EVERYONE IS DIFFERENT:

Client-side Diversification for Defending Against Extension Fingerprinting

Erik Trickel, Oleksii Starov, Alexandros Kapravelos, Nick Nikiforakis, and Adam Doupé

Browser Extensions

Browser Extensions

Customization at a Cost

- Extension granted more privileges
- Cookieless identification across browsing sessions
- Inferences based on installed extensions

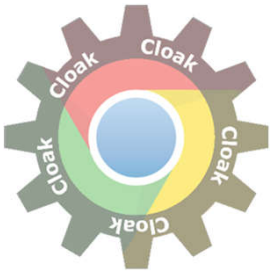
Customization at a Cost

https://github.com/prophittcorey/nefarious-linkedin

How to prevent this?

CloakX

- Extension cloaking tool
- Static and dynamic analysis
- Client-side modification
  - Without modification to browser
  - Without requiring extension developers to modify their code



Extension Fingerprinting

- Extension fingerprinting is not intentionally supported but side-channels exist
- Web Accessible Resources (WARs) Fingerprinting
  - *ACM CODASPY 2017*
- DOM Fingerprinting (XHound)
  - *Oakland 2017*

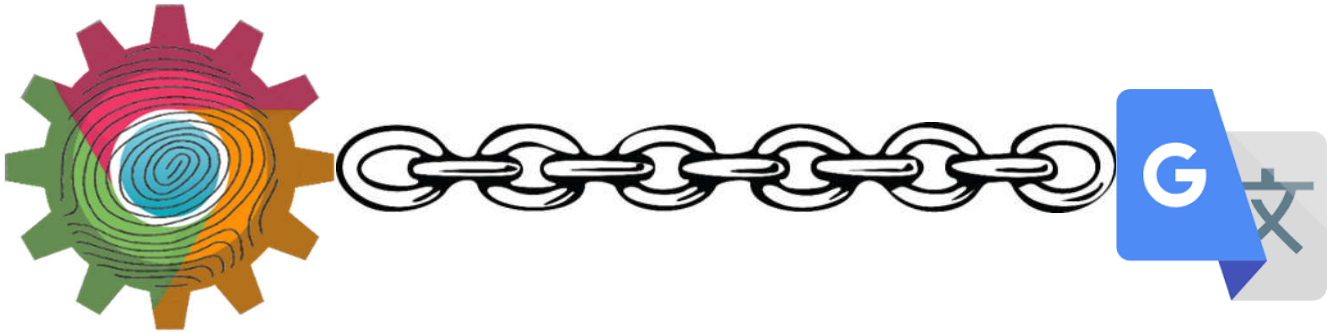
WAR Fingerprinting

- WARs are uniquely identifiable resources that extensions deliberately expose to webpages
- WAR Fingerprints
  - 16,479 extensions
  - 50% of the top 1,000 extensions

DOM Fingerprinting

- XHound
  - Exercises extensions
  - Track DOM modifications to create fingerprint
- 5,323 extensions create a DOM fingerprint

Detection



Detection—Anchorprints

- An anchor is a unique identifier used by the extension and accessible to webpages
- WARs, IDs, class names, and custom attributes
- Save to Pocket adds

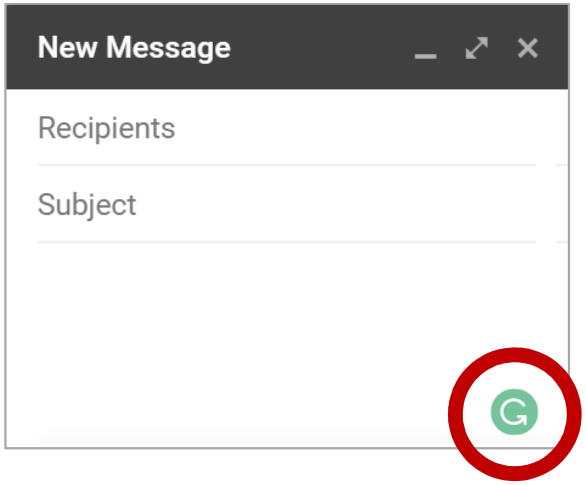
```
<svg class="pocketIconStroke_1zNwYwpH"…>
```

Detection—Structureprints

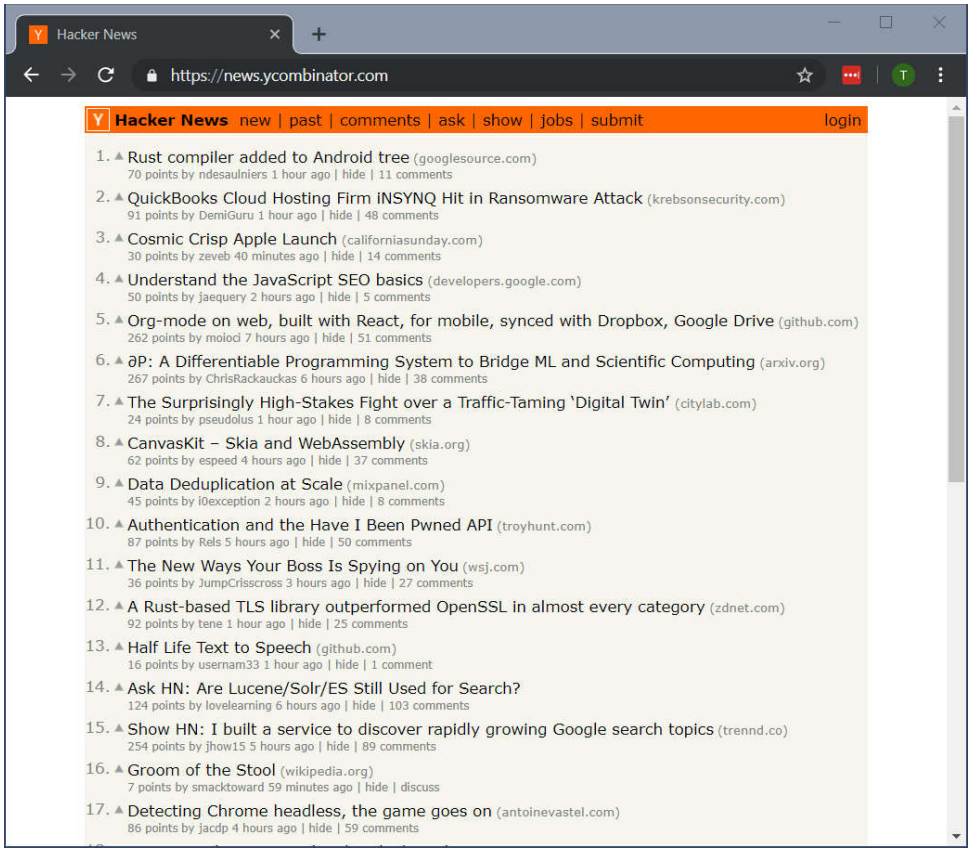
- Uses the structure of the changes an extension makes to a webpage
- Google calendar extension injects an `<a>` and an `<img>` each with specific attributes that no other extension adds

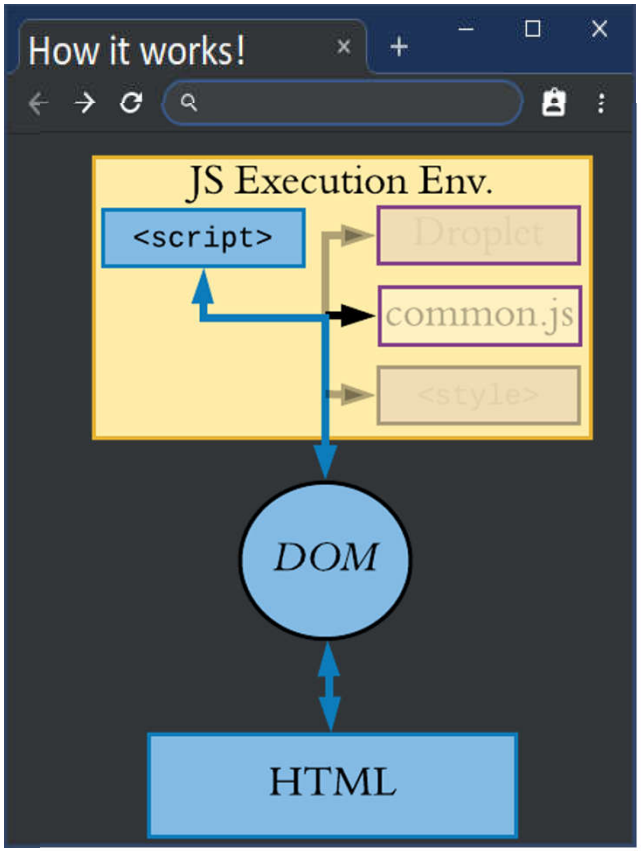
Detection—Behaviorprints

- Target an extension's behavior
- Grammarly injects a green image into a textarea

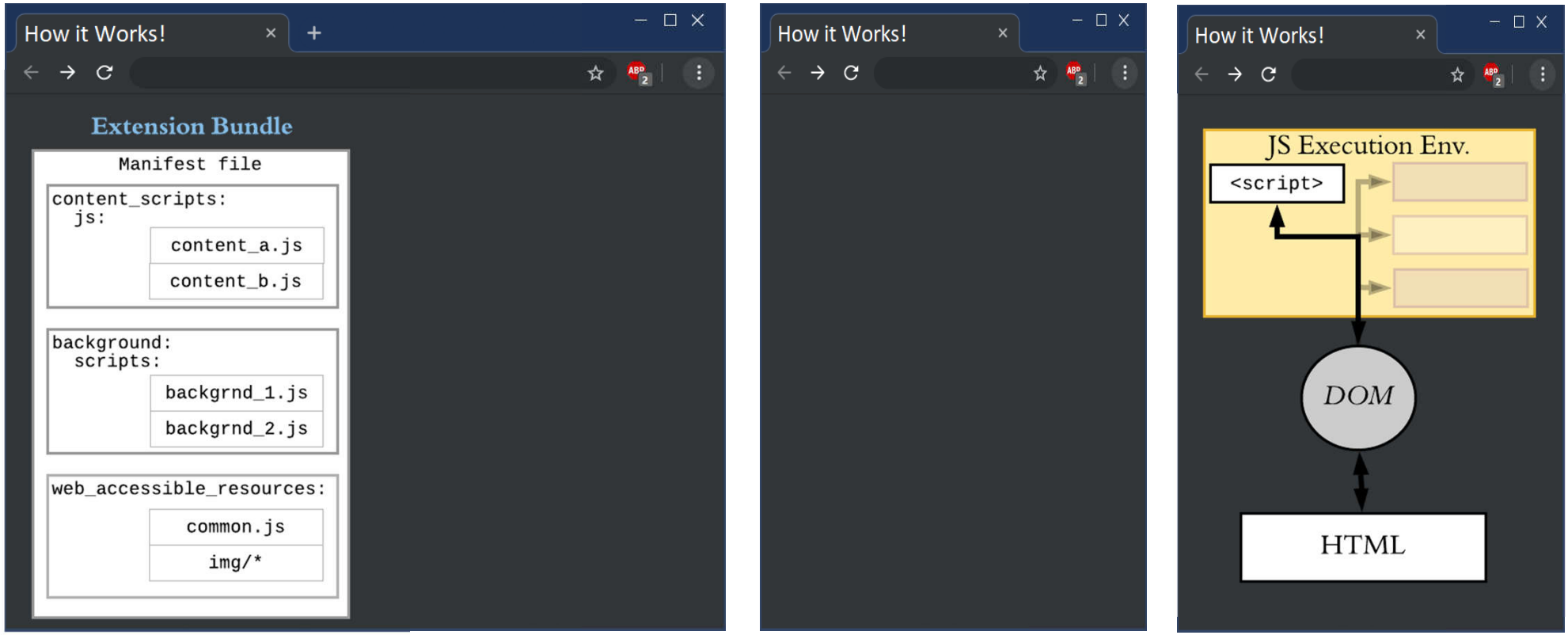


Webpage Environment

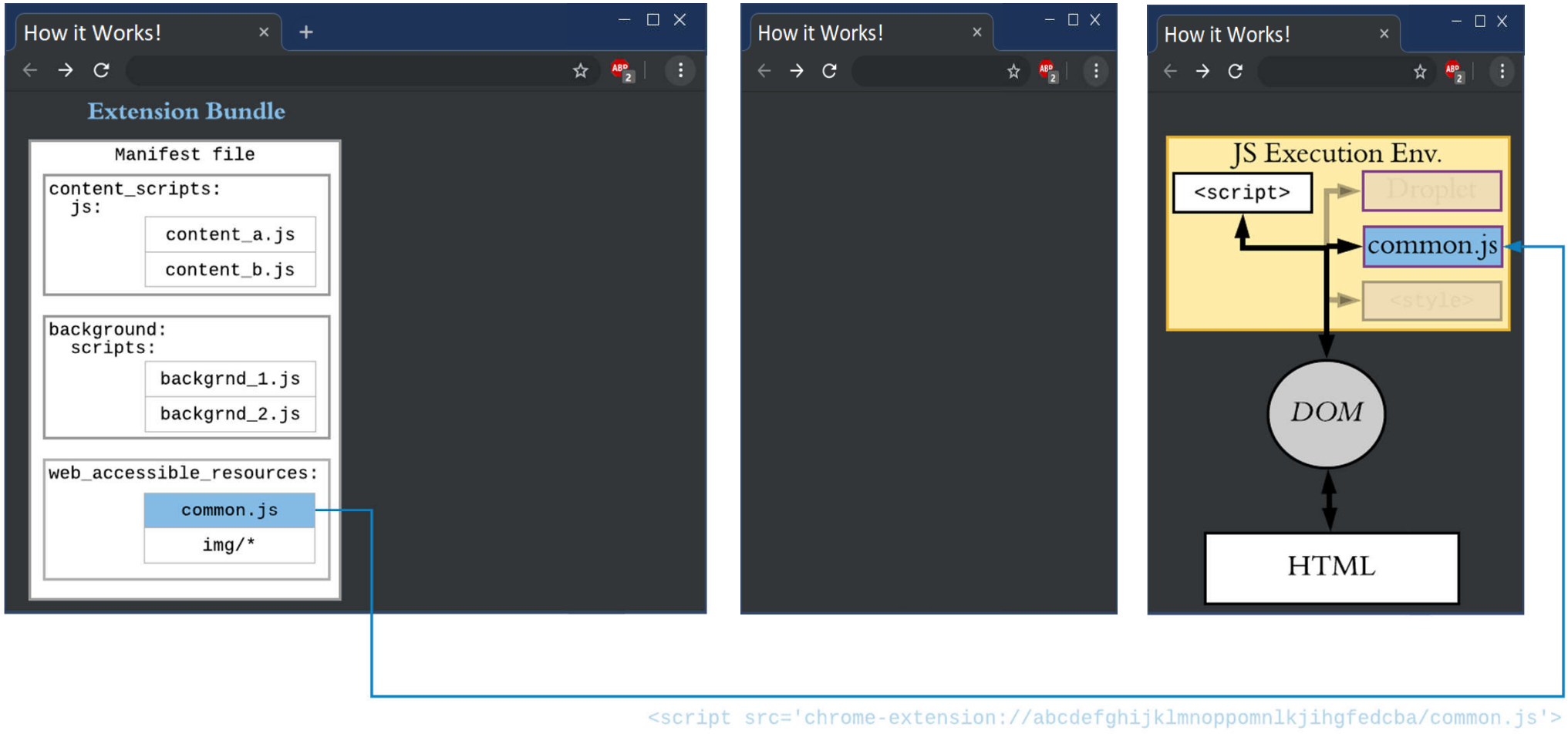




Extensions in Chrome



Extensions in Chrome



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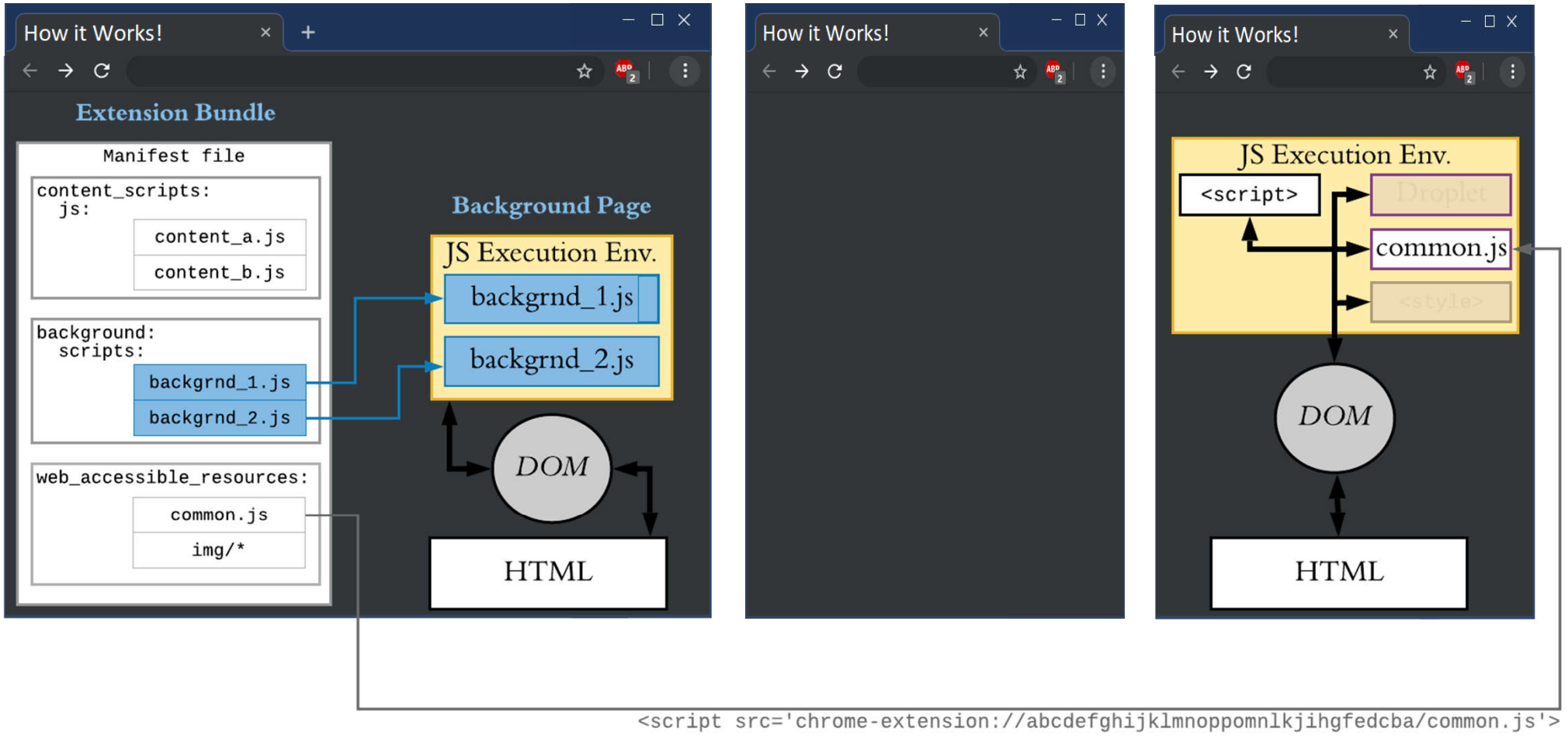
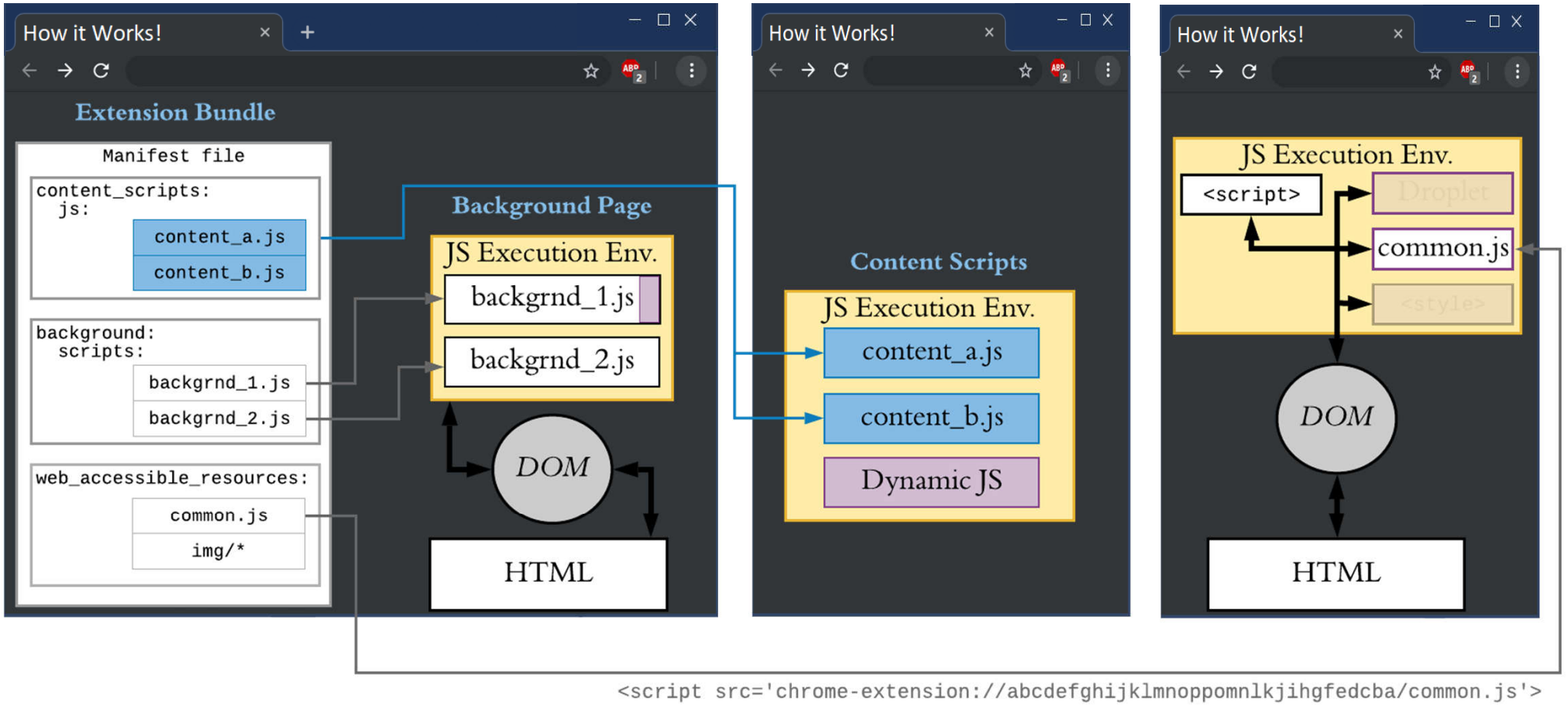
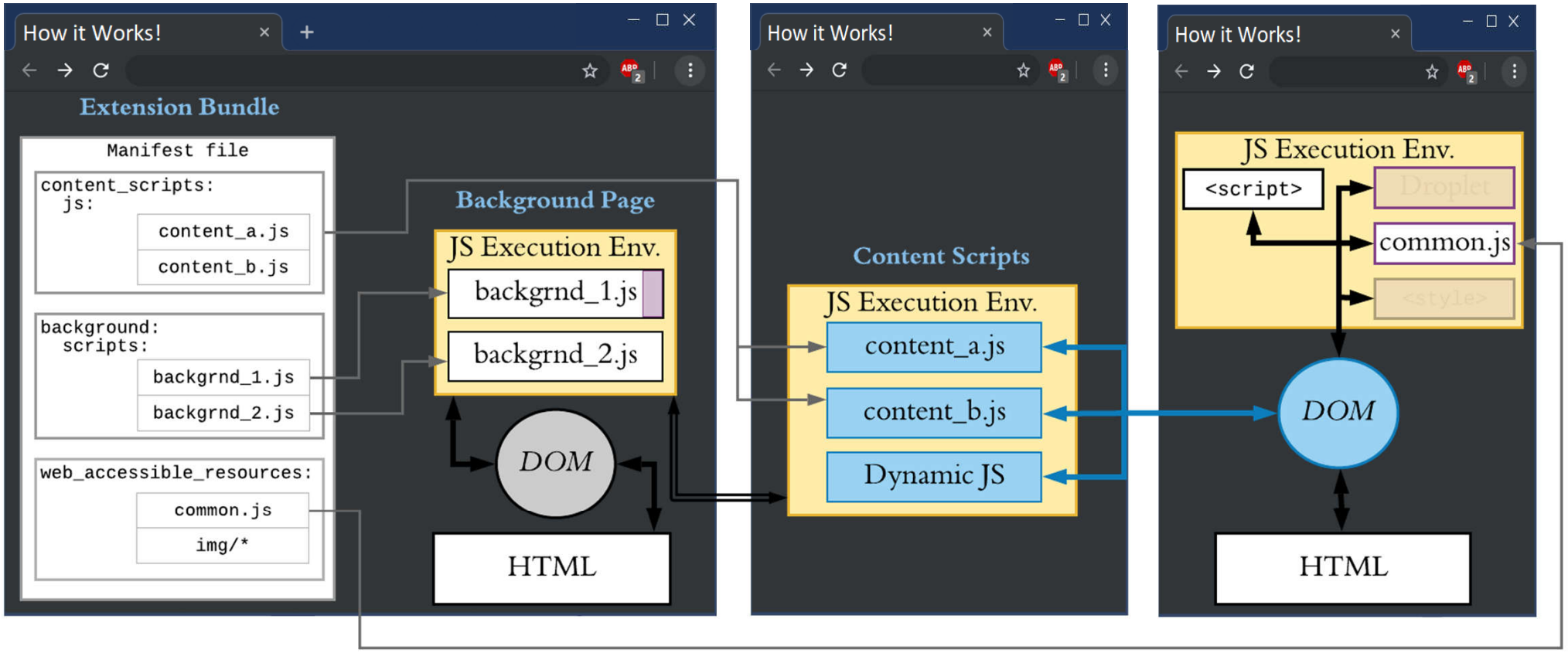


Extensions in Chrome




```
<script src='chrome-extension://abcdefghijklmnoppomnlkjihgfedcba/common.js'>
```

Extensions in Chrome



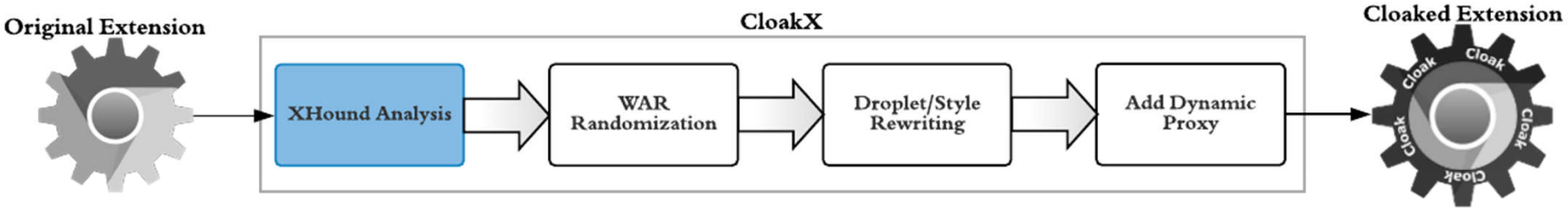

```
<script src='chrome-extension://abcdefghijklmnoppomnlkjihgfedcba/common.js'>
```

CloakX

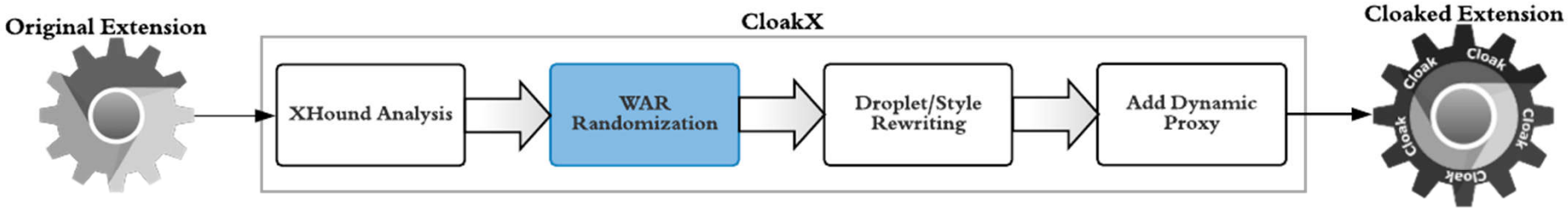
Cloaking Extensions

- Renaming
  - WARs
  - IDs
  - Class names
- Random Insertion
  - Tags
  - IDs and custom attributes

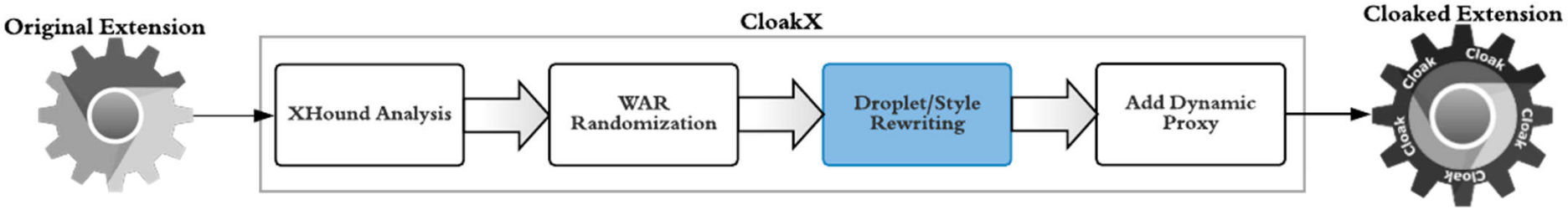
Cloaking Process



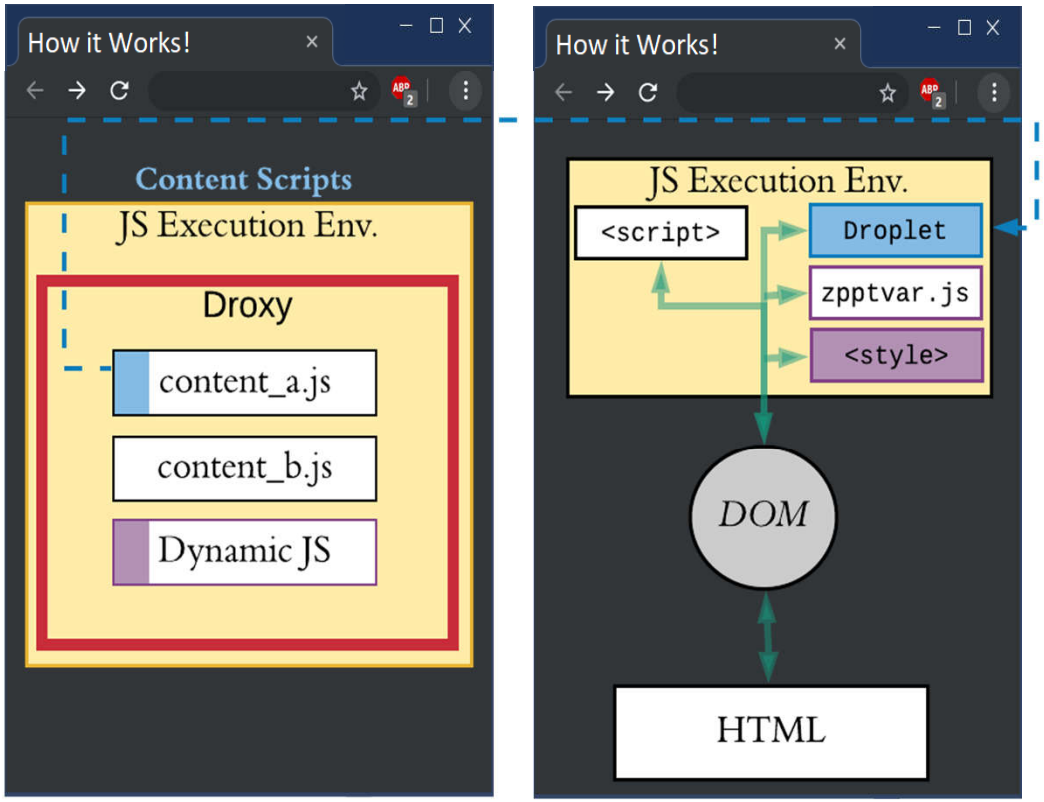
Cloaking Process



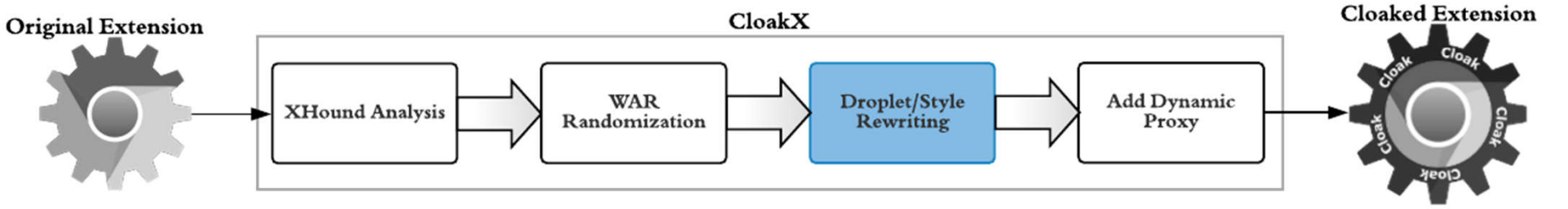
Cloaking Process



Droplets

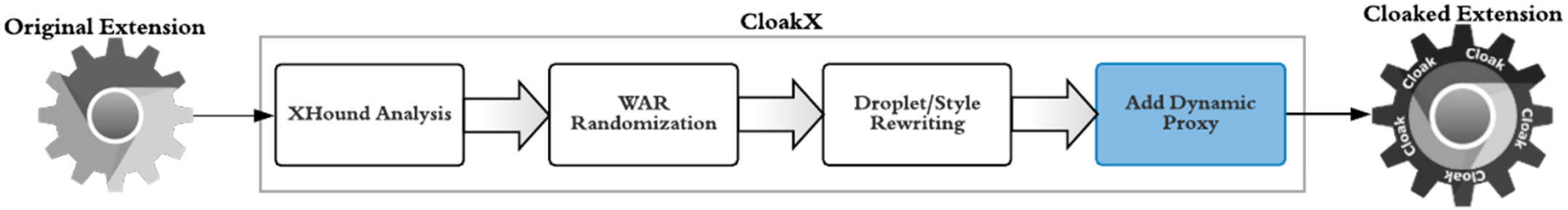

How it Works!
Content Scripts
JS Execution Env.
Droxy
content_a.js
content_b.js
Dynamic JS
How it Works!
JS Execution Env.
<script>
Droplet
zpptvar.js
<style>
DOM
HTML

Cloaking Process

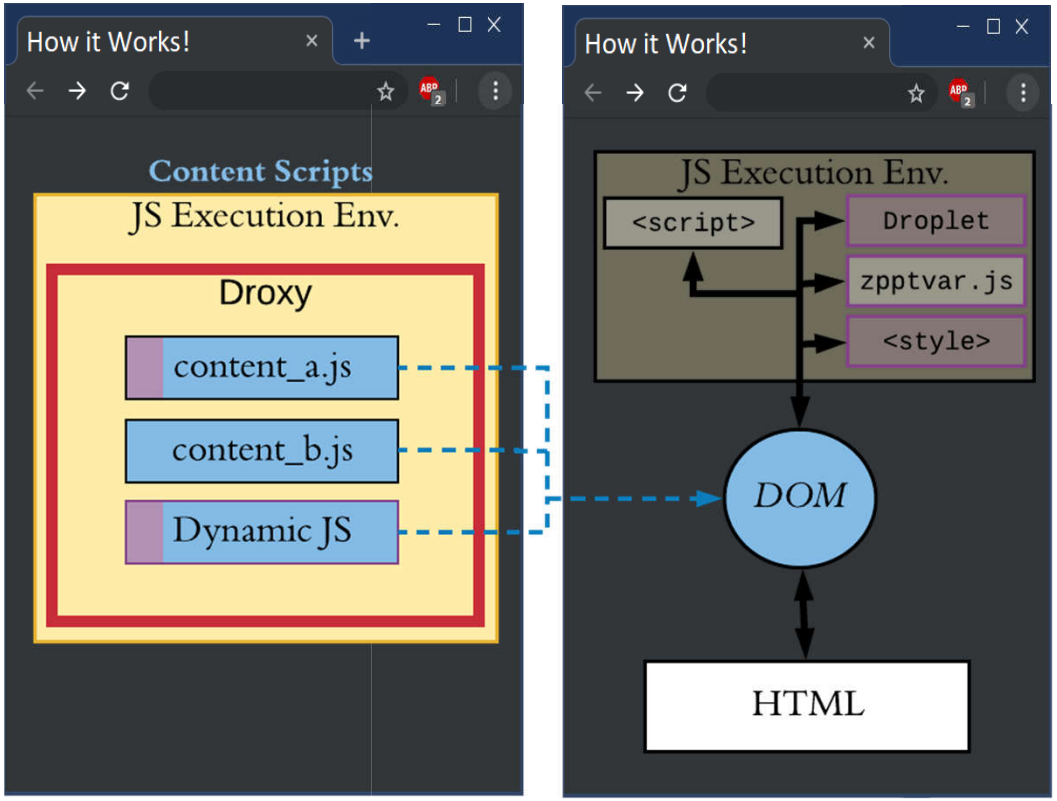


- TAJS – Type Analysis for JavaScript
  - Added taint analysis
  - Limiting changes to the use of ID and class names that interacted with DOM
- Rewrite IDs and class names inside droplets

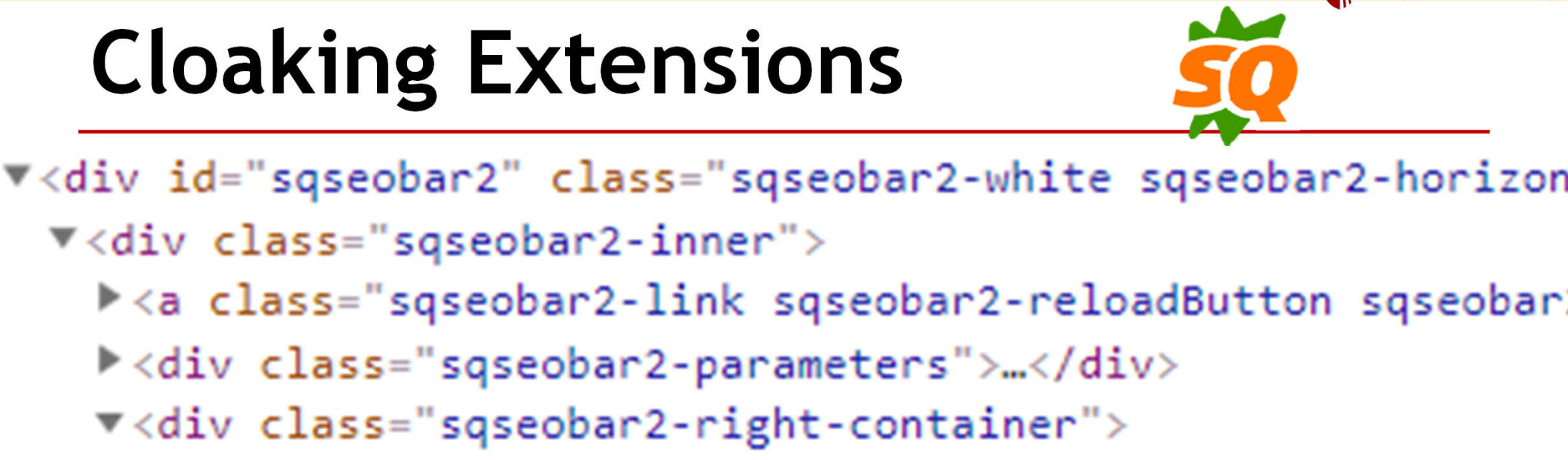
Cloaking Process



Cloaking Extensions



Cloaking Extensions



Evaluation

- Functionality Experiments
  - Low Fidelity
  - High Fidelity
- Detectability Experiments
  - Anchorprints
  - Structureprints
  - Behaviorprints

Low Fidelity

- 18,937 fingerprintable extensions tested
- WAR Fingerprintable 99.0% passed
- DOM Fingerprintable 98.7% passed
- WAR & DOM Fingerprintable 97.9% passed

High Fidelity

- 150 tested
- WAR Fingerprintable 50 passed
- DOM Fingerprintable 48 passed
- WAR & DOM Fingerprintable 47 passed

Evaluation - Errors

- Remote code loading
- Hardcoded values that Droxy alters
- Droxy limitations

Detection-Anchorprints

- 17,678 extensions tested
- Cloaked extensions were undetectable
- But 96 of the cloaked extensions did not maintain equivalent functionality

Detection-Structureprints

- 5,311 extensions tested with fuzzy matching
- Tags, Attributes, Text, 4.2% detected
- Tags and Attributes, 1.8% detected
- Tags 1.7% detected

Detection-Behaviorprints

- Ten of the most popular extensions
  - Seven detectable
- Randomly selected ten extensions
  - Five detectable

Summary

- Extension fingerprinting is a real problem
- Successfully performed late-stage customizations on browser extensions to break extension fingerprints
- Cloaked extensions:
  - 99.9% undetectable using anchorprints
  - 98.3% undetectable using structureprints

Thank you

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