



German  
**OWASP**  
Day 2025

*I have no idea how to make it safer:*  
Studying Security and Privacy Mindsets of  
Browser Extension Developers

***Shubham Agarwal, Rafael Mrowczynski, Maria Hellenthal, Ben Stock***

German OWASP Day 2025 - Düsseldorf, DE

whoami



German  
**OWASP**  
Day 2025



**Shubham Agarwal**

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**OWASP**  
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## Shubham Agarwal

Security and Privacy Engineering (SPRING) Lab

Web Applications Security, Data Privacy, Large-scale Vulnerability Analysis, Browser Extensions, Stakeholders Analysis

whoami



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- Scientific Researcher at Max Planck Institute-Security and Privacy, Bochum, DE.



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- Scientific Researcher at Max Planck Institute-  
Security and Privacy, Bochum, DE.
- Likes to talk/hear on all things Applications Security  
& Data Privacy.
- Now (also) interested in Digital Harms & S&P  
Guidelines for Stakeholders.



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# Have you developed/used browser extensions?

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Malwarebytes™



NordVPN®



grammarly



METAMASK



ADGUARD



HOSTERY®



Google Scholar



QuillBot

LastPass...|



Adblock Plus



bitwarden

# Why do we care about extensions?

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## Supply chain attack hits Chrome extensions, could expose millions

Threat actor exploited phishing and OAuth abuse to inject malicious code

## Compromised Browser Extensions - A Growing Threat Vector

Learn how threat actors leverage browser extensions as an attack vector, including examples for Cyberhaven and GraphQL Network Inspector.



Pulsedive Threat Research  
25 Feb 2025 • 15 min read

## Universal Code Execution by Chaining Messages in Browser Extensions

Jul 7, 2024 • 2111 words • 10 minute read

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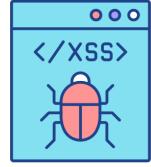
# What do we know, what have we learnt?

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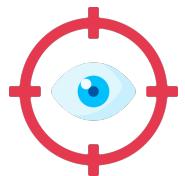
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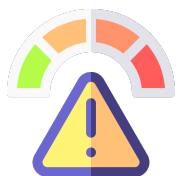
Cross-Site Scripting



Information Leaks



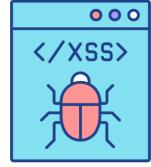
Security Header Modifications



Extension Fingerprinting

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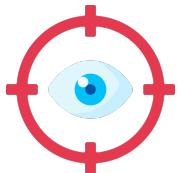
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Cross-Site Scripting



Highlight: Malicious Benign-but-Buggy  
Extensions



Security Header Modifications



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Extension Fingerprinting

# Our Recent Research

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***What is the Security & Privacy Mindset of Browser Extension Developers?***

# Our Recent Research

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***What is the Security & Privacy Mindset of Browser Extension Developers?***



Qualitative Interviews  
with 21 Browser  
Extension Developers

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Development Experience

# Our Recent Research

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Development Experience



Coding Tasks (CTs)

# Our Recent Research



## *What is the Security & Privacy Mindset of Browser Extension Developers?*



Qualitative Interviews  
with 21 Browser  
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Development Experience



Coding Tasks (CTs)



S&P Mindset

*~120 minutes of Semi-structured Interviews*

*Solution Strategy >>> Solution*

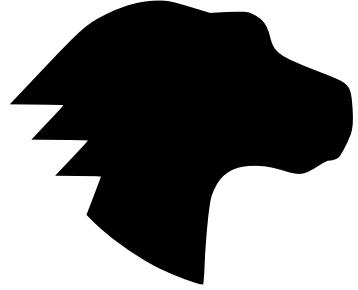
# Real-World Development Settings

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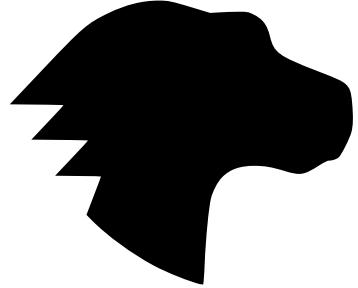
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# Case I: Privacy Mindset of Developers

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---



Task: *Allow Autocomplete of Address Data on Purchase Page.*

# Case I: Privacy Mindset of Developers

---



Task: *Allow Autocomplete of Address Data on Purchase Page.*

Order Details

Address Line 1

Address Line 2

City

State

Country

Pincode

Number of Copies

Language

English

Save Address for Later

Autofill Address Data

Continue to Payment

# Case I: Privacy Mindset of Developers



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# Case I: Actions & Observations

---



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---



*“...we would collect I guess the address we would then store that through the **localStorage API**”*

Privacy-unfriendly data storage strategy:  
**Web Storage APIs >>> chrome.storage APIs**

Unclear privacy benefits of the dedicated **chrome.storage API** over **Web Storage APIs**.

*“...if I were to call **chrome.storage.sync API** here and save this address, would other extensions have access to this?”*

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*“...if I were to call **chrome.storage.sync API** here and save this address, would other extensions have access to this?”*

**The S&P benefits of existing APIs and their actions are, at best, unclear to developers.**

# Case I: What do vendors say?

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Although this API is similar to `Window.localStorage` it is recommended that you don't use `Window.localStorage` in the extension code to store extension-related data. Firefox will clear data stored by extensions using the `localStorage` API in various scenarios where users clear their browsing history and data for privacy reasons, while data saved using the `storage.local` API will be correctly persisted in these scenarios.

You can examine the stored data under the Extension Storage item in the [Storage Inspector](#) tab of the [developer toolbox](#), accessible from `about:debugging`.

 **Note:** The storage area is not encrypted and shouldn't be used for storing confidential user information.

<https://developer.mozilla.org/en-US/docs/Mozilla/Add-ons/WebExtensions/API/storage>

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## Can extensions use web storage APIs?

While extensions can use the `Storage` interface (accessible from `window.localStorage`) in some contexts (popup and other HTML pages), we don't recommend it for the following reasons:

- Extension service workers can't use the Web Storage API.
- Content scripts share storage with the host page.
- Data saved using the Web Storage API is lost when the user clears their browsing history.

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***Interestingly, official documents also lacks explicit S&P context! (Surprise?!)***

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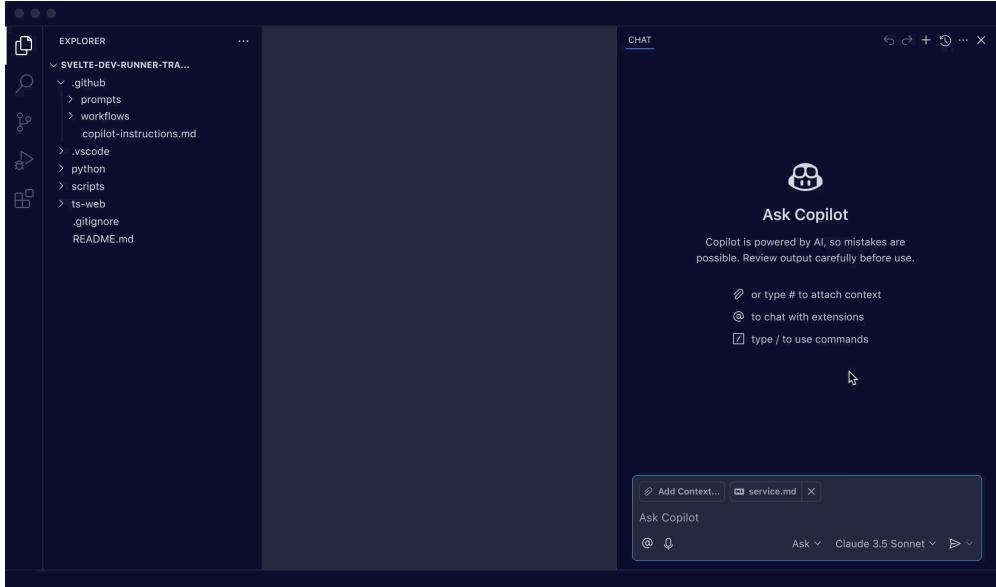
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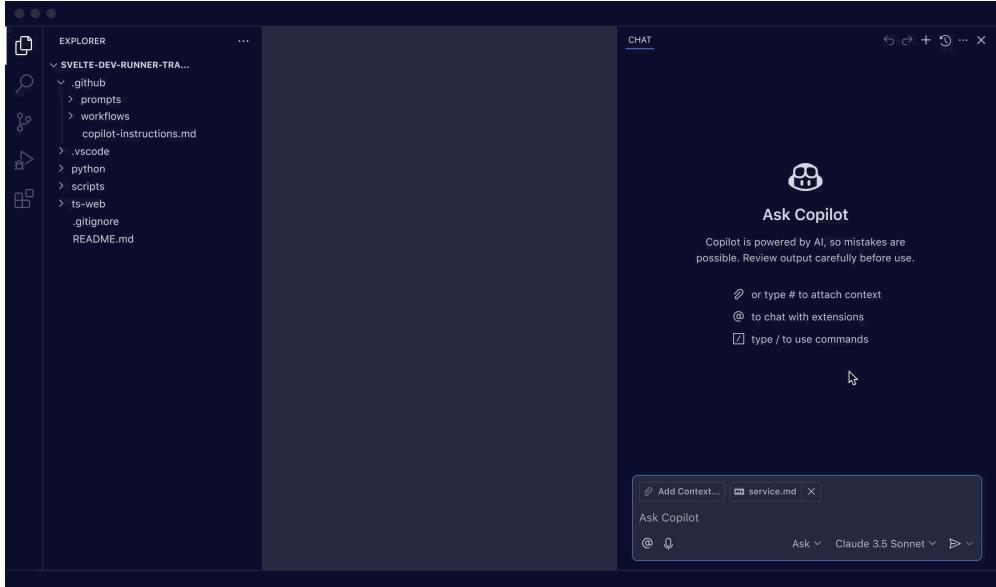
<https://developer.chrome.com/docs/extensions/reference/api/storage>

# Development Sources – AI Assistants



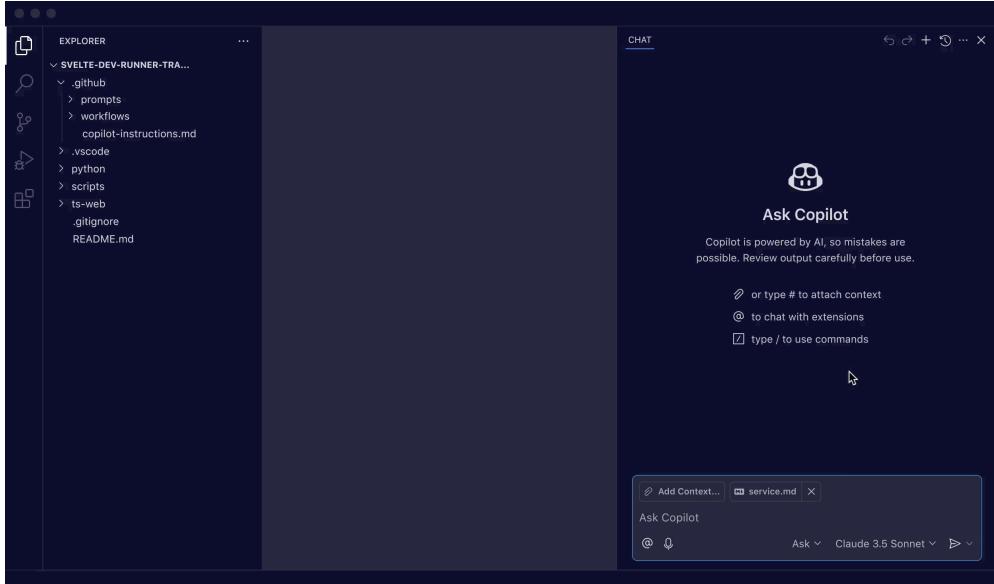
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# Development Sources – AI Assistants



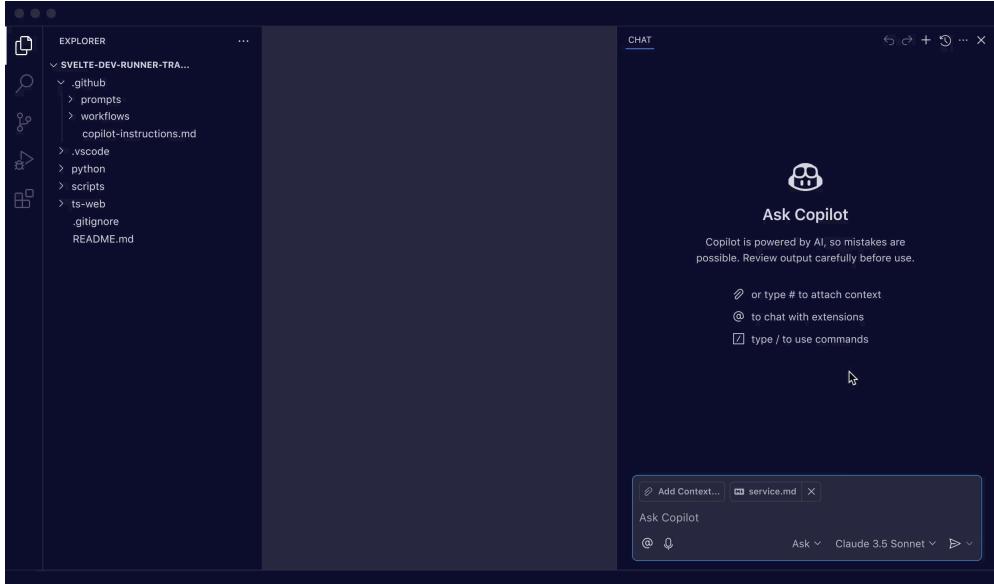
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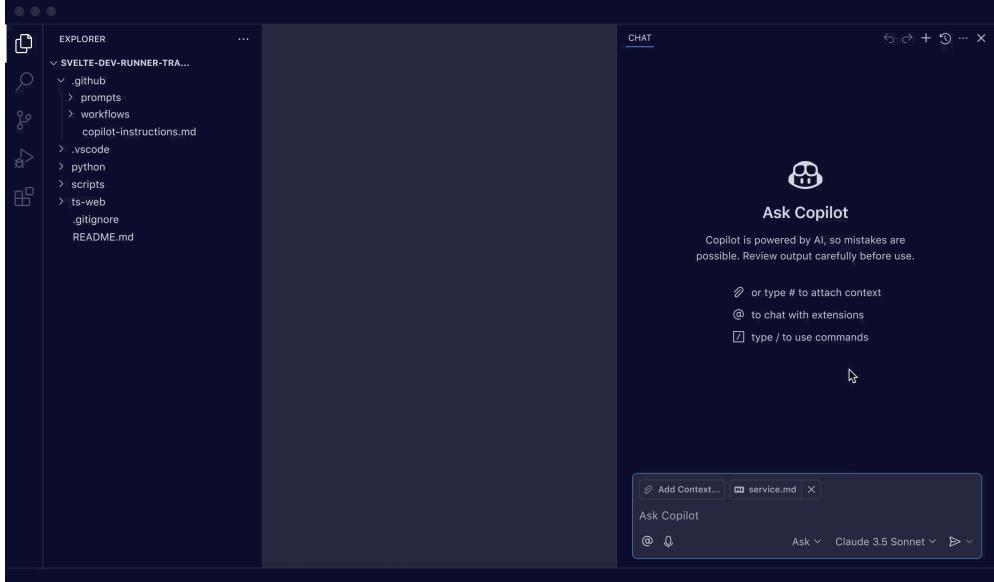
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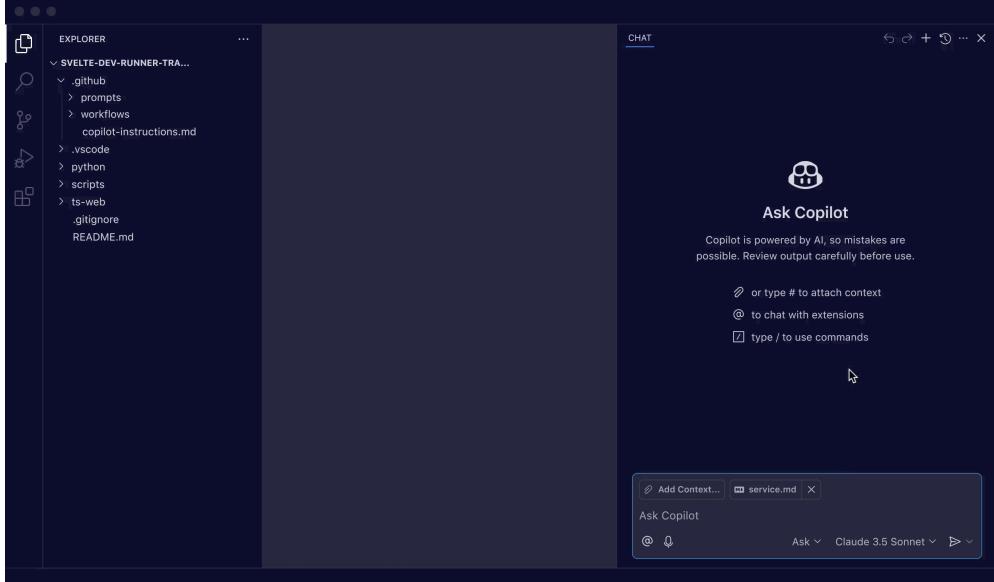
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***AI Assistants may only be helpful to the extent of your knowledge!***



# How did the AI Assistants fare?

---



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---



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  try {
    console.log("Address Data:", addressData);
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# How did the AI Assistants fare?



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/* */

async function recordAddressData(addressData) : Promise<any> { Show usages
  chrome.storage.local.set({ addressData });
}

async function retrieveAddress() : Promise<void> { Show usages
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# How did the AI Assistants fare?



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    console.error(e);
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}
```

***The developer “seed” could determine the solution!***

# Case II: Security Mindset of Developers

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Task: *Embed amazon.de in an iframe to check for corresponding product price.*

# Case II: Security Mindset of Developers

---



Task: *Embed amazon.de in an iframe to check for corresponding product price.*

The screenshot shows a product listing for 'Clean Code: A Handbook of Agile Software Craftsmanship' by Robert C. Martin. The book cover is visible at the top, showing a dark background with a glowing blue and red ring. Below the cover, the title and author are displayed in white text. The original price of \$18.99 is crossed out in red, and the discounted price of \$9.49 is shown in black. At the bottom, there are two buttons: a yellow 'Order Now' button and a grey 'Check on Amazon' button.

**Clean Code: A Handbook of Agile Software Craftsmanship**

Robert C. Martin

**\$18.99** \$9.49

[Order Now](#)

[Check on Amazon](#)

# Case II: Security Mindset of Developers



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Clean Code: A Handbook of Agile Software Craftsmanship

Robert C. Martin

\$18.99 \$9.49

[Order Now](#)

[Check on Amazon](#)

amazon Deliver to Germany All Clean Code: A Handbook of Agile Software Craftsmanship

We're showing you items that ship to Germany. To see items that ship to a different country, change your delivery address.

Results

Clean Code: A Handbook of Agile Software Craftsmanship

Part of: Robert C. Martin Series (18 books) | by Robert C. Martin | Aug 11, 2008

★★★★★ 6,510

Paperback

No featured offers available

\$13.98 (21 used & new offers)

Audible Audiobook

\$0<sup>00</sup> \$21.49

Free with Audible trial

Available instantly

Kindle

\$26<sup>01</sup> Digital List Price: \$47.99

Available instantly

Other format: Spiral-bound

Sponsored

Mastering Agile Software Development: A Quality Code, Requirements, and Craftsmanship Guide

by L.D. Knowings | Aug 20, 2024

★★★★★ 126

Paperback

\$16<sup>99</sup>

Delivery Wed, May 7

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X-Cache	NotCacheable from child
X-Content-Type-Options	nosniff
X-Frame-Options	SAMEORIGIN
X-Ua-Compatible	IE=edge
X-Xss-Protection	1;

## Case II: Actions & Observations

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*“...can’t really think of another way to get around this!”*

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Preferred to explore potential alternatives (new tabs, popups, etc.)

## Case II: Actions & Observations



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***Developers may even be inherently mindful of overly security-critical actions and take responsive decisions even when not aware of its implications.***

# What did the LLMs think of the challenge?

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# What did the LLMs think of the challenge?

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Unfortunately, if a website sets the `X-Frame-Options` header to disallow framing (such as with values like `DENY` or `SAMEORIGIN`), it's a security feature implemented by the website itself, and there is no way to bypass it from the client side legally or ethically. This is designed to prevent clickjacking attacks and ensure that websites cannot be embedded in unauthorized third-party pages.

Here are a few legitimate alternatives:

1. **API or Data Embedding:** If you're trying to include content or data from another website, check if they provide an API. This can allow you to fetch and embed the data or content without using an iframe.
2. **Redirecting Users:** If you need to send users to that website, consider adding a link or a button that redirects them to the site in a new tab, rather than embedding it.
3. **Proxy Server (with Permission):** If you have control of the backend or have permission from the target site, you can set up a proxy on your server to retrieve the content and display it. However, this requires both technical permission and respect for the website's terms of service.
4. **Contacting the Website Owner:** Sometimes, website owners can whitelist specific domains to allow embedding. If this is important for your project, consider reaching out to them to see if they would permit it.

Attempting to bypass these protections without permission can lead to legal consequences and is against most websites' terms of use.



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  "header": "X-Frame-Options",  
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}  
]  
,  
"condition": {  
  "urlFilter": "example.com",  
  "resourceTypes": ["main_frame", "sub_frame"]  
}  
}
```

However, this will not work for security headers like `X-Frame-Options`, as Chrome restricts this modification.

## Alternative Approach:

- **Requestly Extension:** If you are testing or need a quick fix for development purposes, you can use an extension like [Requestly](#), which allows you to modify response headers directly within the browser. This is a tool that can help you bypass `X-Frame-Options` in a non-production environment for testing purposes.

## Conclusion:

Chrome extensions, for security reasons, cannot use `declarativeNetRequest` to bypass `X-Frame-Options` directly. The best approach for bypassing this limitation is setting up a proxy server or using an alternative tool for local development and testing.

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## Conclusion:

Chrome extensions, for security reasons, cannot use `declarativeNetRequest` to bypass `X-Frame-Options` directly. The best approach for bypassing this limitation is setting up a proxy server or using an alternative tool for local development and testing.

***“Security” & “Legal” concerns of LLMs often serve as strong indicator of overall correctness!***

# Security, Privacy & Compliance

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## Trustworthy Chrome Extensions, by default

Monday, October 1, 2018

<https://blog.chromium.org/2018/10/trustworthy-chrome-extensions-by-default.html>



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### Deal with remote hosted code violations



Remotely hosted code, or RHC, is what the Chrome Web Store calls anything that is executed by the browser that is loaded from someplace other than the extension's own files. Things like JavaScript and WASM. It *does not* include data or things like JSON or CSS.

#### Why is RHC no longer allowed?

With Manifest V3 extensions now need to bundle *all* code they are using inside the extension itself. In the past, you could dynamically inject script tags from any URL on the web.

<https://developer.chrome.com/docs/extensions/develop/migrate/remote-hosted-code>

# Security, Privacy & Compliance

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# Security, Privacy & Compliance

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***Browser extension still compliant with store policies!***

# Threat Perception & Modeling

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**Vibe-coding will thrive...**



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- “*...users shouldn't be held responsible!*”
  - Then, who should act as the wise man here?



# Summary

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Find more details about  
our study here.



**THANK YOU!**



@shubh401



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