ShadowBlock: A Lightweight and Stealthy Adblocking Browser

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Project URL : https://github.com/seclab-ucr/ShadowBlock

Overview

□ More than 600 million devices globally use adblockers as of December 2016

□ The rise of adblocking has jeopardized the ad-powered business model and publishers have been deploying anti-adblocking paywalls

It looks like you're
using an ad-blocker!

□ Users are losing control of what ads they want to see and protect themselves from malvertising.

□ We propose ShadowBlock, a Chromium-based adblocking browser that bypasses anti-adblocking paywalls

□ ShadowBlock bypasses anti-adblocking paywalls with 100% success rate and performs comparably as state-of-the-art adblockers in terms of ads coverage and page loading speed

Shadow Elements

□ How do anti-adblockers detect the use of adblockers?
  □ Blocking ads introduces different states that are observable to JavaScript runtime

```
// Example anti-adblocking code
var adblock_state =
document.getElementById('some_ad');
window.setTimeout(function() {
   if (adblock_state === undefined)
      show_paywall();
}, some_timeout);
```

  □ The key of hiding adblockers is masking the difference

```
// What difference to mask?
var adblock_state =
document.getElementById('some_ad');
```

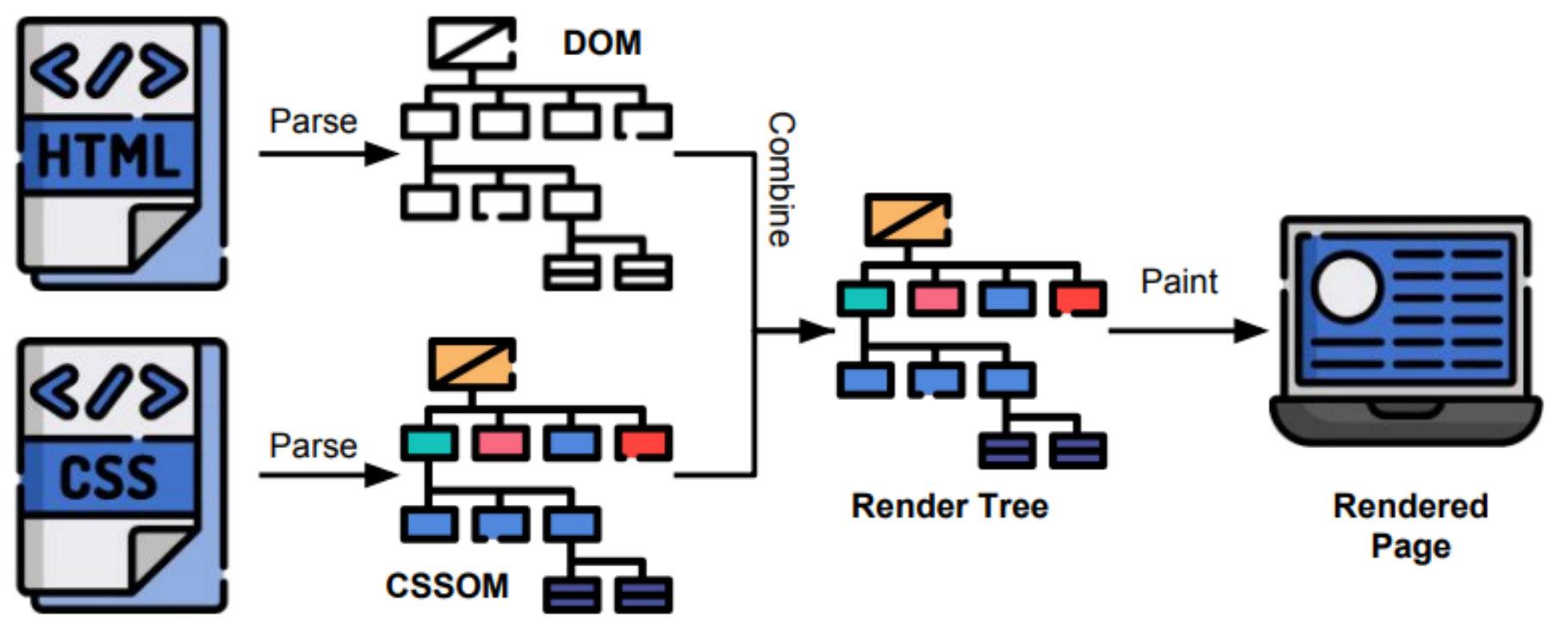
JavaScript API

Ad
DOM element

□ We must mask the state returned to `getElementById()` for DOM element "`some_ad`" as if it is still intact, even though it has been hidden by us

Hiding Mechanism

□ DOM/CSS Layer: parse flat HTML and CSS in plain-text
□ Render Tree Layer: combined from DOM and CSSOM
□ Paint Layer: generating rendered pixels
to user's viewpoint according to Render Tree

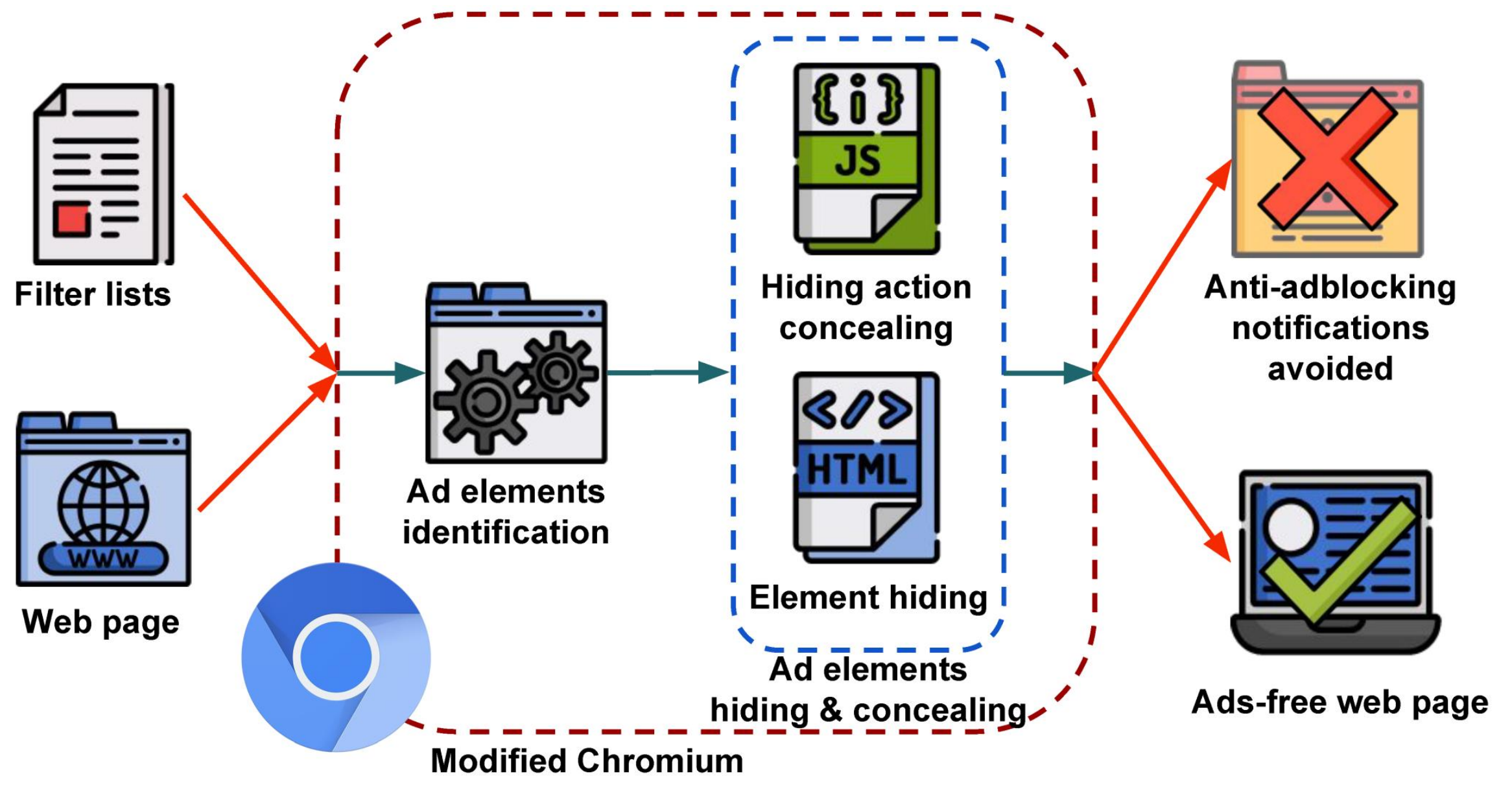


□ We choose to toggle CSS property **`visibility: visible`** as our ad element hiding mechanism
  □ Low-level enough so there are minimum number of channels leaking the action to hook
  □ High-level enough to avoid complex object translation

ShadowBlock

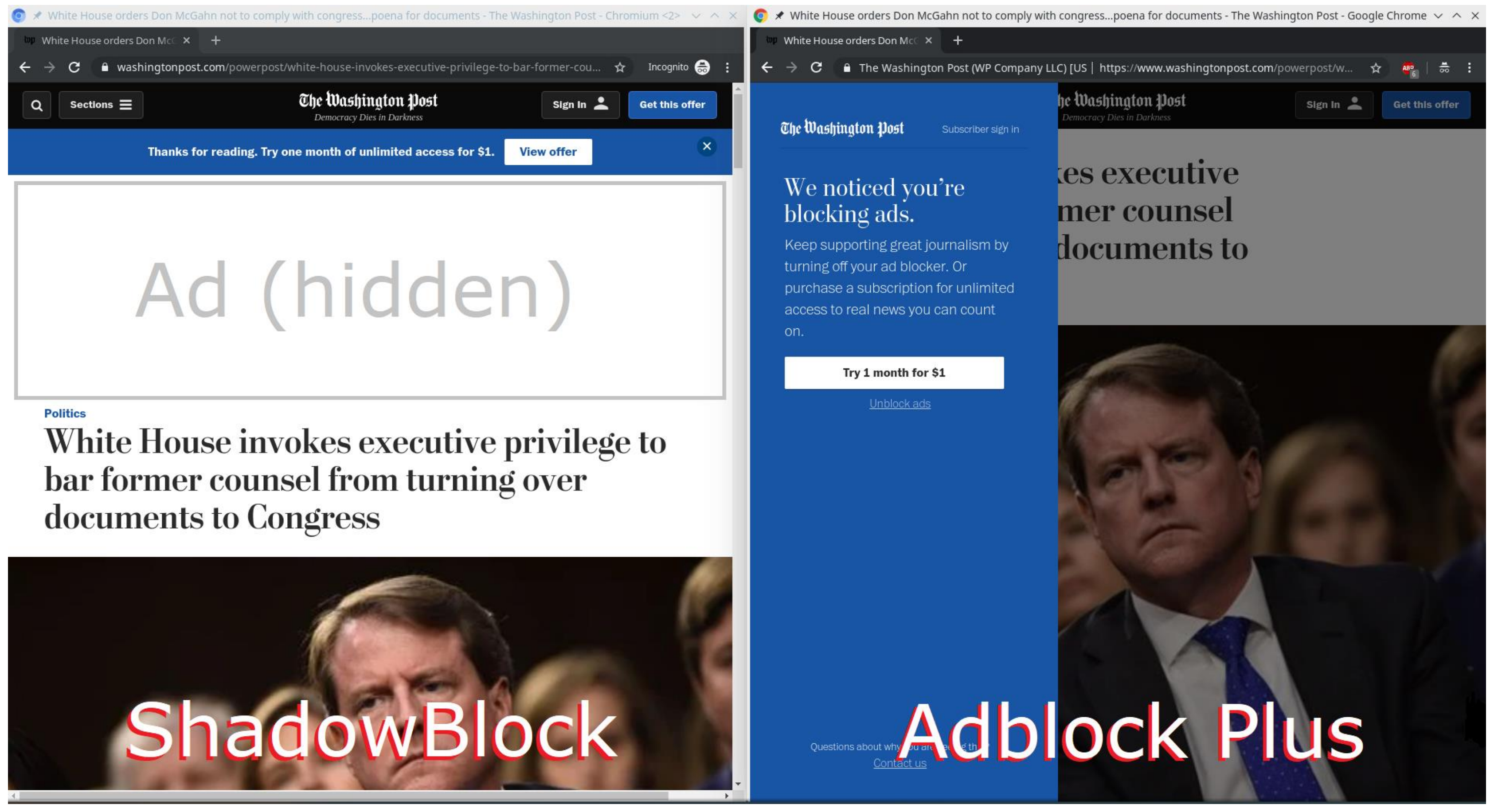
□ Ads Identification
  □ Statically created *ads* are detected by monitoring attribute change events
  □ Dynamically (JavaScript) created *ads* are detected by monitoring elements created with ad scripts

□ Ads Hiding
  □ ShadowBlock hides the traces of adblocking in a stealthy manner by masking different states caused by toggling **`visibility`** property
  □ All JavaScript APIs that can be used by anti-adblockers to probe the actual states of ad elements are hooked to present a fake state as if ads are still intact



Filter lists
Web page
Ad elements identification
Hiding action concealing
Element hiding
Ad elements hiding & concealing
Modified Chromium
Anti-adblocking notifications avoided
Ads-free web page

Demo



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Ad (hidden)

Politics

White House invokes executive privilege to bar former counsel from turning over documents to Congress

White House orders Don McGahn not to comply with congress...poena for documents - The Washington Post - Google Chrome

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Unblock ads

Results & Evaluation

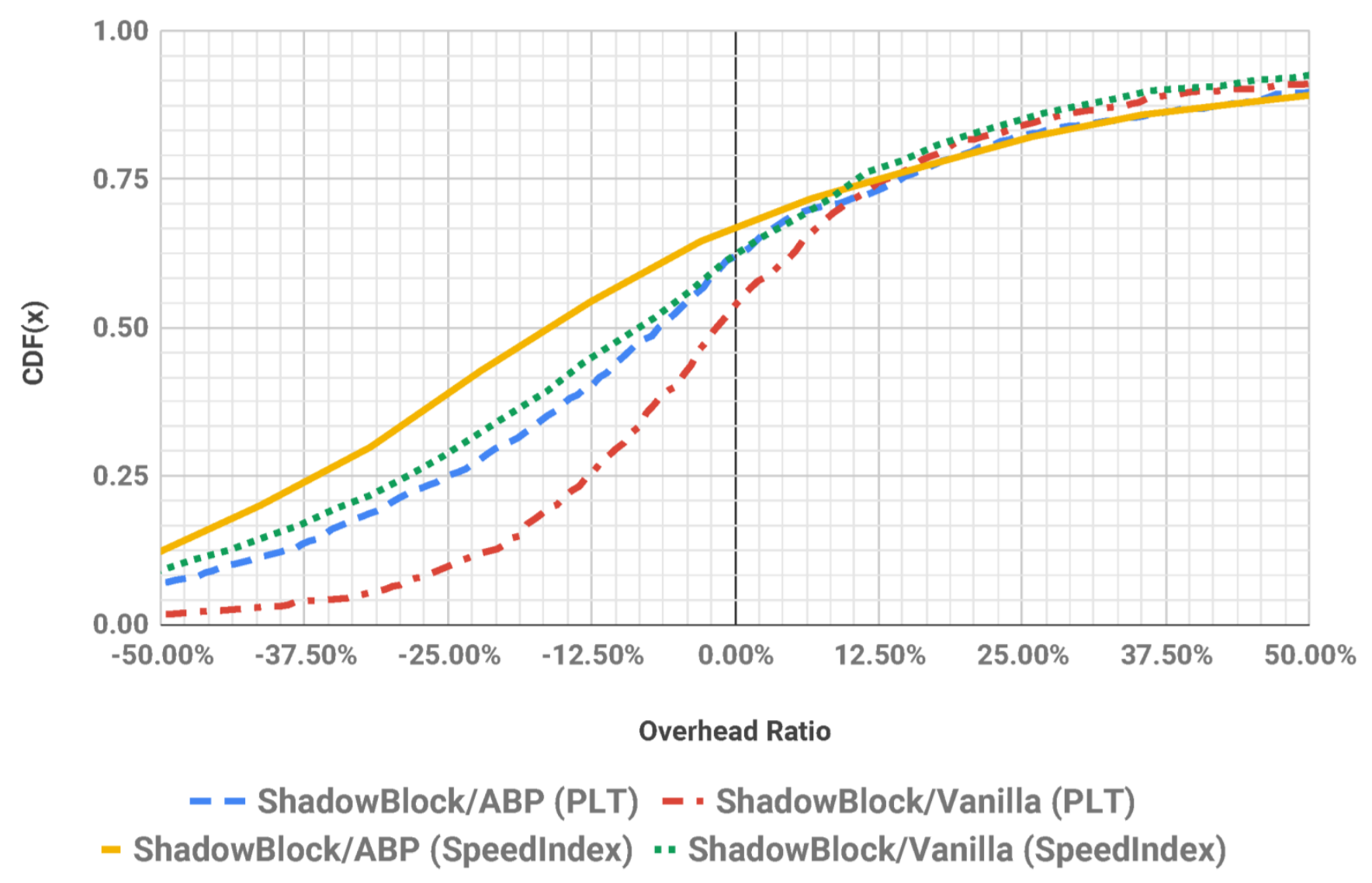
□ 100% success rate against anti-adblockers whereas dedicated filter lists have only 29% success rate

□ 97.7% accuracy, with 98.2% recall and 99.5% precision in blocking ads on Alex top-1K websites

□ Speeds up page loads by 5.96% in terms of median Page Load Time (PLT) and 6.37% in terms of median SpeedIndex on Alexa top-1K websites

Tool	Notification	Ad Switching	Crypto-mining
Total	201	5	1
ShadowBlock	201 (100%)	5 (100%)	1 (100%)
Filter lists	59 (29%)	1 (20%)	0 (0%)

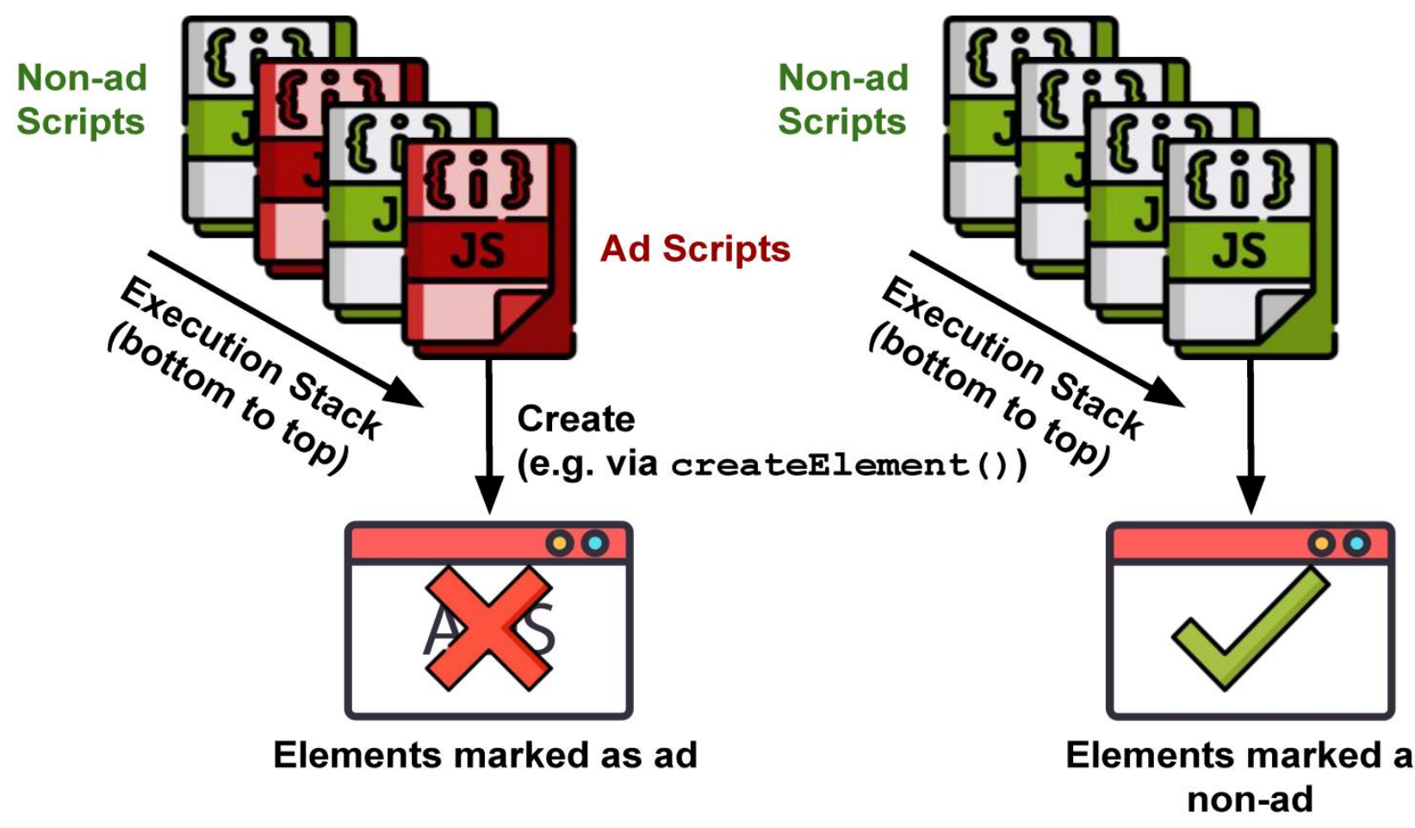
Event	TP	FN	TN	FP
Count	926 (98.2%)	17 (2.8%)	938 (99.5%)	5 (0.5%)



Execution Projection

□ Dynamically created ad elements can be identified by tracking execution stack
  □ Determining the ad-ness by asserting whether there is any ad script on stack at DOM events
  □ Feasible due to single-threaded JavaScript execution

```
// Typical dynamically created ad
var ad_img = document.createElement("img");
ad_img.src = "https://advertiser.com/ad.jpg";
document.body.appendChild(ad_img);
```



Non-ad Scripts
Ad Scripts
Execution Stack (bottom to top)
Create (e.g. via createElement())
Elements marked as ad
Non-ad Scripts
Execution Stack (bottom to top)
Elements marked as non-ad

Chromium Instrumentation

□ Low level instrumentation makes ShadowBlock stealthy and efficient

□ We instrument two major components in Chromium: Blink and V8
  □ Blink is responsible for constructing the rendering tree
  □ Bindings module handles interaction between V8 and Blink

□ Hooking for ad identification
  □ Capture element creation and modification
  □ Capture JavaScript execution stack

□ Hooking for concealing actions
  □ CSS/Style related – `getComputedStyle()`
  □ Event Related – `onfocus`
  □ Hit testing related – `elementFromPoint()`

□ Keep track of ad related scripts in execution stack and their activity (*execution projection*) and element modifications for identifying ad elements

Key Contributions

□ Design and implement a stealthy adblocking browser

□ Evade 100% of anti-adblockers and replicate EasyList with 98.3% accuracy with less than 0.6% breakage

□ We find that ShadowBlock loads pages as fast as stock Chromium running Adblock Plus

□ We open source our implementation to allow reproducibility as well as help future extensions by the research community (`https://github.com/seclab-ucr/ShadowBlock`)

More details in our WWW'19 paper:
ShadowBlock: A Lightweight and Stealthy Adblocking Browser
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