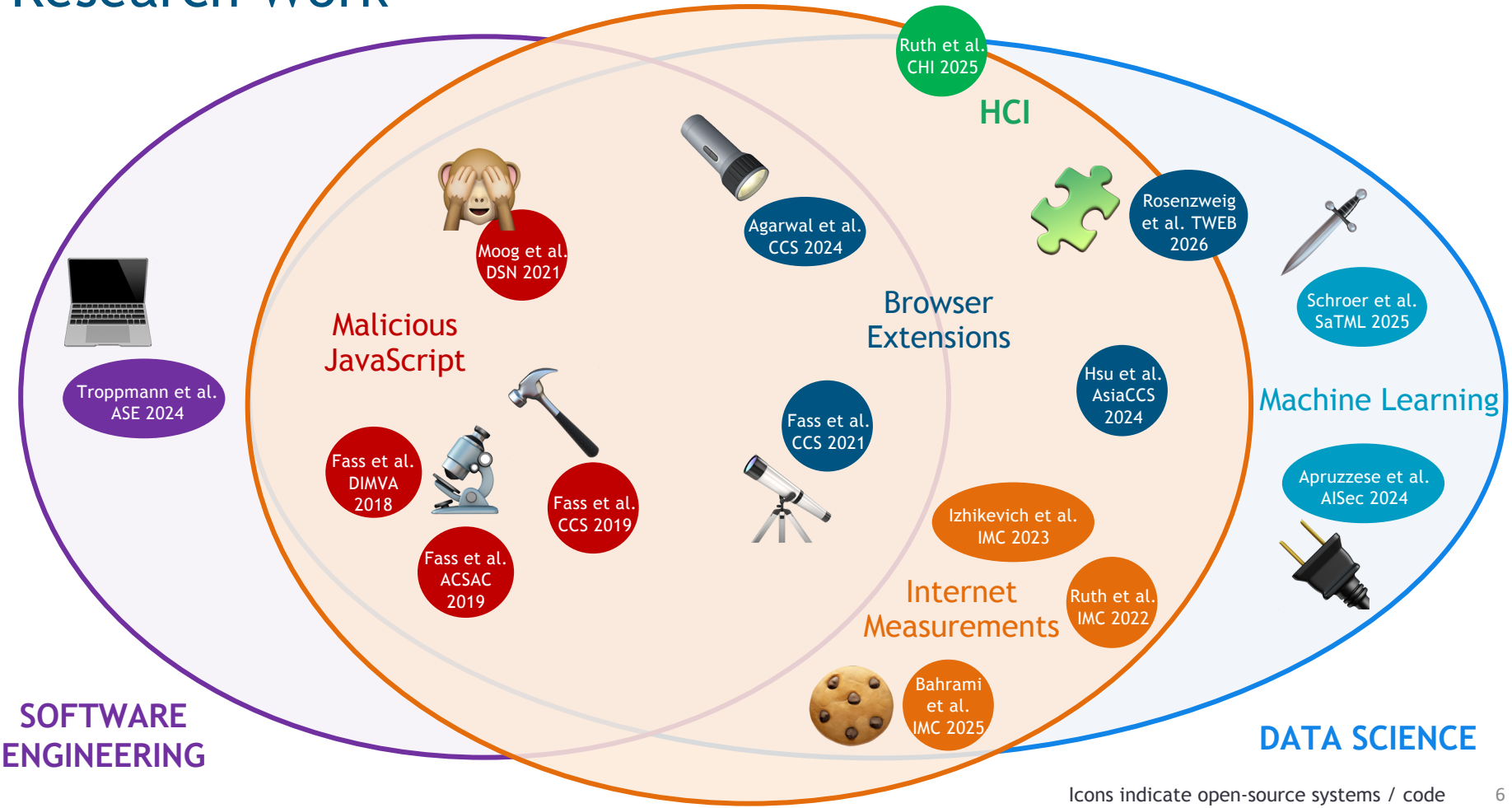

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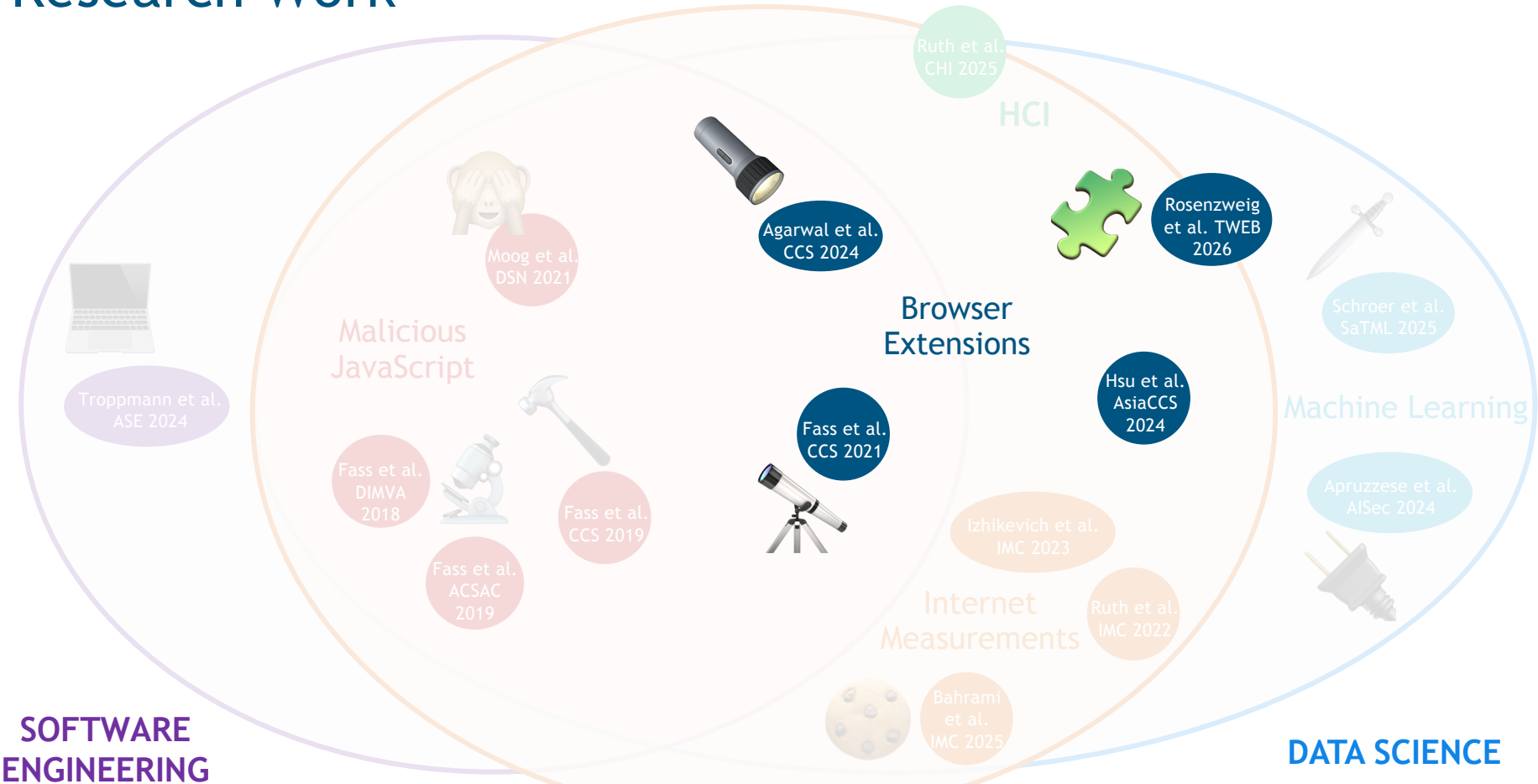

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Outline

- Background: Browser Extensions
- Investigating Security-Noteworthy Extensions (SNE)
- Detecting Vulnerable Extensions
  - Threat model and automated tool (DOUBLEX)
  - Case studies, results, and potential defense strategies
- Detecting Fingerprintable Extensions
  - Presentation of 3 fingerprinting vectors, results, and potential mitigations
- Detecting Malicious Extensions
  - Lab setting vs. real world

Hsu et al. AsiaCCS 2024

Fass et al. CCS 2021

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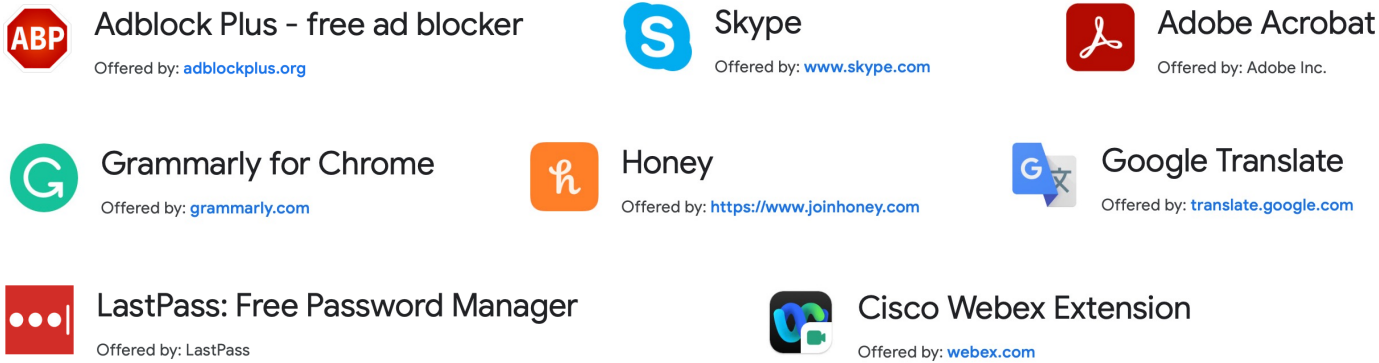
What are Browser Extensions?

- Third-party programs to **improve user browsing experience**



- **~250k** Chrome extensions totaling almost **2B** active users
  - ➢ Necessitates a thorough **security and privacy assessment**

Background — `manifest.json`

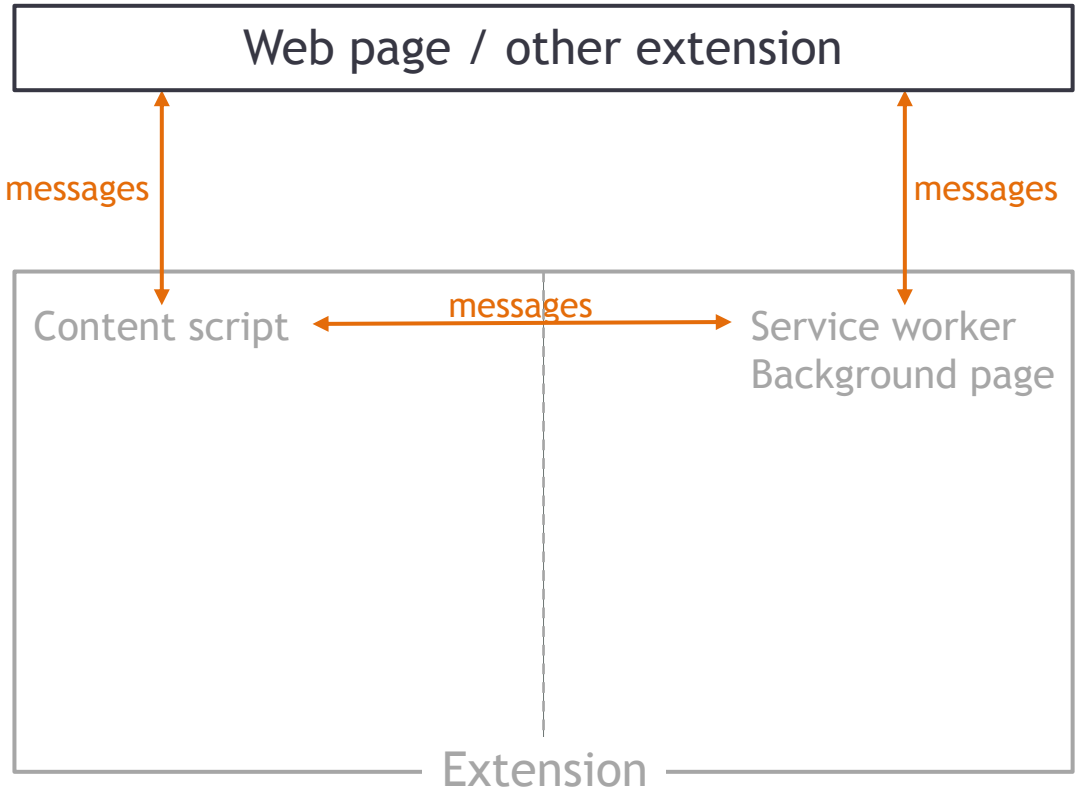
- Every extension needs a manifest written in JSON, called `manifest.json`, which gives essential information, e.g.,
  - Extension's name, version, and manifest's version
  - Main components of an extension (CS, BP/SW, …)
  - Permissions of an extension (`downloads`, `history`, …)
  - …

https://developer.chrome.com/docs/extensions/reference/manifest

Background — Extension Architecture

- Service worker (SW in MV3) / Background page (BP in old MV2):
  - Core logic of an extension
  - Executed independently of the lifetime of a tab / window
  - Privileged part of an extension
- Content scripts (CS):
  - Injected by an extension into (a) web page(s)
  - Can use standard DOM APIs to read / modify a web page
  - Similar to scripts directly loaded by a web page + some more privileges
  - Restricted access to extension APIs

Background — Extension Architecture & Messages



Background — Authorized APIs & Permissions

- Extensions only have access to:
  - APIs explicitly declared in the `manifest.json`, e.g.,
    - `storage` - store/access data from the *extension storage*
    - `downloads` - download files
    - `history` - access to a user's browsing history
    - `bookmarks`, `cookies`, `topSites`, …
  - `host` declared in the `manifest.json` = web pages an extension can access (read/write), e.g., to do some *cross-origin* requests

- https://developer.chrome.com/docs/extensions/mv3/declare_permissions/

- https://developer.mozilla.org/en-US/docs/Mozilla/Add-ons/WebExtensions/manifest.json/permissions

Background – manifest.json -- example

```
{
  "name": "My Extension",
  "version": "versionString",
  "description": "A plain text description",
  "manifest_version": 3
  "permissions": ["downloads", "history"],
  "host_permissions": ["https://example.com/*"],
  "background": {
    "service_worker": ["service_worker.js"],
  },
  "content_scripts": [{
    "matches": ["<all_urls>"],
    "js": ["content_script.js"]
  }],


}
```

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How Secure are Browser Extensions?

- Browser extensions provide additional functionality…
- … so browser extensions need additional & elevated privileges compared to web pages
  - e.g., ad-blockers need to modify web page content or intercept network requests
  - e.g., extensions can download arbitrary files and access cross-domain data; while web pages cannot (blocked by the Same-Origin Policy)

➢ Browser extensions are an attractive target for attackers 😈

Dangerous Browser Extensions

→ Extensions can put their users' security & privacy at risk:

- **Contain malware**: designed by malicious actors to harm victims
  - E.g., propagate malware, steal users' credentials, track users [1, 3]
- **Contain vulnerabilities**: designed by well-intentioned developers… but buggy
  - E.g., can lead to user-sensitive data exfiltration [1, 2]
- **Violate the Chrome Web Store policies**
  - E.g., deceive users, promote unlawful activities, lack a privacy policy [1]
- **Be fingerprintable**: can be recognized and uniquely identified
  - E.g., can lead to user tracking or inferring of user personal information [4]

[1] Hsu, Tran, and Fass; *AsiaCCS* 2024 | [2] Fass, Somé, Backes, and Stock; *CCS* 2021 | [3] Rosenzweig, Dalla Valle, Apruzzese, and Fass; *TWEB* 2026 | [4] Agarwal, Fass, and Stock; *CCS* 2024

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➢ **Security-Noteworthy Extensions (SNE)** [1]

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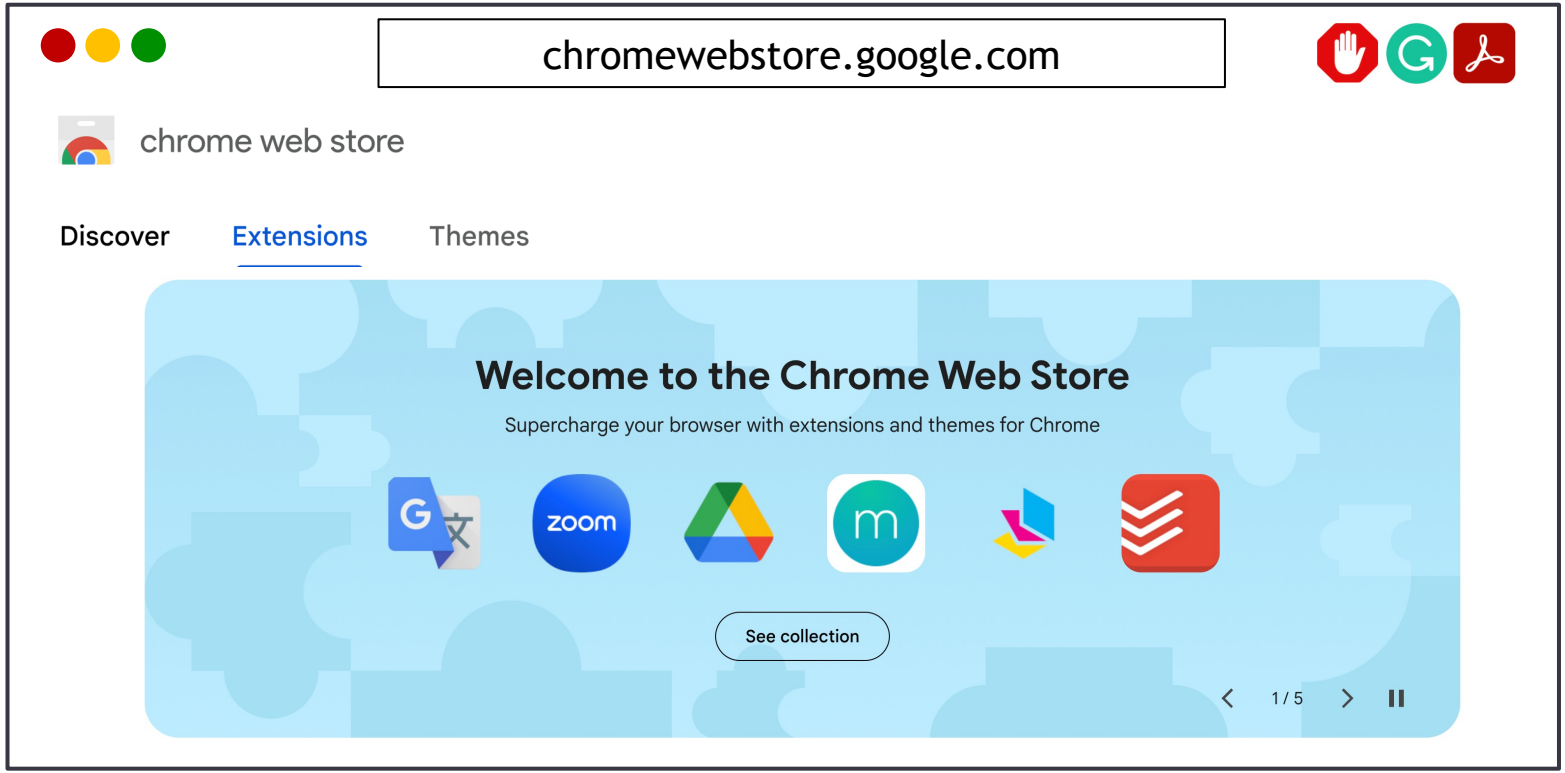
How are Security-Noteworthy Extensions (SNE) Installed?



[1] Hsu, Tran, and Fass; *AsiaCCS* 2024

How are Security-Noteworthy Extensions (SNE) Installed?

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Main Findings on the Chrome Web Store

- **350M users** installed **Security-Noteworthy Extensions** in 2020—2023
- These **dangerous extensions** stay in the Chrome Web Store ***for years***
- **60%** of extensions have **never received a single update**

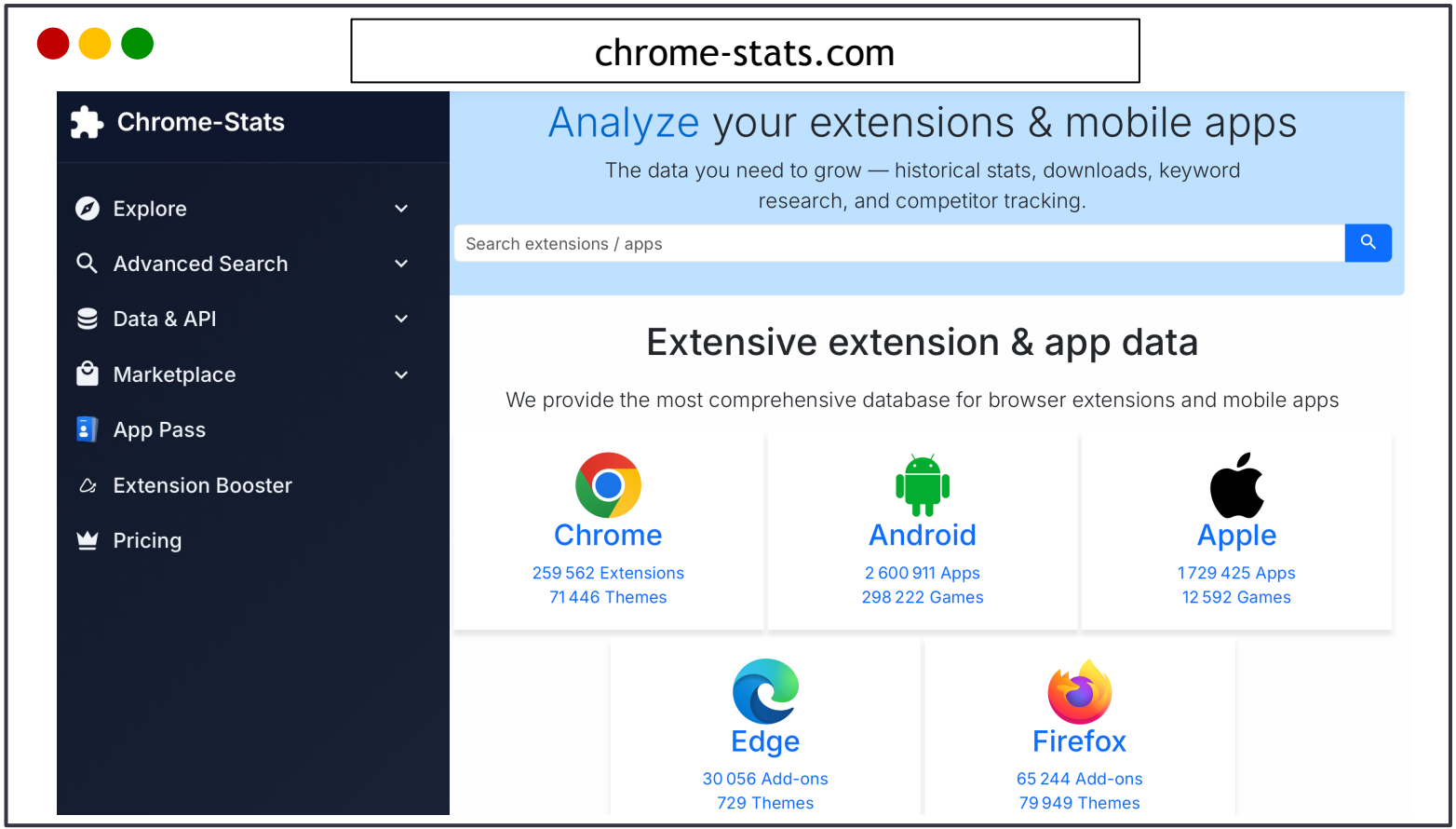

What is in the Chrome Web Store?
Sheryl Hsu, Stanford University
Manda Tran, Stanford University
Aurore Fass, Stanford University, CISPA Helmholtz Center for Information Security

> What is in the Chrome Web Store?

In *ACM AsiaCCS* 2024. Sheryl Hsu, Manda Tran, and Aurore Fass

Hsu et al. AsiaCCS 2024

Browser Extension Collection: Chrome-Stats



[1] Hsu, Tran, and Fass; *AsiaCCS* 2024

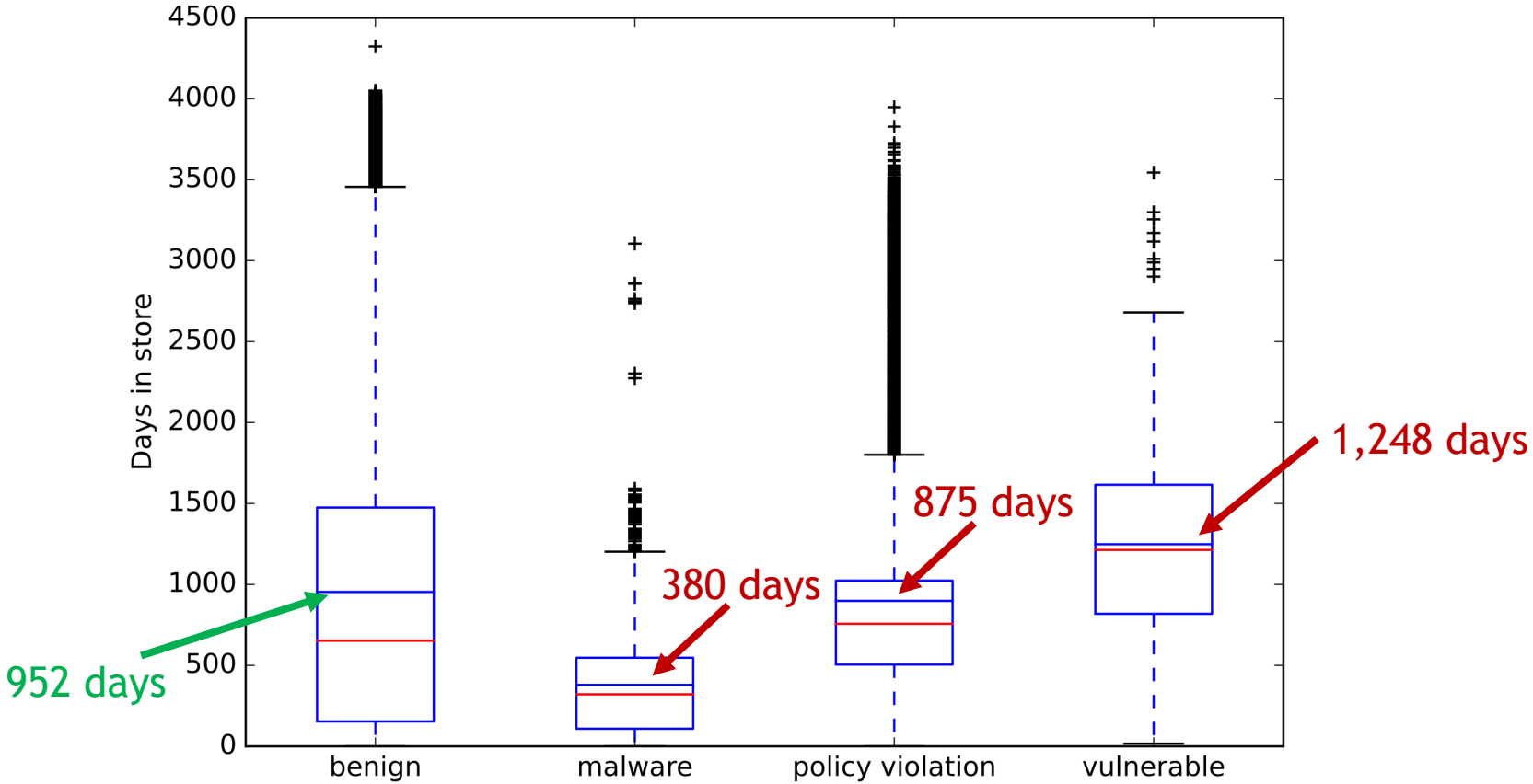
Browser Extension Collection: Chrome-Stats

Category	#Extensions Metadata collected	#Extensions Code collected	When collected
SNE	26,014	16,377	Before May 1, 2023
- Malware-containing	10,426	6,587	Before May 1, 2023
- Policy-violating	15,404	9,638	Before May 1, 2023
- Vulnerable [2]	184	152	March 16, 2021
“Benign” extensions	226,762	92,482	Before May 1, 2023

[1] Hsu, Tran, and Fass; *AsiaCCS* 2024

[2] Fass et al.; *CCS* 2021

Number of Days in the CWS



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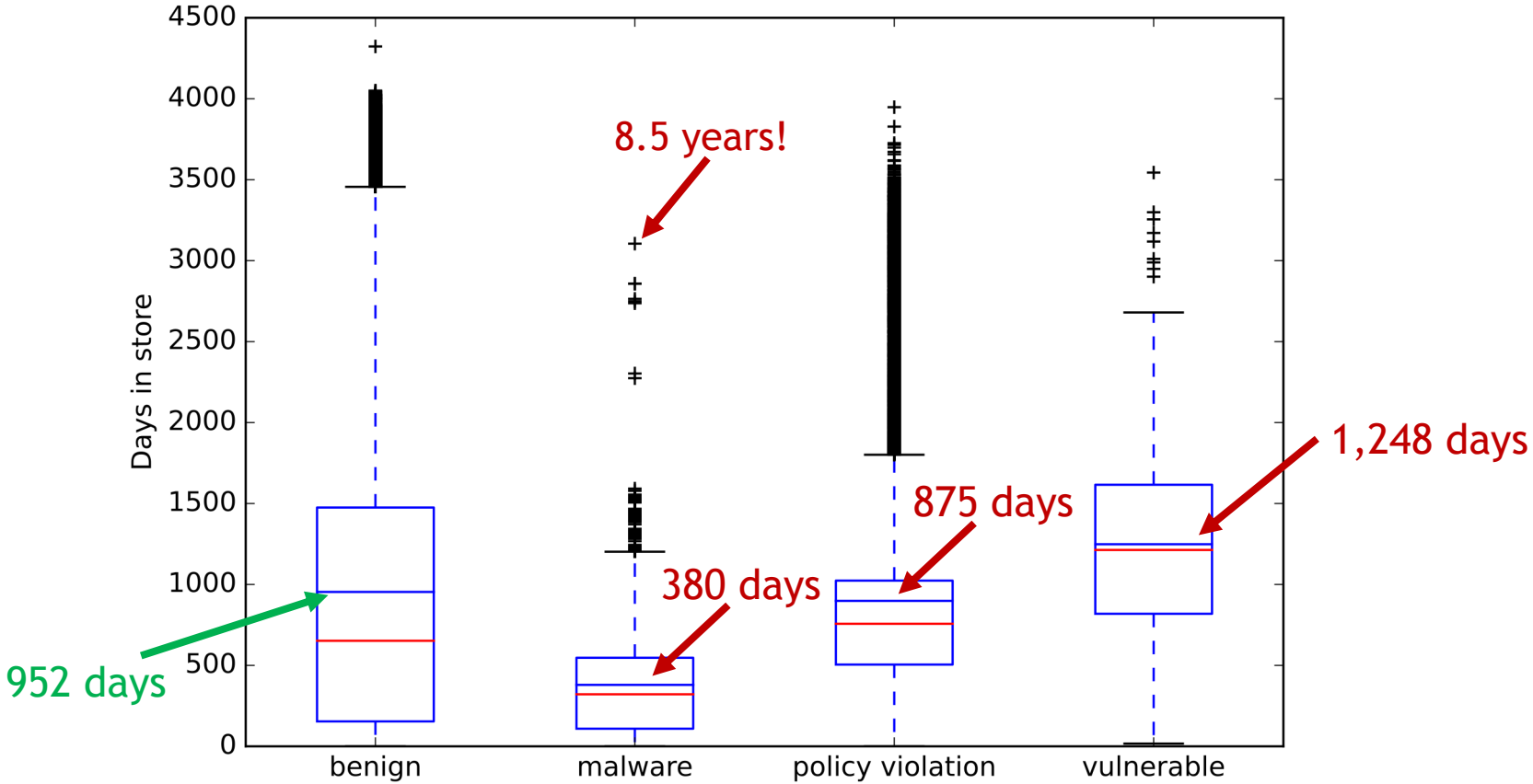


[1] Hsu, Tran, and Fass; *AsiaCCS* 2024

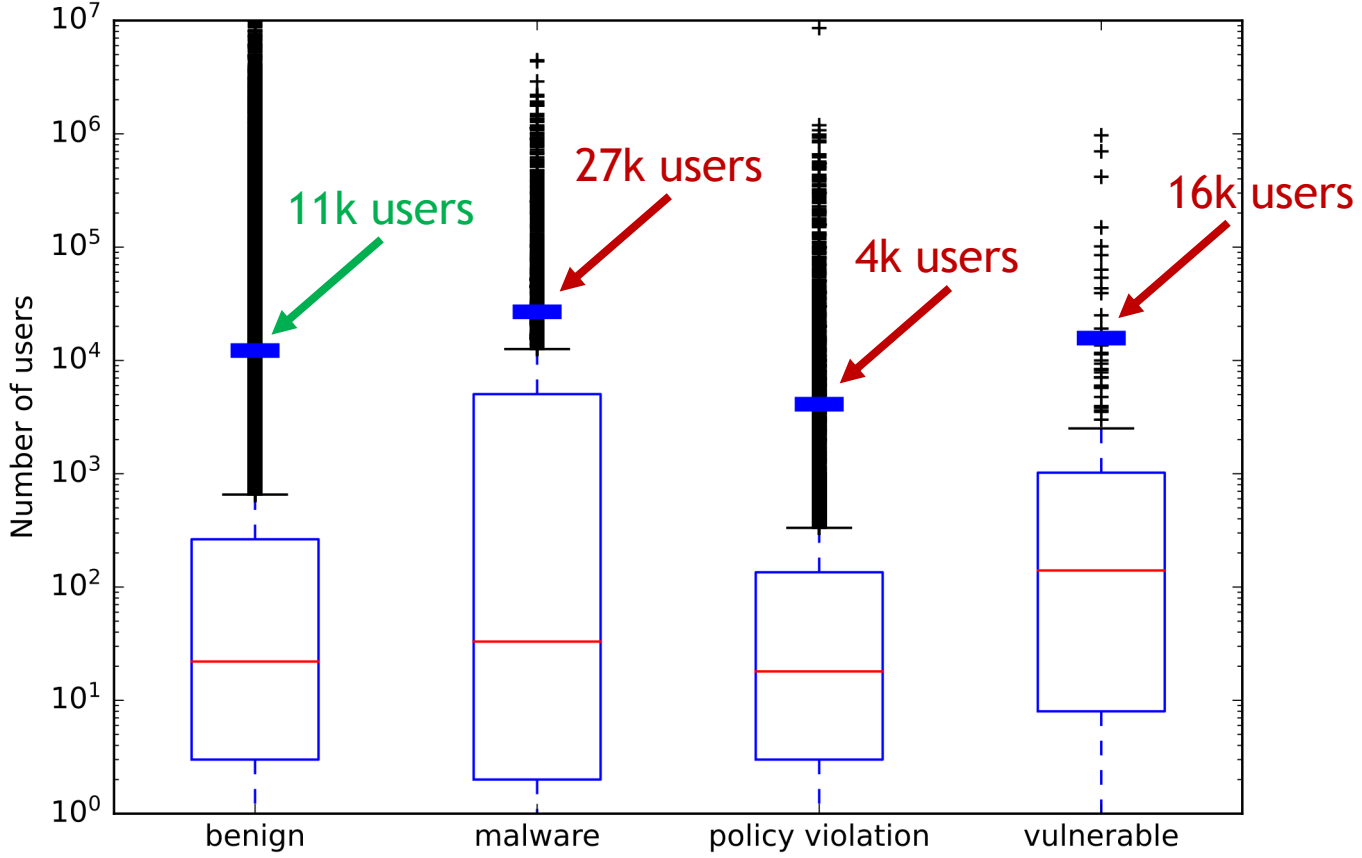
Number of Days in the CWS

- SNE put the security & privacy of Web users **at risk *for years***

,248 days

[1] Hsu, Tran, and Fass; *AsiaCCS* 2024

Number of Users



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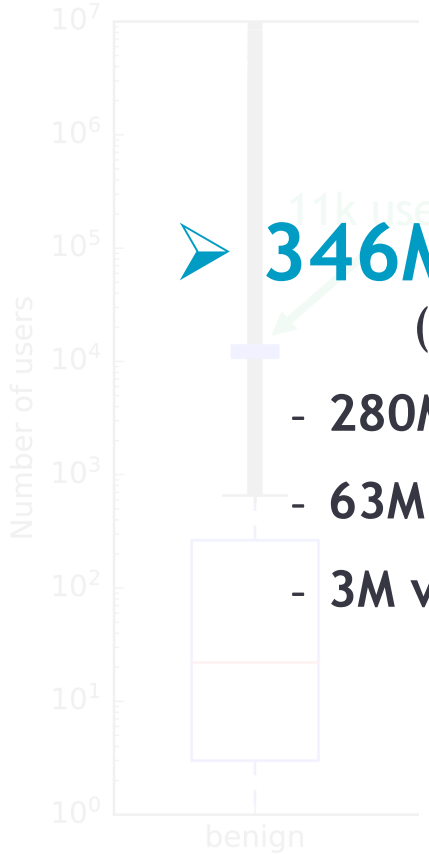

- **346M users installed SNE**
  (between 2020—2023):
  - **280M malware-containing**
  - **63M policy-violating**
  - **3M vulnerable extensions**

[1] Hsu, Tran, and Fass; *AsiaCCS* 2024

Media Coverage

Forbes

FORBES > INNOVATION > CYBERSECURITY

280 Million Google Chrome Users Installed Dangerous Extensions, Study Says

Davey Winder Senior Contributor

Davey Winder is a veteran cybersecurity writer, hacker and analyst.

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Jun 24, 2024, 06:57am EDT

How safe are Google Chrome extensions? SOPA IMAGES/LIGHTROCKET VIA GETTY IMAGES

The Register

Risk of installing dodgy extensions from Chrome store way worse than Google's letting on, study suggests

All depends on how you count it – Chocolate Factory claims 1% fail rate

Thomas Claburn

Sun 23 Jun 2024 // 10:36 UTC

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Google is failing miserably at weeding out bad extensions, new research indicates

July 5, 2024 · 7 min read

TECHSPOT

TRENDING FEATURES REVIEWS THE BEST DOWNLOADS PRODUCT FINDER FORUMS

SECURITY THE WEB MALWARE CHROME

Researchers say 280 million people have installed malware-infected Chrome extensions in the last 3 years

Google claims less than 1% of all installs include malware

By Rob Thubron June 24, 2024 at 11:39 AM

[1] Hsu, Tran, and Fass; *AsiaCCS* 2024

Media Coverage

This review process weeds out the overwhelming majority of bad extensions before they even get published. In 2024, less than 1% of all installs from the Chrome Web Store were found to include malware. We're proud of this record and yet some bad extensions still get through, which is why we also monitor published extensions.

https://security.googleblog.com/2024/06/staying-safe-with-chrome-extensions.html

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Analysis of Vulnerable Extensions: Threat Model

Challenging to detect due to their inherently benign intent (*benign-but-buggy*)

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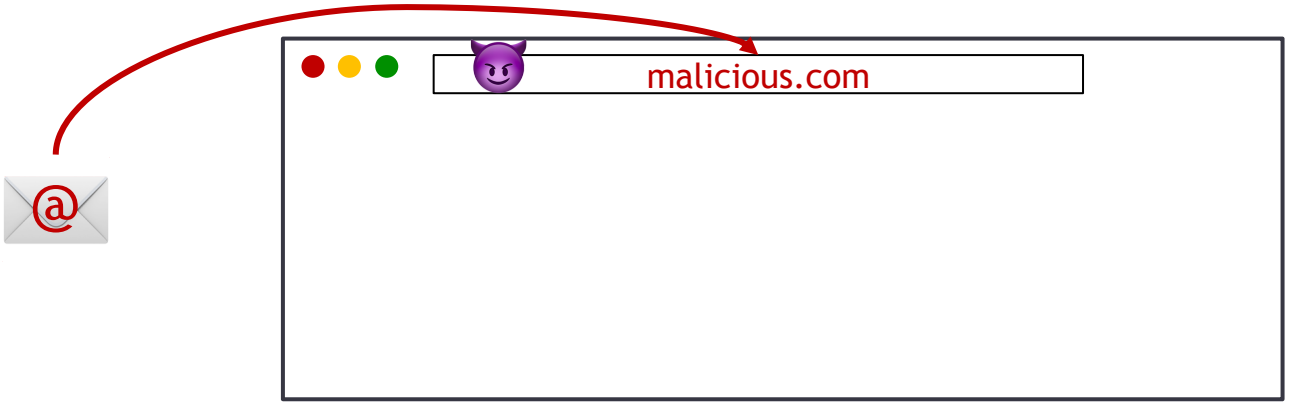

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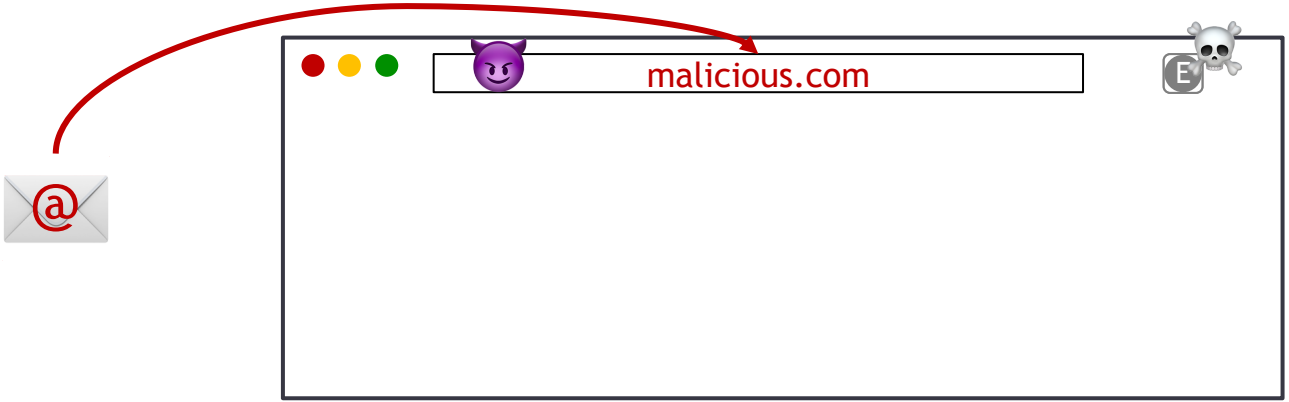

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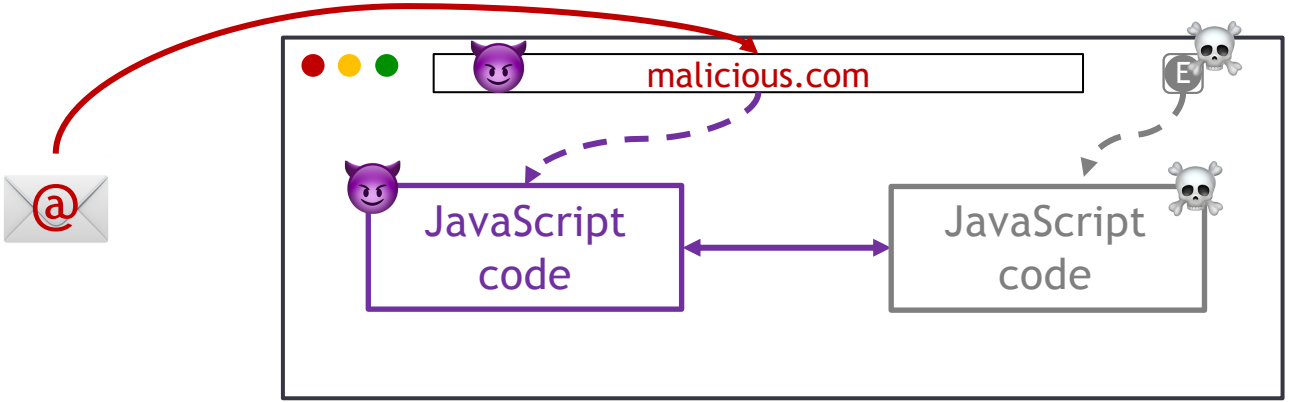

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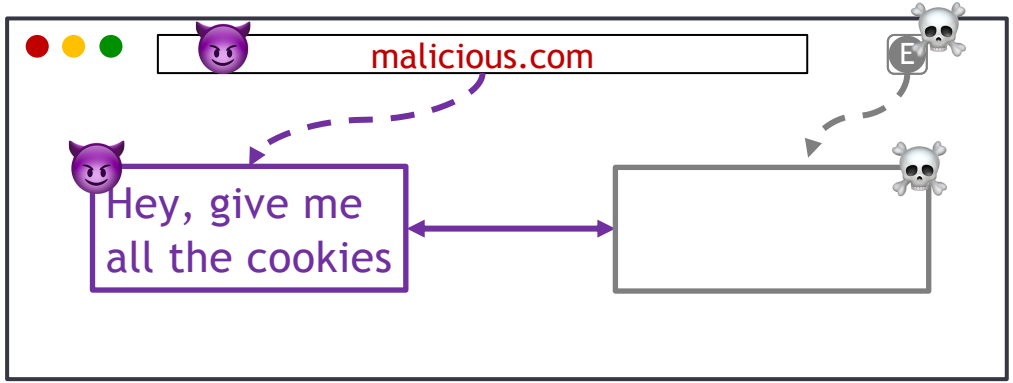

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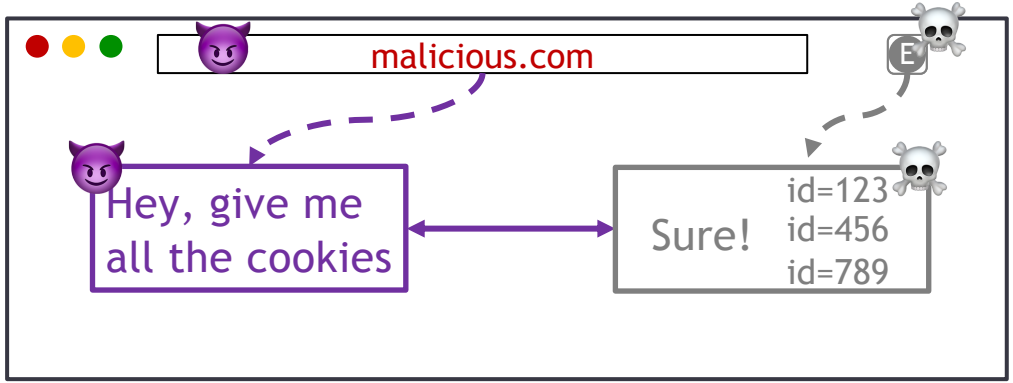

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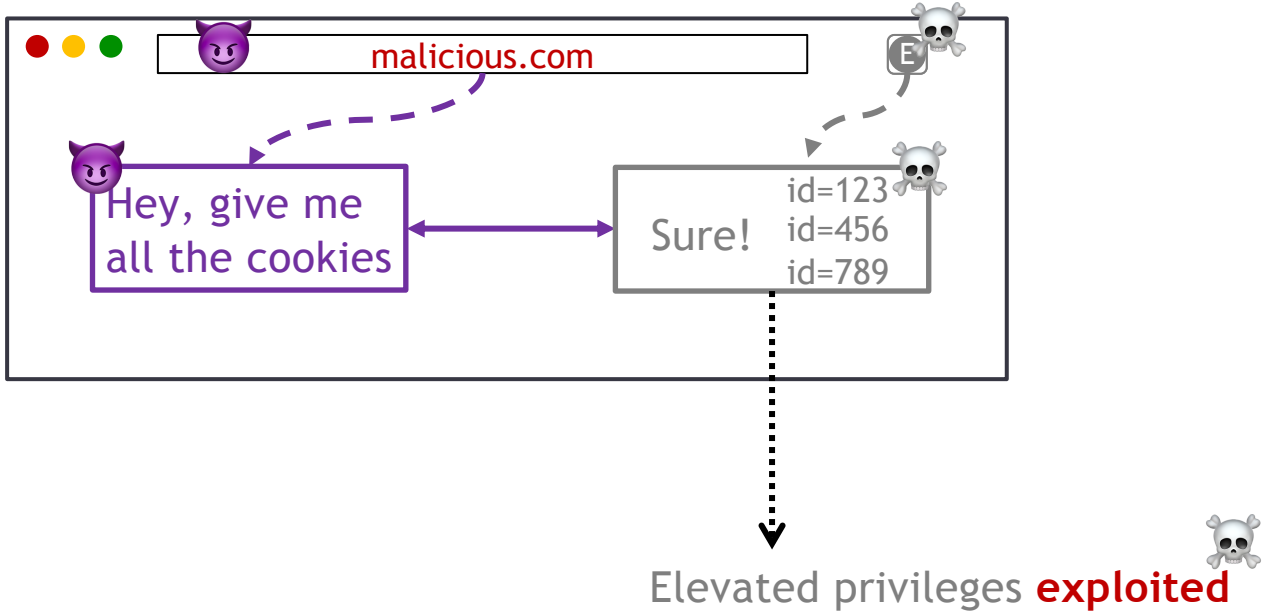

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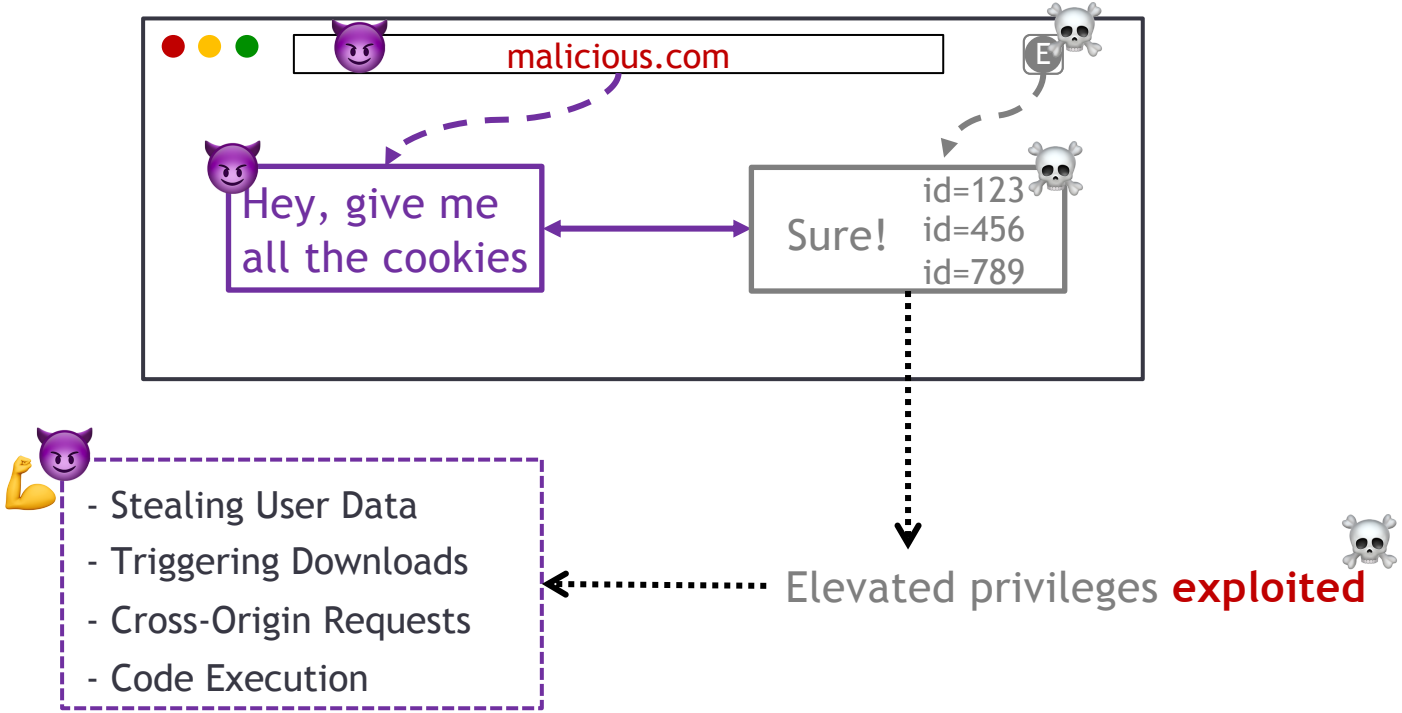

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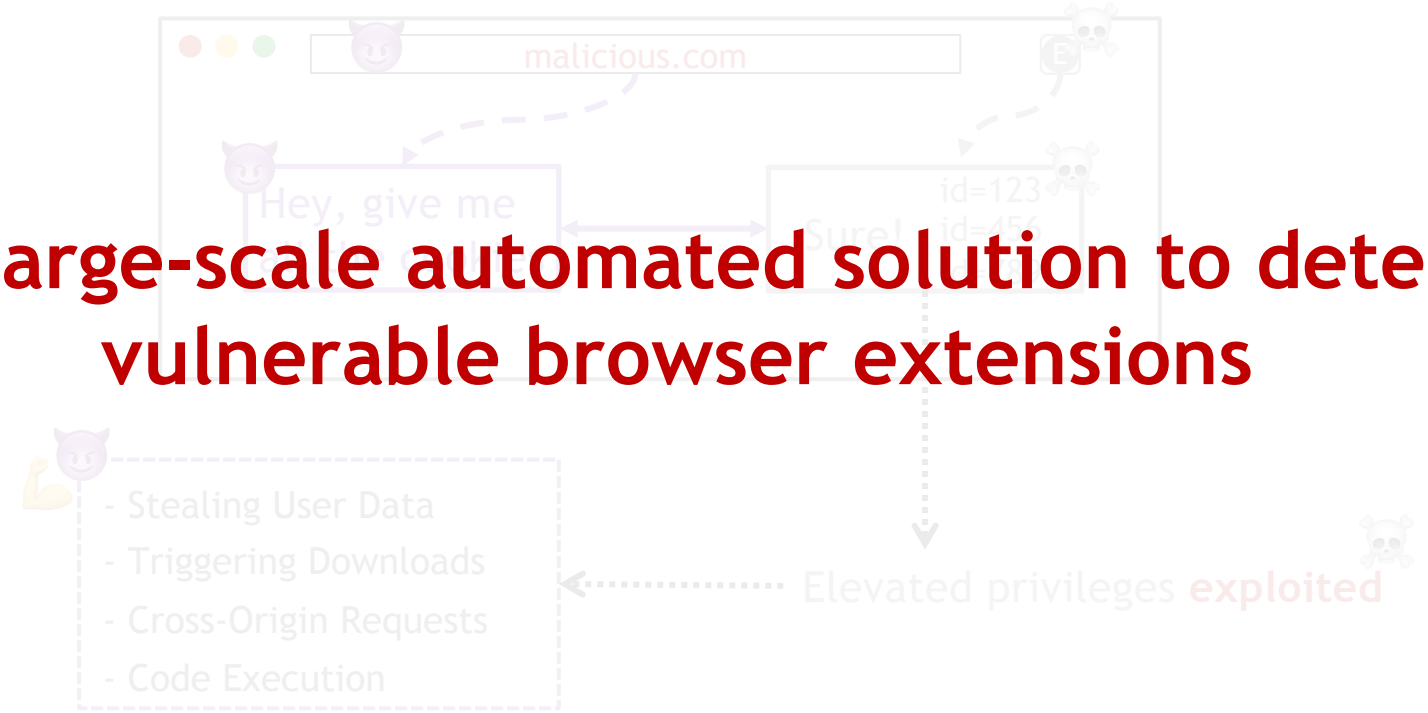

No large-scale automated solution to detect vulnerable browser extensions

[2] Fass et al.; *CCS* 2021

Detecting Vulnerable Extensions

Fass et al.
CCS 2021

DoubleX: Statically Detecting Vulnerable Data Flows in Browser Extensions at Scale

Aurore Fass, Dolière Francis Somé, Michael Backes, and Ben Stock
CISPA Helmholtz Center for Information Security
{aurore.fass,doliere.some,backes,stock}@cispa.de

Abstract

Browser extensions are popular to enhance users' browsing experience. By design, they have access to security- and privacy-critical APIs to perform tasks that web applications cannot traditionally do. Even though web pages and extensions are isolated, they can communicate through messages. Specifically, a vulnerable extension can receive messages from another extension or web page, under the control of an attacker. Thus, these communication channels are a way for a malicious actor to elevate their privileges to the capabilities of an extension, which can lead to, e.g., universal cross-site scripting or sensitive user data exfiltration. To automatically detect such security and privacy threats in benign-but-buggy extensions, we propose our static analyzer DoubleX. DoubleX defines an Extension Dependence Graph (EDG), which abstracts extension code with control and data flows, pointer analysis, and models the message interactions within and outside of an extension. This way, we can leverage this graph to track and detect suspicious data flows between external actors and sensitive APIs in browser extensions.

We evaluated DoubleX on 154,484 Chrome extensions, where it flags 278 extensions as having a suspicious data flow. Overall, we could verify that 89% of these flows can be influenced by external actors (i.e., an attacker). Based on our threat model, we subsequently demonstrate exploitability for 184 extensions. Finally, we evaluated DoubleX on a labeled vulnerable extension set, where it accurately detects almost 93% of known flaws.

CCS Concepts

• **Security and privacy → Web application security; Browser security.**

Keywords

Web Security, Browser Extension, JavaScript, Vulnerability Detection, Static Analysis, Data Flow Analysis

ACM Reference Format:
Aurore Fass, Dolière Francis Somé, Michael Backes, and Ben Stock. 2021. DoubleX: Statically Detecting Vulnerable Data Flows in Browser Extensions at Scale. In *Proceedings of the 2021 ACM SIGSAC Conference on Computer and Communications Security (CCS '21), November 15–19, 2021, Virtual Event, Republic of Korea.* ACM, New York, NY, USA, 16 pages. https://doi.org/10.1145/3460120.3484745

CCS '21, November 15–19, 2021, Virtual Event, Republic of Korea

ACM ISBN 978-1-4503-8454-4/21/11...$15.00
https://doi.org/10.1145/3460120.3484745

1 Introduction

The Web has become a popular ecosystem used by billions of people every day. To extend their browser functionality, users install browser extensions. For the most popular desktop browser Chrome (with a market share of 67% [78]), there are almost 200,000 extensions, totaling over 1.2 billion installs [26]. While some extensions merely customize user browser interface, others serve more security- and privacy-critical tasks, e.g., to be effective, an ad-blocker needs to modify web page content or intercept network requests. To achieve this, and contrary to regular JavaScript in web pages, extensions have privileged capabilities, such as downloading arbitrary files or accessing arbitrary cross-domain data.

Given their elevated privileges, extensions attract the interest of attackers [1, 35, 39, 81, 82]. Still, Google engineers are actively working on detecting such malicious extensions in their store. In February 2020, they removed 500 extensions that were exfiltrating user data [41]; in April 2020, 49 additional extensions that were hijacking users' cryptocurrency wallets [42]; in June 2020, an extra 70 spying extensions [48]; and, in December 2020, extensions redirecting to phishing websites [43]. In addition, before being published, extensions are reviewed by Chrome's vetting system to flag extensions requiring many or powerful privileges for further analyses [16] and to directly detect the ones that may contain or spread malicious software. This process makes it harder to have malicious extensions in the store today.

Still, malicious extensions represent only a fraction of the extensions that may lead to security or privacy issues. In fact, an attacker can also abuse vulnerable extensions to elevate its privileges through the capabilities of an extension. To this end, an attacker can leverage an extension's communication channels to send payloads to this extension, tailored to exploit its vulnerabilities. Such vulnerabilities can lead to, e.g., universal cross-site scripting (XSS) (i.e., the ability to execute code in every website even without a vulnerability in the site itself) or sensitive user data exfiltration. Due to their inherently benign intent, these vulnerable extensions are more challenging to detect than malicious ones, e.g., as they are not doing anything suspicious. Furthermore, even though they do require powerful privileges, their benign nature allows them to pass the review process. While some previous works have focussed on vulnerable extensions, they were either purely formal [7], specific to the deprecated Firefox XPCOM [52] infrastructure [5, 6], or based on primarily manual analysis [8]. To the best of our knowledge, only EmPoWeb from Somé [72] focuses on analyzing extensions' susceptibility to attacks through external messages at scale. In practice, though, his work is based on a lightweight call graph analysis and yields an extremely high number of reported extensions to manually vet: of the 66k Chrome extensions analyzed, it flagged 3.3k as suspicious, and 95% of them were false alarms. In fact, we

> DOUBLEX: Statically Detecting Vulnerable Data Flows in Browser Extensions

In *ACM CCS* 2021. Aurore Fass, Dolière Francis Somé, Michael Backes, and Ben Stock

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Detecting Vulnerable Extensions


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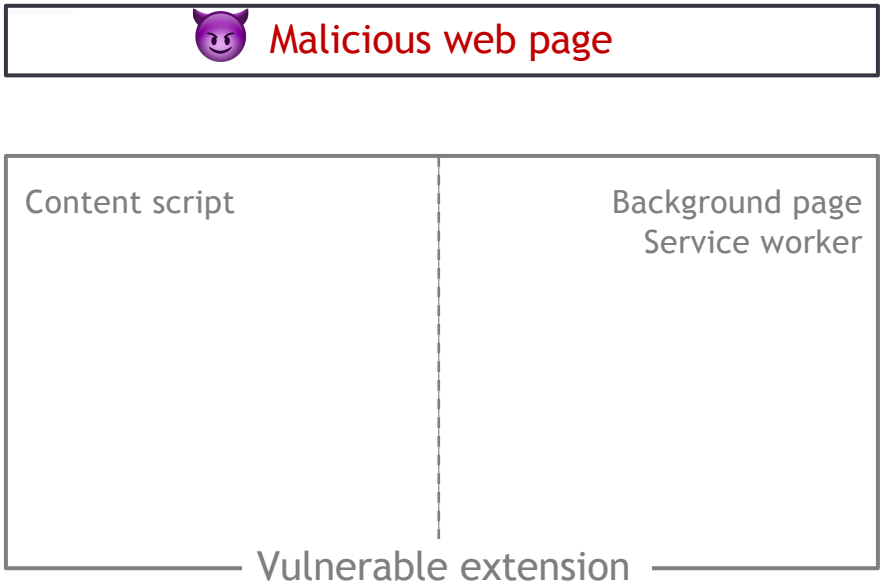

[2] Fass et al.; *CCS* 2021

Detecting Vulnerable Extensions

Fass et al.
CCS 2021


DoubleX: Statically Detecting Vulnerable Data Flows in Browser Extensions at Scale
Aurore Fass, Dolière Francis Somé, Michael Backes, and Ben Stock
CISPA Helmholtz Center for Information Security

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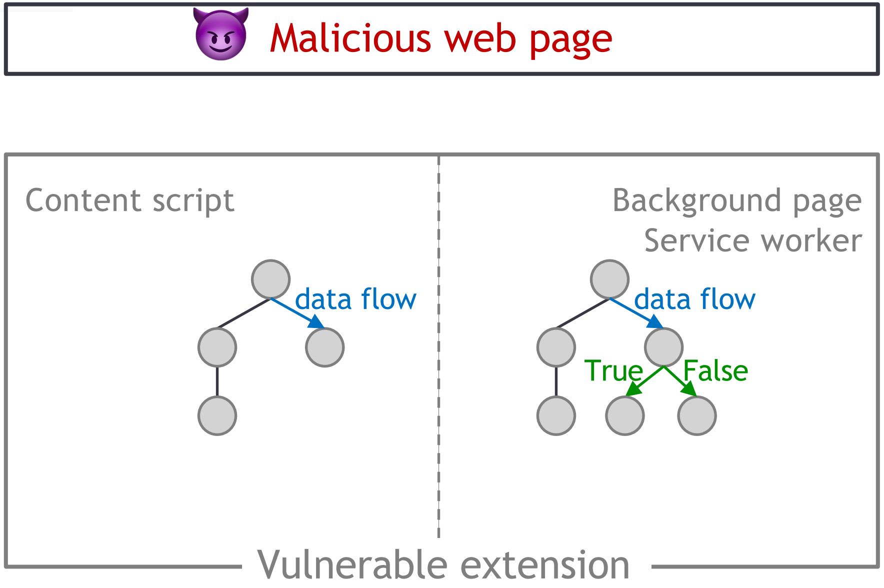

Per-component JavaScript code abstraction

- AST (Abstract Syntax Tree)
- Control flow
- Data flow
- Pointer analysis

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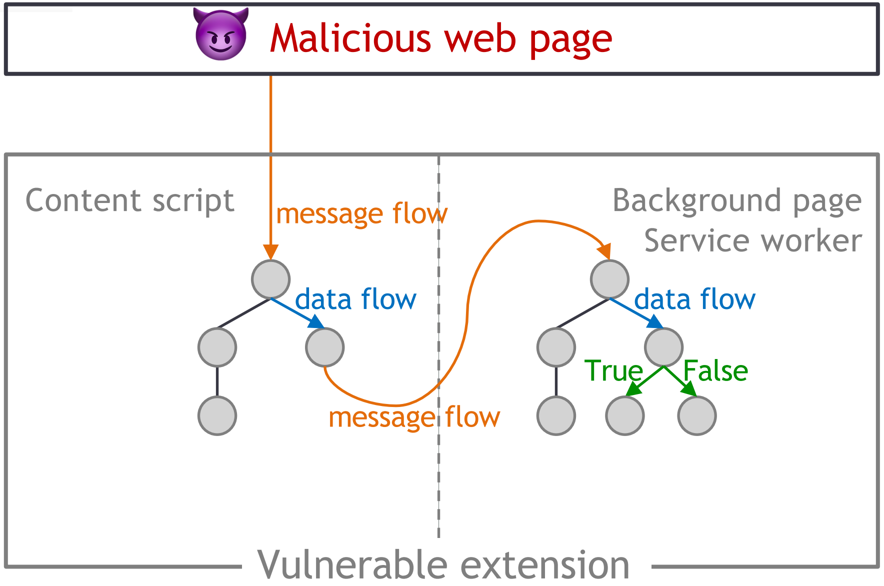

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Extension Dependence Graph (EDG)

➢ Message interactions

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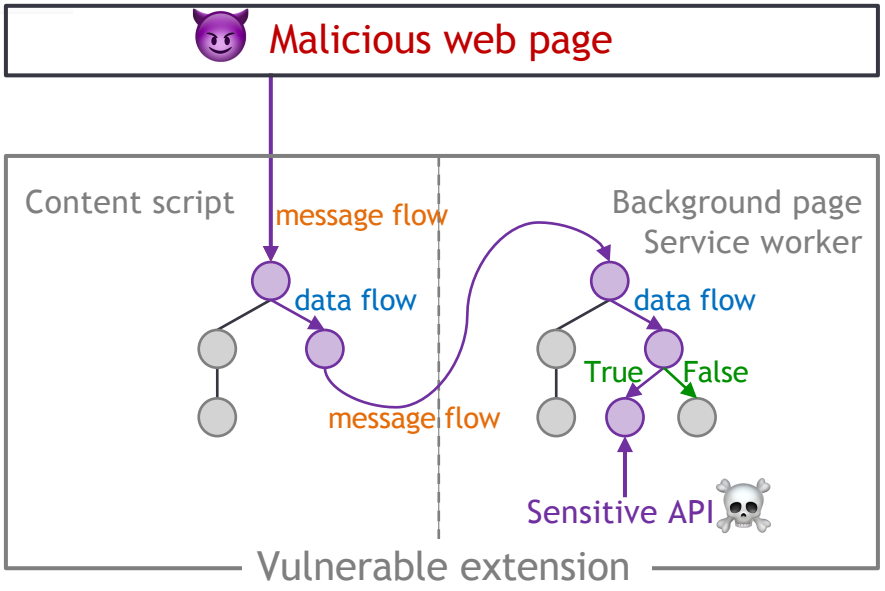

Per-component JavaScript code abstraction

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Extension Dependence Graph (EDG)

➢ Message interactions

Suspicious data flow tracking

➢ Detects any path between an attacker & sensitive APIs

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Simplified Example of a Vulnerability

```
1  // Content script code = from the extension
2  window.addEventListener("message", function(event) {
3
4
5
6  })
```

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Simplified Example of a Vulnerability

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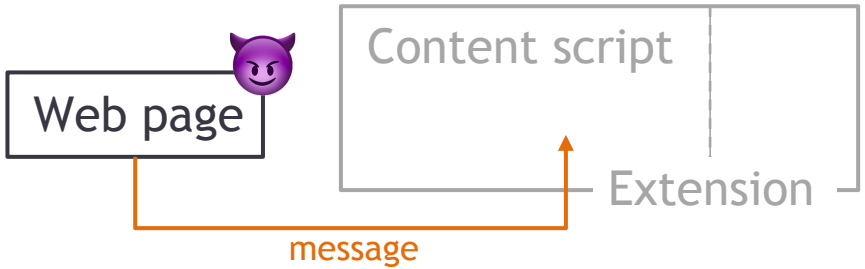

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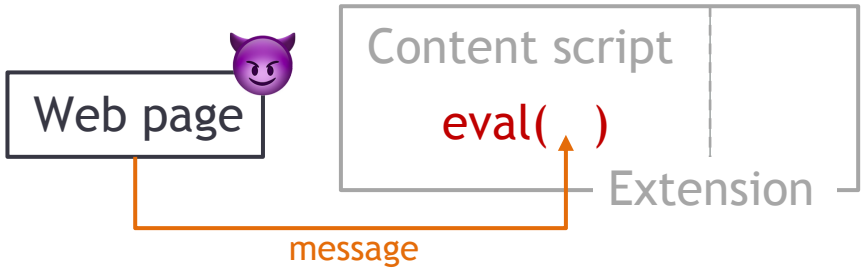

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```
// DOUBLEX report 🔭
{"direct-danger1": "eval",
"value": "eval(event.data)",
"line": "4 - 4",
"dataflow": true, ✅
"param1": {
  "received": "event",
  "line": "2 - 2"}}
```

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// Content script code = from the extension
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```
// Attacker code = from the targeted web page
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(very) malicious payload

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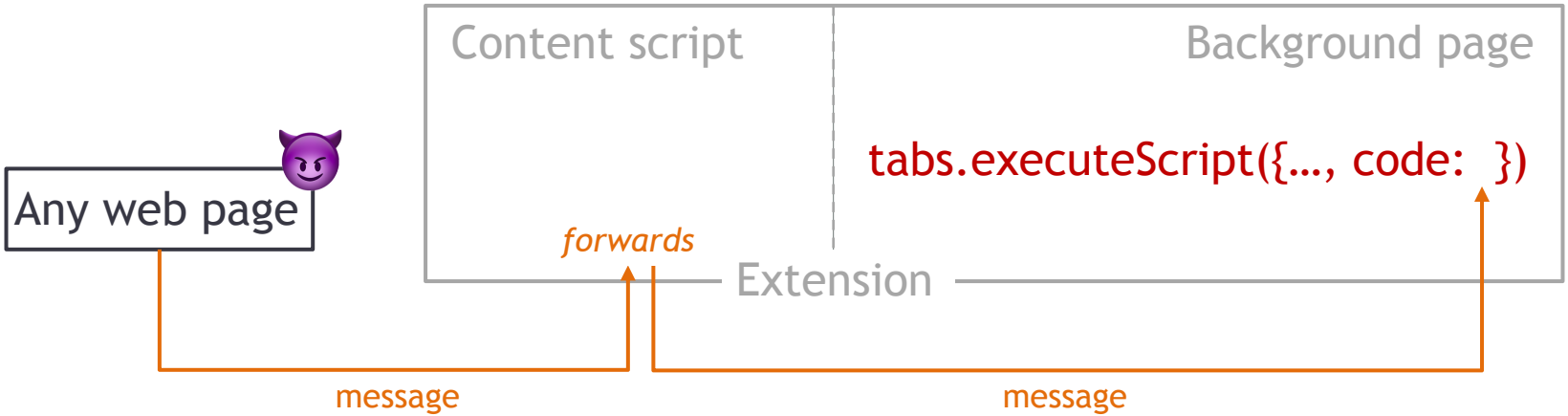
Case Study of Vulnerable Chrome Extensions

Arbitrary code execution (*cdi*…, 4k+ users):



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Detecting Vulnerable Extensions with DOUBLEX

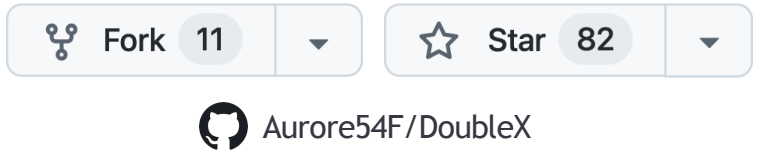
Analyzed 155k Chrome extensions from 2021 with DOUBLEX (takes 2—3s per extension)

- **184 vulnerable Chrome extensions**
- Impacting **3M users*** (* based on Google's definition)

- **Precision: 89%** of the flagged extensions are vulnerable
- **Recall: 93%** of known vulnerabilities [Somé, S&P 2019] are detected

- **Open source**, for developers and Web users

  (even in other fields, e.g., mini apps [Wang et al., ICSE 2023])



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Defenses & Perspectives

- (Migrate an extension to Manifest V3)
- Know that communication with external actors may be dangerous
- Only allow communication with specified extensions or web pages
- Limit code execution by sanitizing messages
- DOUBLEX could provide a feedback channel for developers

[2] Fass et al.; *CCS* 2021

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Hsu et al. AsiaCCS 2024

Fass et al. CCS 2021

Agarwal et al. CCS 2024

Rosenzweig et al. TWEB 2026

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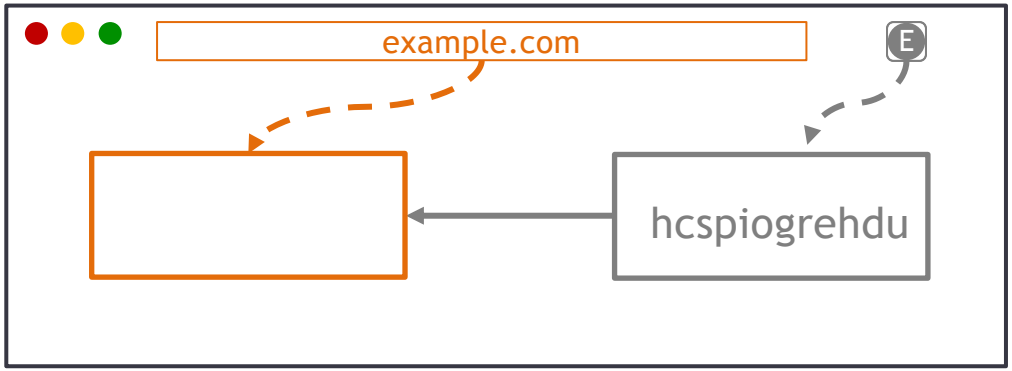

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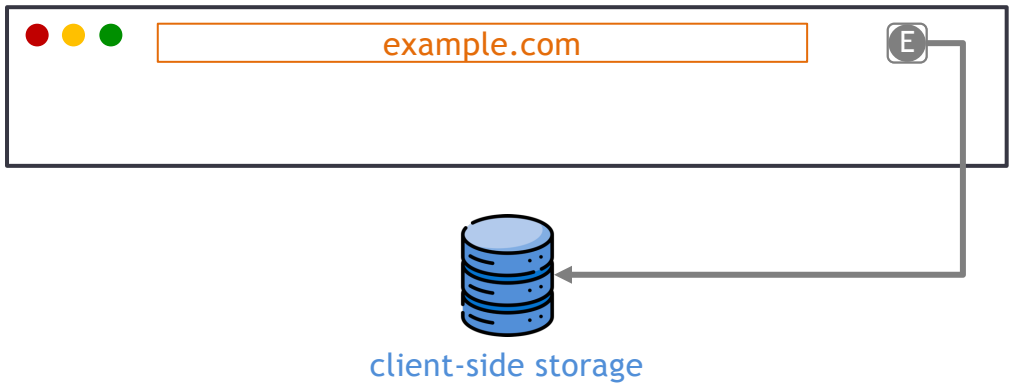

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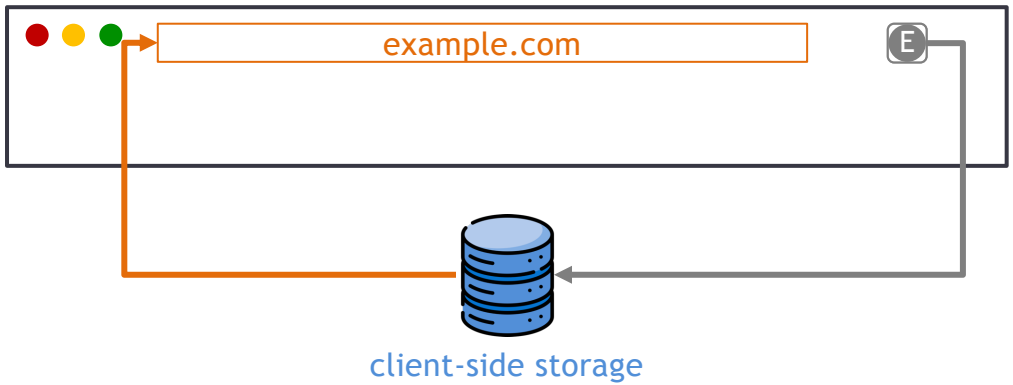

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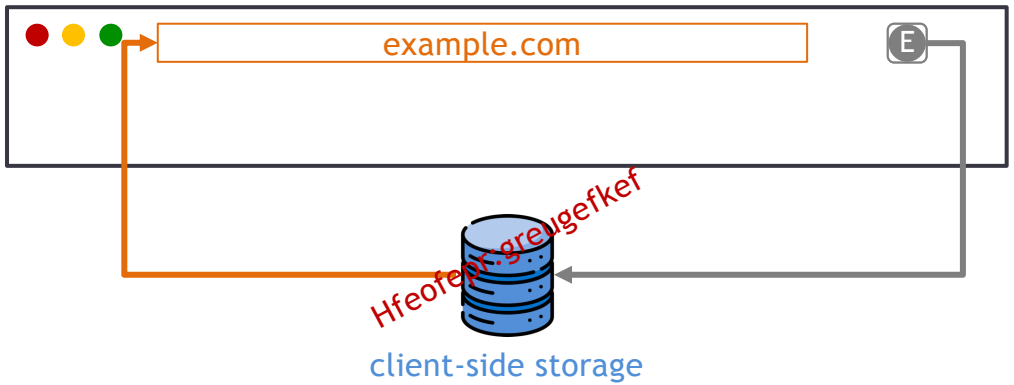

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Why is this bad?

- "Malicious" websites can **track users** by fingerprinting their extensions
- Extensions can **reveal personal user information**, e.g., geolocation, ethnicity, social/personal interests, medical issues, religion, etc. [Karami; NDSS'19]

[4] Agarwal, Fass, and Stock; *CCS* 2024

Detecting Fingerprintable Extensions

*How many extensions can be **uniquely fingerprinted** through these observable side effects?*

Detecting Fingerprintable Extensions

*How many extensions can be **uniquely fingerprinted** through these observable side effects?*


Peeking through the window: Fingerprinting Browser Extensions through Page-Visible Execution Traces and Interactions

Shubham Agarwal
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Aurore Fass
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Ben Stock
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stock@cispa.de

ABSTRACT

1 INTRODUCTION

> Peeking through the `window`: Fingerprinting Browser Extensions through Page-Visible Execution Traces and Interactions

In *ACM CCS* 2024. Shubham Agarwal, Aurore Fass, and Ben Stock

Detecting Fingerprintable Extensions with Raider

Analyzed 38k Chrome extensions from 2024 with Raider

- **2,747 fingerprintable Chrome extensions** (lower bound)
- Impacting **169M users**

- **Notified 1,967 developers** about their fingerprintable extension(s)
  - Only 30 (!) replied
  - Of those, only 16 positively acknowledged the issues
    - But: they heavily rely on our fingerprinting vectors (e.g., script injection or data storage) for their extensions' functionality

- Raider PoC is **available online**  Raider-ext/raider

[4] Agarwal, Fass, and Stock; *CCS* 2024

Mitigations

- Global APIs:
  - ensure that browser extension code runs before the attacker code (inject at document_start)
  - ensure that APIs cannot be overwritten (freeze their native definition)
- Global variables: scope appropriately
- Storage: use the chrome.storage API instead

[4] Agarwal, Fass, and Stock; *CCS* 2024

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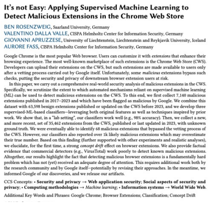
Detecting Malicious Extensions — Lab Setting

Rosenzweig et al. TWEB 2026



It's not Easy: Applying Supervised Machine Learning to Detect Malicious Extensions in the Chrome Web Store

BEN ROSENZWEIG, Saarland University, Germany
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Google Chrome is the most popular Web browser. Users can customize it with *extensions* that enhance their browsing experience. The most well-known marketplace of such extensions is the Chrome Web Store (CWS). Developers can upload their extensions on the CWS, but such extensions are made available to users only after a vetting process carried out by Google itself. Unfortunately, some *malicious* extensions bypass such checks, putting the security and privacy of downstream browser extension users at risk.

In this paper, we carry out a comprehensive real-world security analysis of malicious extensions in the CWS. Specifically, we scrutinize the extent to which automated mechanisms reliant on supervised machine learning (ML) can be used to detect malicious extensions on the CWS. To this end, we first collect 7,140 malicious extensions published in 2017–2023 and which have been flagged as malicious by Google. We combine this dataset with 63,598 benign extensions published or updated on the CWS before 2023, and we develop three supervised-ML-based classifiers—leveraging both original features as well as techniques inspired by prior work. We show that, in a "lab setting", our classifiers work well (e.g., 98% accuracy). Then, we collect a new, and more recent, set of 35,462 extensions from the CWS, published or last updated in 2023, with unknown ground truth. We were eventually able to identify 68 malicious extensions that bypassed the vetting process of the CWS. However, our classifiers also reported over 1k likely malicious extensions which may overestimate their true number. Based on this finding (further supported with other experiments and realistic analyses), we elucidate, for the first time, a strong *concept drift* effect on browser extensions. We also provide factual evidence that commercial detectors (e.g., VirusTotal) work poorly to detect known malicious extensions. Altogether, our results highlight the fact that detecting malicious browser extensions is a fundamentally hard problem which has not (yet) received an adequate degree of attention. This requires additional work both by the research community and by Google itself—potentially by revising their approaches. In the meantime, we informed Google of our discoveries, and we release our artifacts.

CCS Concepts: • **Security and privacy → Web application security**; **Social aspects of security and privacy**; • **Computing methodologies →** *Machine learning*; • **Information systems → World Wide Web**.

Additional Key Words and Phrases: Google Chrome; Browser Extensions; Classification; Concept Drift

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Detecting Malicious Extensions — Lab Setting

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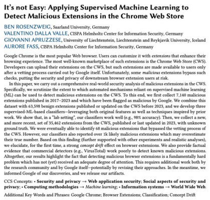

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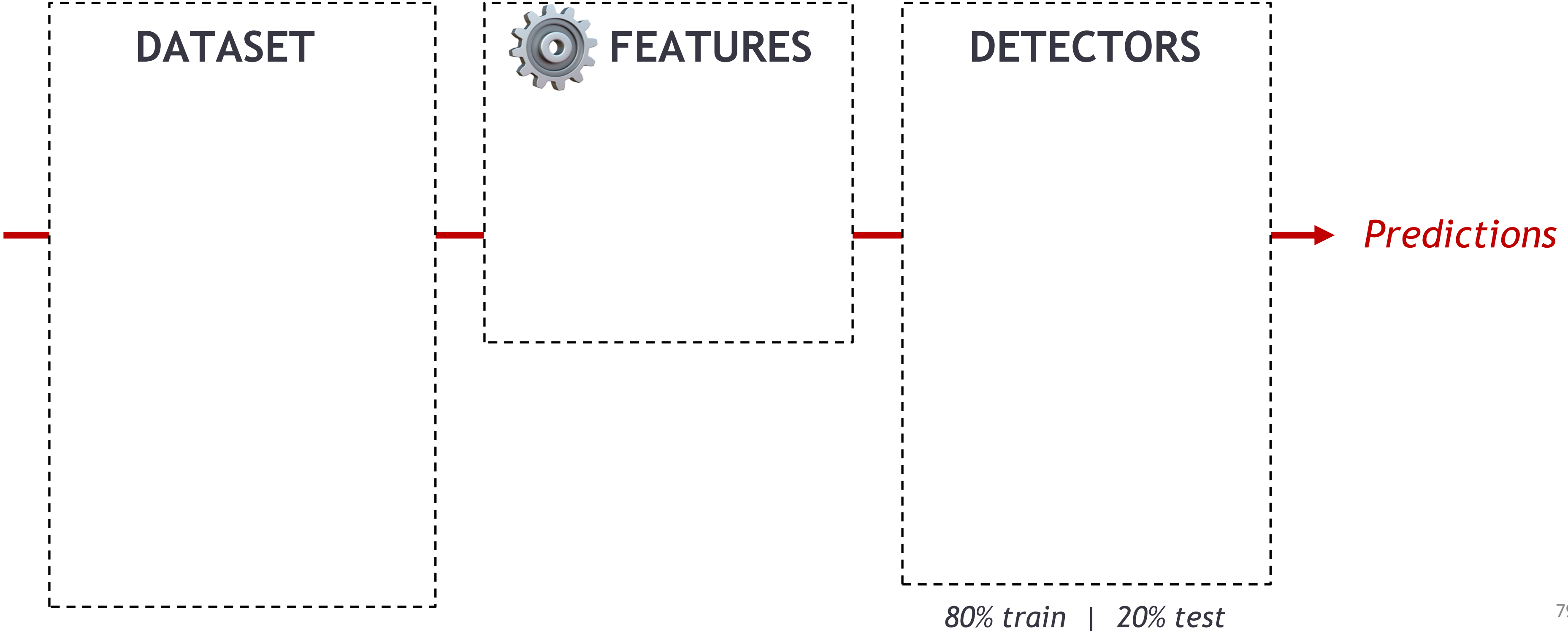
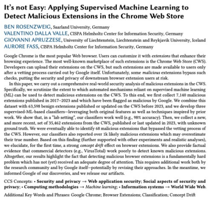


Detecting Malicious Extensions — Lab Setting

Rosenzweig et al. TWEB 2026



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DATASET

7,140 malicious extensions

Last update 2017—22

63,598 benign extensions

Last update 2012—22

FEATURES

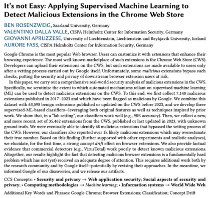
DETECTORS

80% train | 20% test

Predictions

Detecting Malicious Extensions — Lab Setting

Rosenzweig et al. TWEB 2026


It's not Easy: Applying Supervised Machine Learning to Detect Malicious Extensions in the Chrome Web Store

BEN ROSENZWEIG, Saarland University, Germany
VALENTINO DALLA VALLE, CISPA Helmholtz Center for Information Security, Germany
GIOVANNI APRUZZESE, University of Liechtenstein, Liechtenstein and Reykjavik University, Iceland
AURORE FASS, CISPA Helmholtz Center for Information Security, Germany

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In *ACM TWEB* 2026. Ben Rosenzweig, Valentino Dalla Valle, Giovanni Apruzzese, and Aurore Fass

DATASET

7,140 malicious extensions

Last update 2017—22

63,598 benign extensions

Last update 2012—22

FEATURES

Source code [A]

Metadata

[A] Fass et al.; *ACSAC* 2018

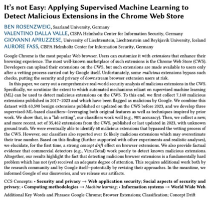
DETECTORS

80% train | 20% test

→ *Predictions*

Detecting Malicious Extensions — Lab Setting

Rosenzweig et al. TWEB 2026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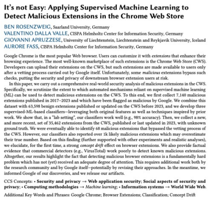
Rosenzweig et al. TWEB 2026



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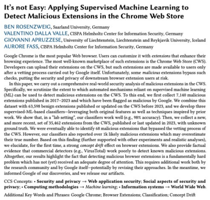
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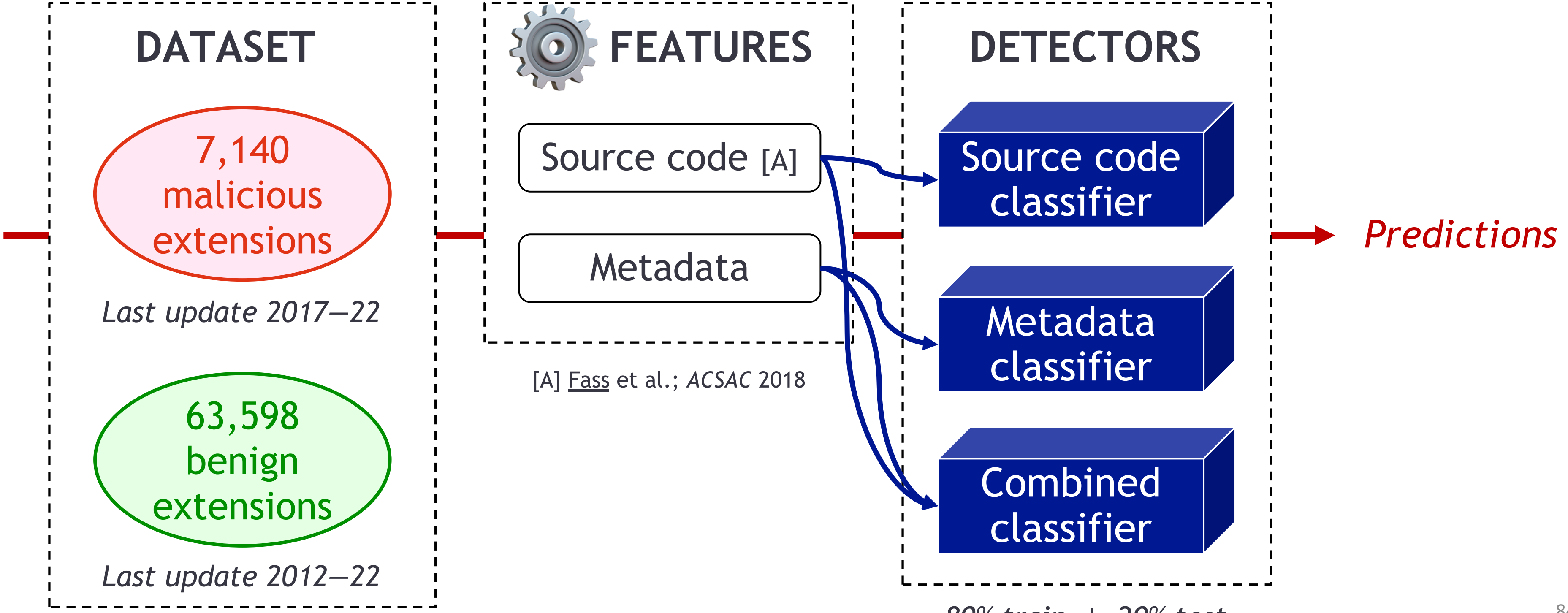

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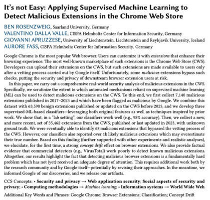
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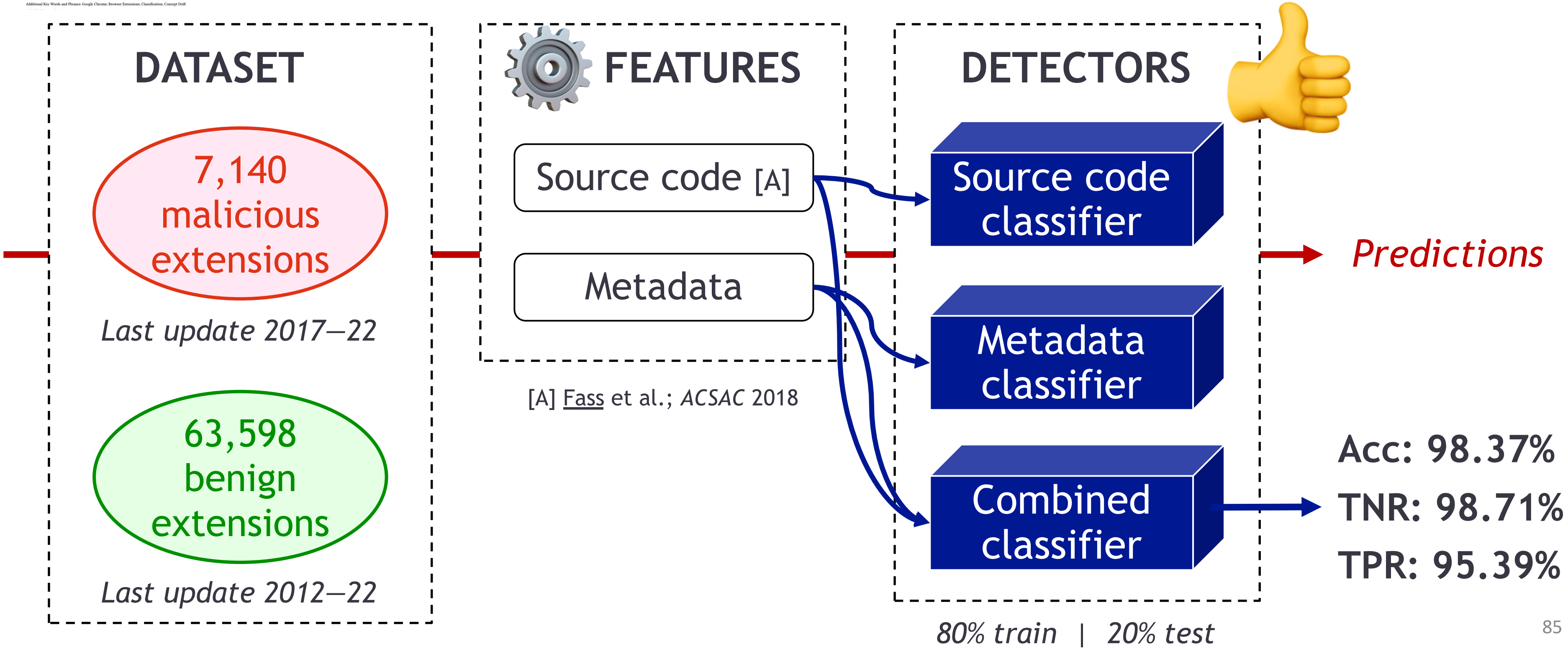

Detecting Malicious Extensions — Real World

30,004 “unknown” extensions

Last update 2023

[3] Rosenzweig et al.; *TWEB* 2026

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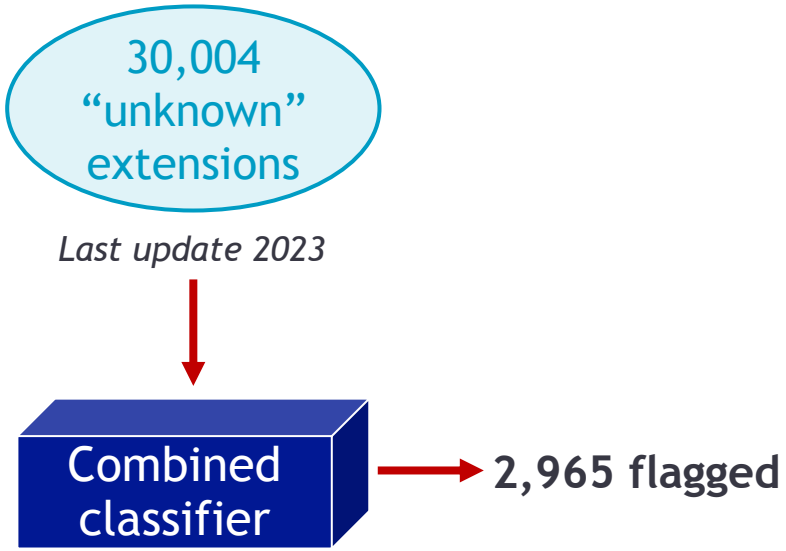

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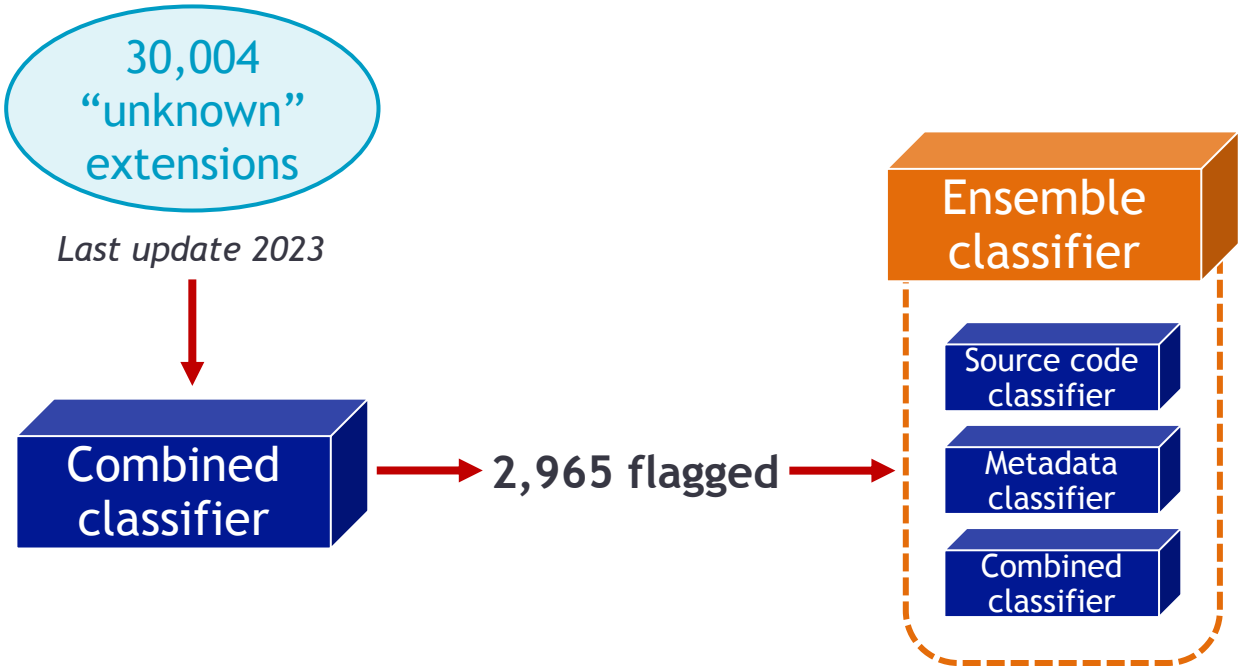

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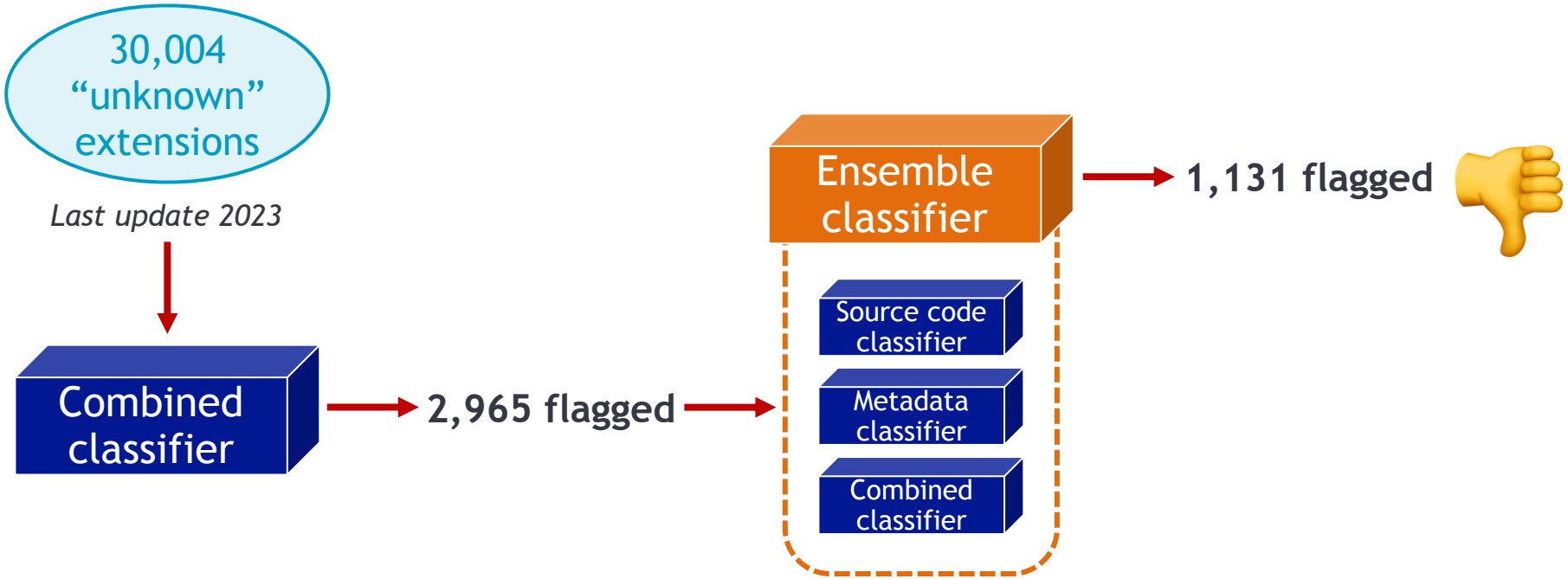

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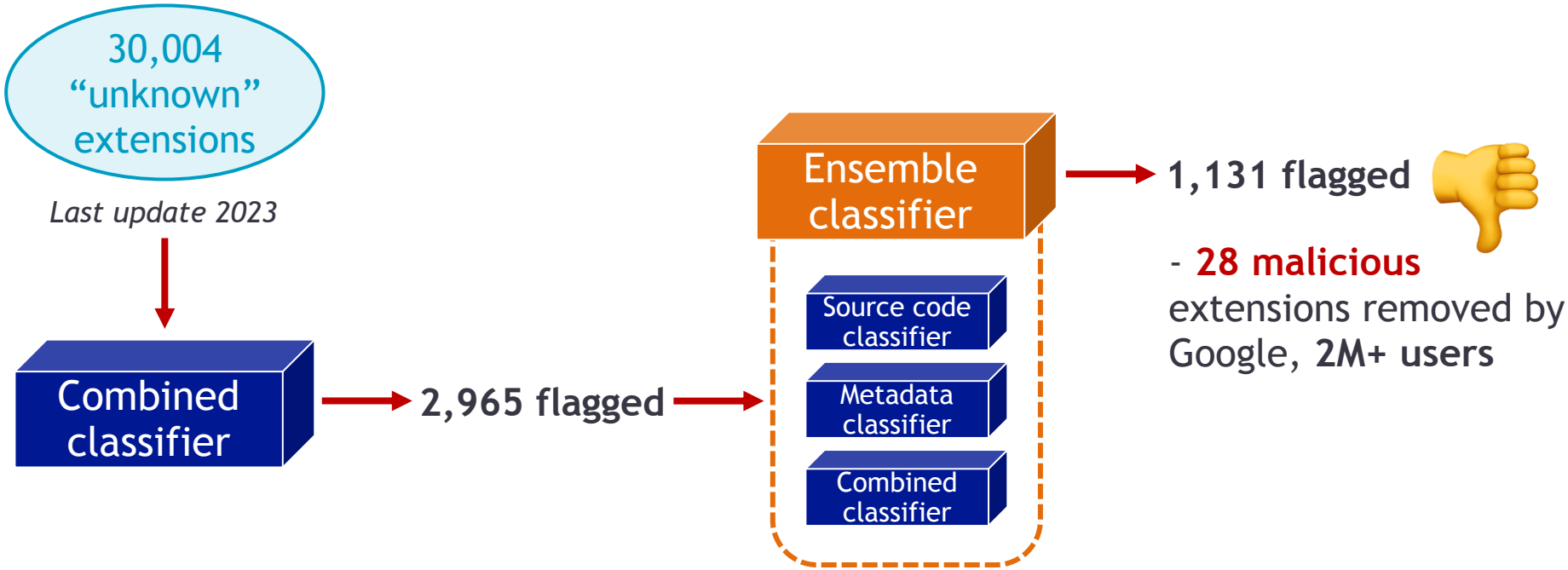

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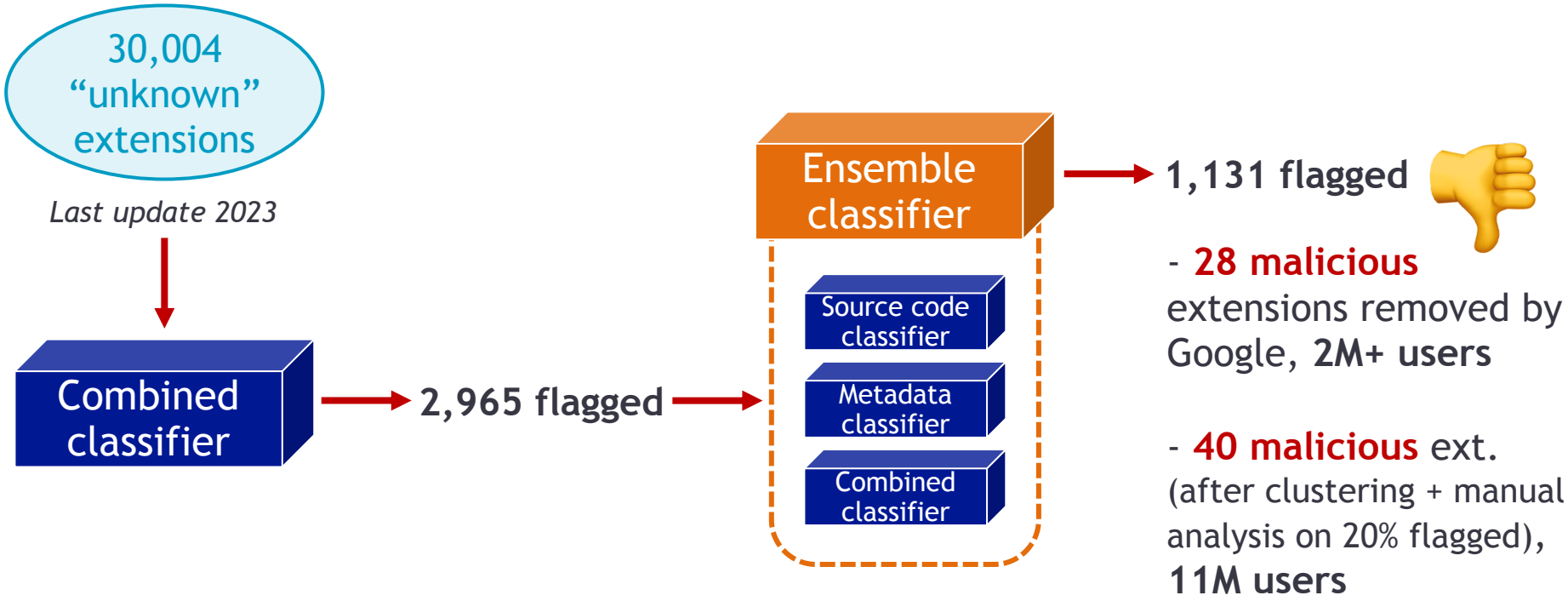

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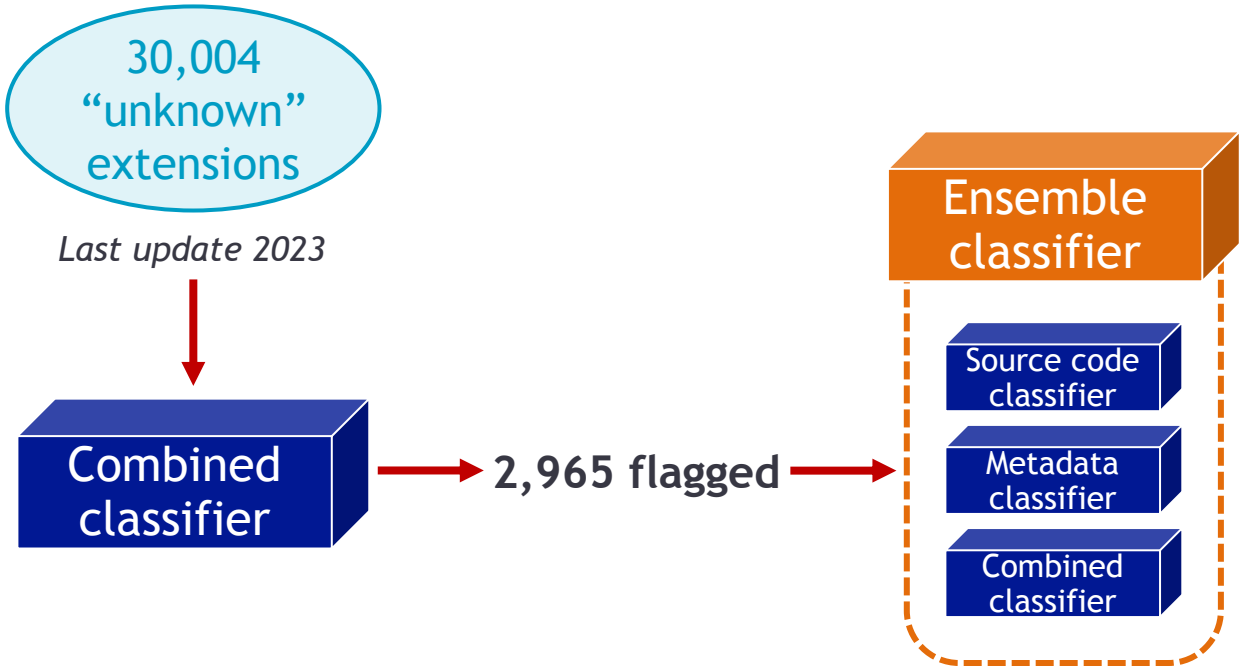


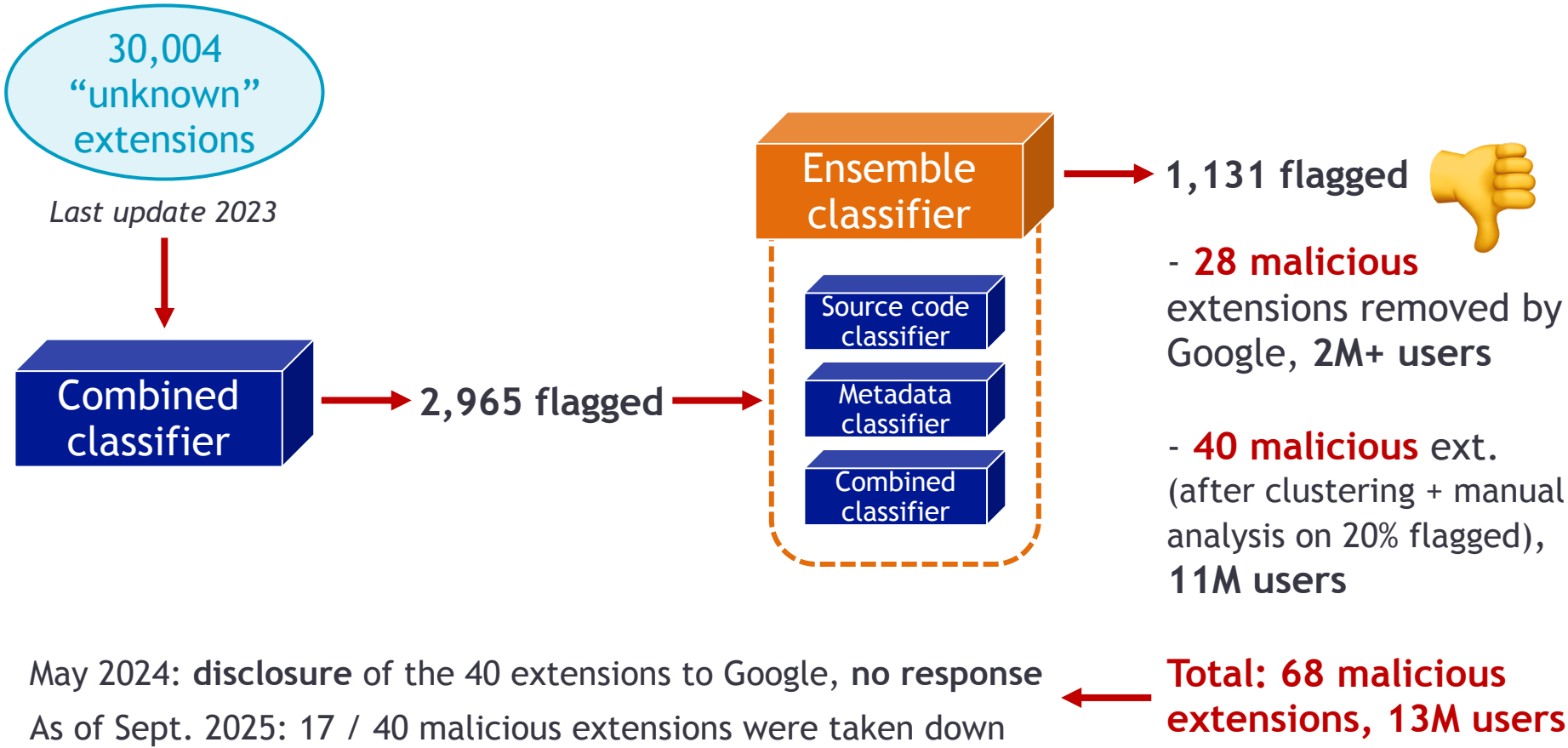
- **28 malicious** extensions removed by Google, **2M+ users**

- **40 malicious** ext. (after clustering + manual analysis on 20% flagged), **11M users**

Total: 68 malicious extensions, 13M users

[3] Rosenzweig et al.; *TWEB* 2026

Detecting Malicious Extensions — Real World



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Detecting Malicious Extensions — Lab Setting vs. Real World

- **Lab setting**: 98.37% accuracy
- **Real world**: 1,131 / 30,004 extensions flagged | 68 verified malicious extensions

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[3] Rosenzweig et al.; *TWEB* 2026

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- **Concept drift**
  - **Intrinsic evolution** of extensions, hard for supervised ML tools to keep a (high) accuracy over time
  - **How** to validate concept drift? → see experiments in the paper
  - **Why** are extensions affected? → see paper (study feature importance)

[3] Rosenzweig et al.; *TWEB* 2026

Detecting Malicious Extensions — Takeaways

- ML evaluations can be **misleading**: detectors performing well in a lab setting are **no guarantee of practical applicability** in the real world
- Detectors need to be **retrained regularly**
- Investigate **active learning** as a **mitigation to concept drift**
  - E.g., *uncertainty sampling*: monthly retraining of the detector on X labeled extensions where the detector is the most uncertain

[3] Rosenzweig et al.; *TWEB* 2026

Summary

Dangerous Browser Extensions

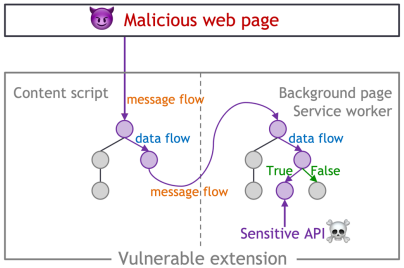
Hsu et al. AsiaCCS 2024

→ **Extensions can put their users' security & privacy at risk:**

- **Contain malware:** designed by malicious actors to harm victims
  - E.g., propagate malware, steal users' credentials, track users
- **Contain vulnerabilities:** designed by well-intentioned developers… but buggy
  - E.g., can lead to user-sensitive data exfiltration
- **Violate the Chrome Web Store policies**
  - E.g., deceive users, promote unlawful activities, lack a privacy policy
- **Be fingerprintable:** can be recognized and uniquely identified
  - E.g., can lead to user tracking or inferring of user personal information

Detecting Vulnerable Extensions with DOUBLEX

Fass et al. CCS 2021



Aurore54F/DoubleX

➢ DOUBLEX detects suspicious data flows in browser extensions

184 vulnerable extensions | **Precision: 89%** | **Recall: 93%**

Detecting Fingerprintable Extensions with Raider

Agarwal et al. CCS 2024

- 1) Extensions send **PostMessage** to web pages
- 2) Extensions store data on the client side through **storage APIs**
  (e.g., cookies, local/session storage, IndexedDB)
- 3) Extensions **inject JavaScript** code directly into web pages
  → registering global variables
  → invocation of global APIs and properties

Raider-ext/raider

➢ Raider detects **2,747** fingerprintable extensions | **169M users**

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Rosenzweig et al. TWEB 2026

its-not-easy/tweb25

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Corresponding Publications

- What is in the Chrome Web Store?

Sheryl Hsu, Manda Tran, and Aurore Fass. In *ACM AsiaCCS* 2024

- DoubleX: Statically Detecting Vulnerable Data Flows in Browser Extensions at Scale

Aurore Fass, Dolière Francis Somé, Michael Backes, and Ben Stock. In *ACM CCS* 2021

- Peeking through the window: Fingerprinting Browser Extensions through Page-Visible Execution Traces and Interactions

Shubham Agarwal, Aurore Fass, and Ben Stock. In *ACM CCS* 2024

- It's not Easy: Applying Supervised Machine Learning to Detect Malicious Extensions in the Chrome Web Store

Ben Rosenzweig, Valentino Dalla Valle, Giovanni Apruzzese, and Aurore Fass. In *ACM TWEB* 2026