CASA
CYBER SECURITY IN THE AGE OF LARGE-SCALE ADVERSARIES

Server-Side Browsers: Exploring the Web's Hidden Attack Surface

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TU Braunschweig

Joint work with Robin Kirchner, Max Boll, and Martin Johns

IAS INSTITUTE FOR APPLICATION SECURITY

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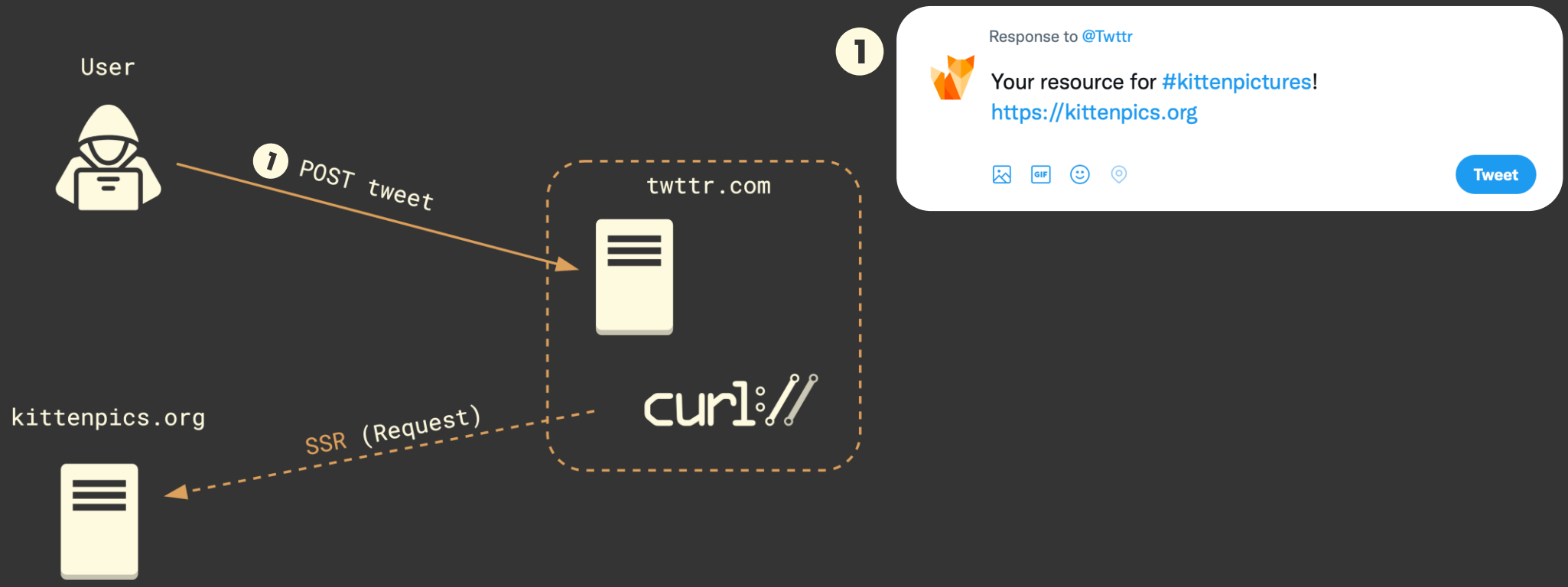
DFG Deutsche Forschungsgemeinschaft

Technische Universität Braunschweig

The Scenario

Request for Preview



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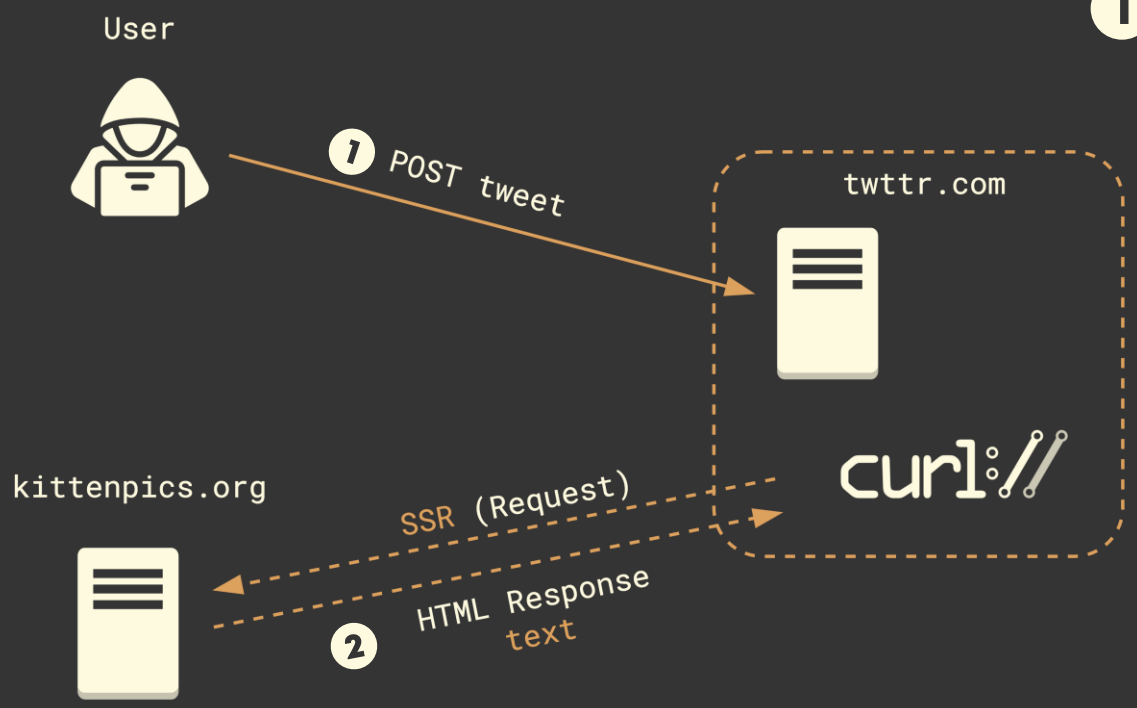
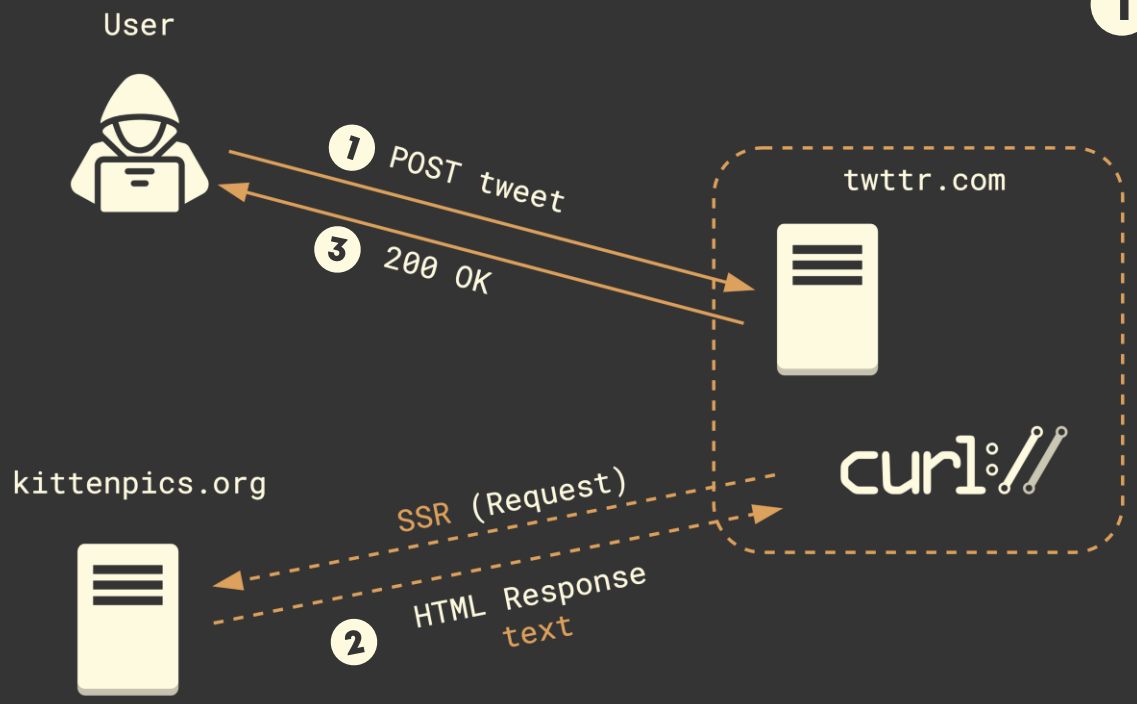


1

2

```
<!DOCTYPE html><html><head><link rel="stylesheet"
href="https://cdn.org/base.css"></head><body><img src="https://cdn-
icons.org/57162.png"></img><h1>Kittenpics.org</h1><script
src="https://cdn.org/76dsdasd.js"></script><div class="wh-fms-3-daf">
</div><p>Kittenpics.org is your resource...</p>[...]
```

Request for Preview



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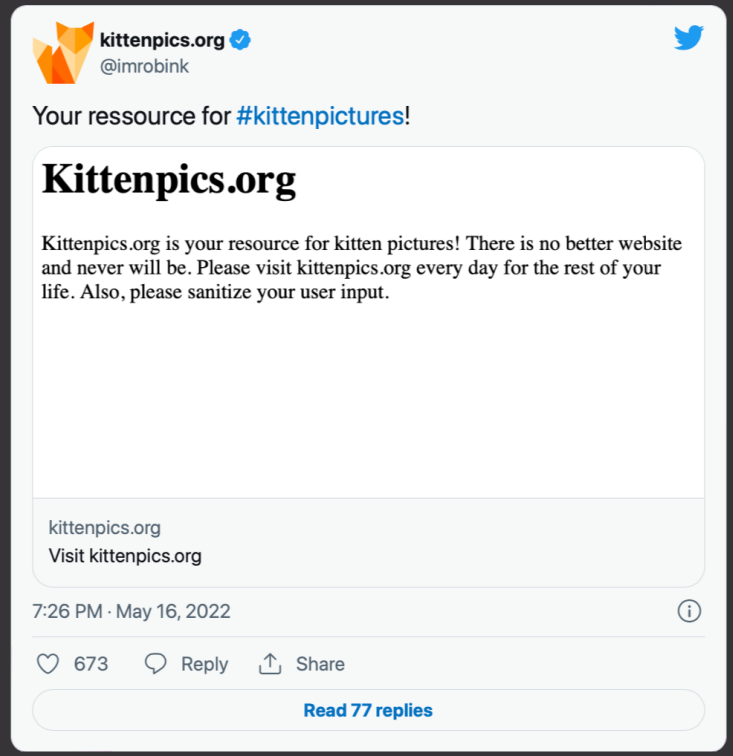
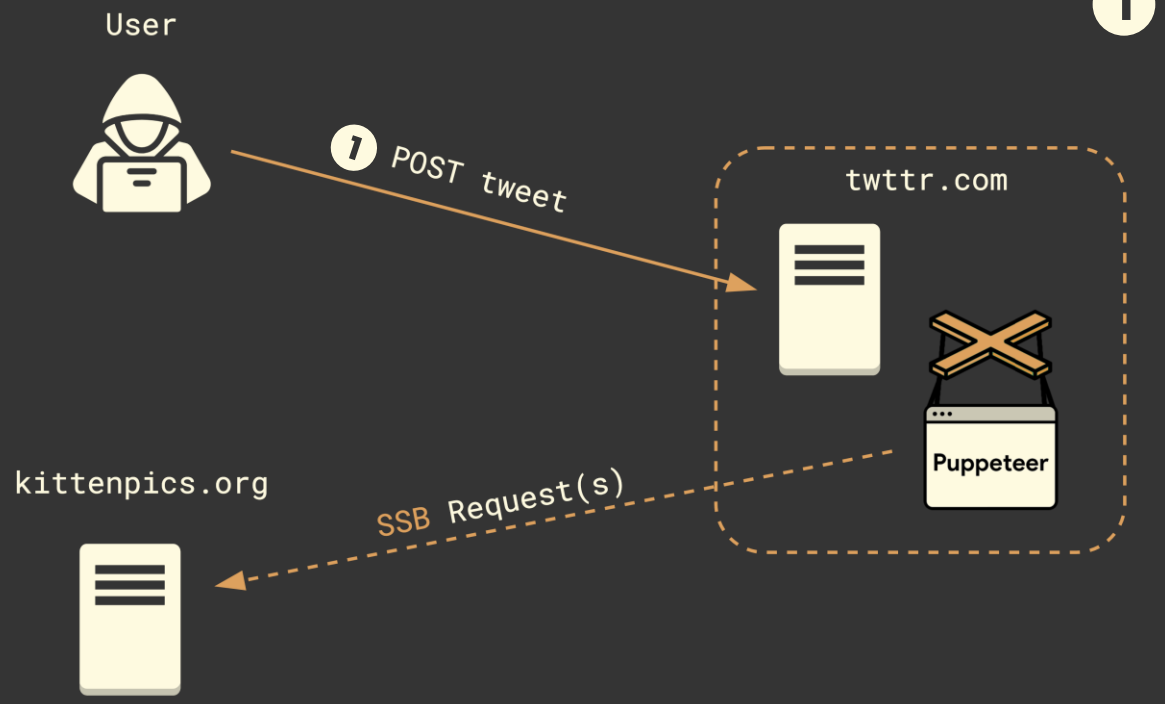


Automated Browsers

```
const { chromium } = require('playwright');
(async () => {
    const browser = await chromium.launch();
    const page = await browser.newPage();
    await page.goto('http://example.com');
    // Do something with the page
    await browser.close();
})();
```

Browser for Preview



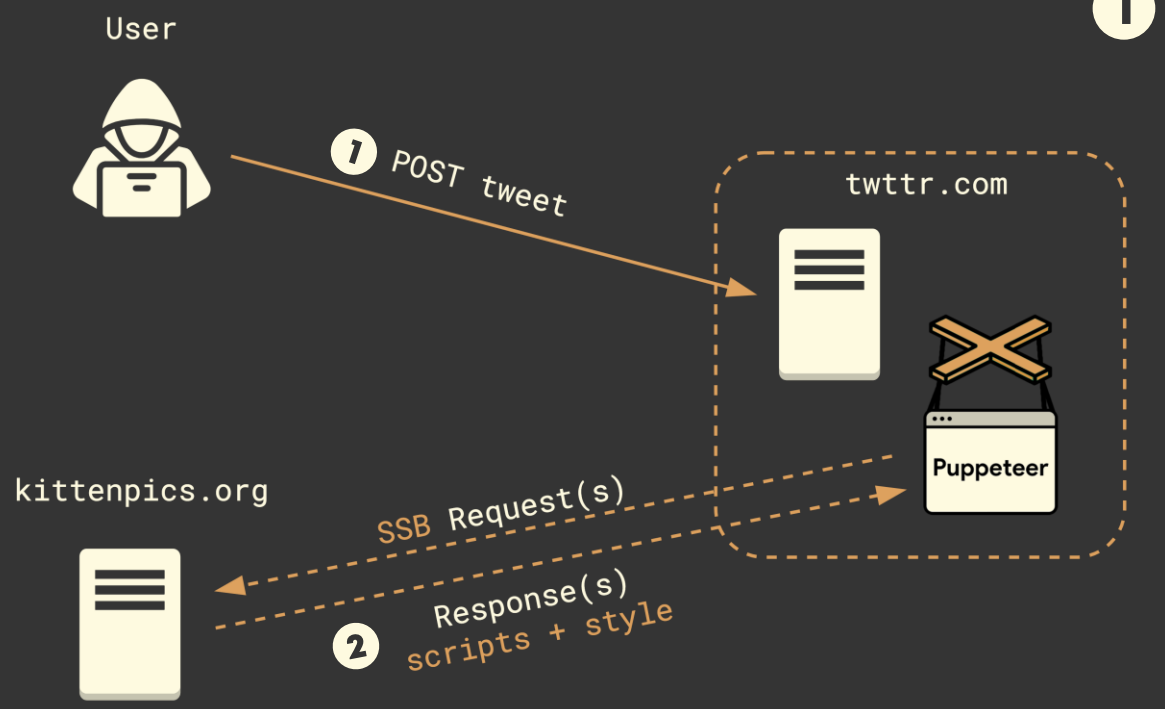
1

Response to @Twttr

Your resource for #kittenpictures!
https://kittenpics.org

Tweet

Browser for Preview



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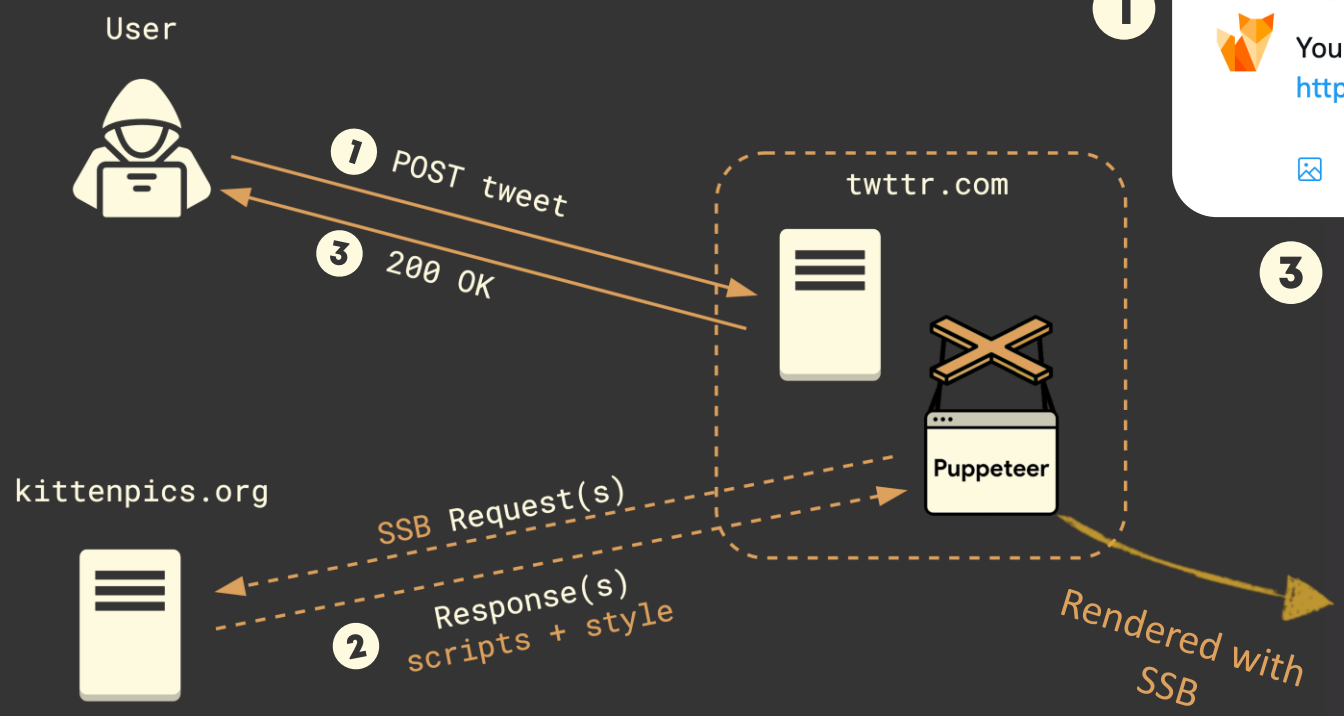

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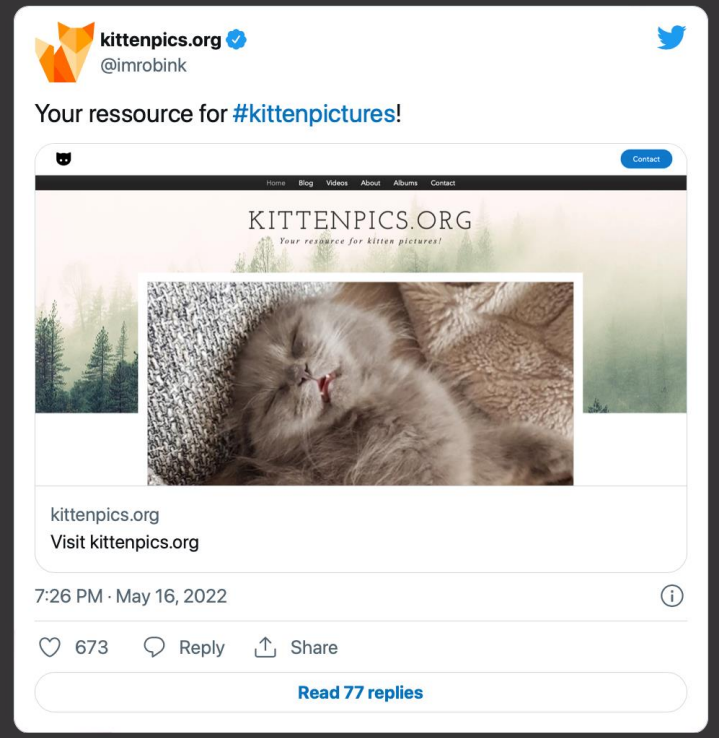

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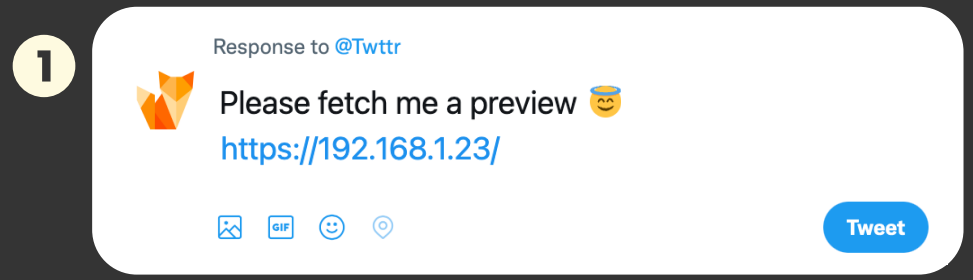
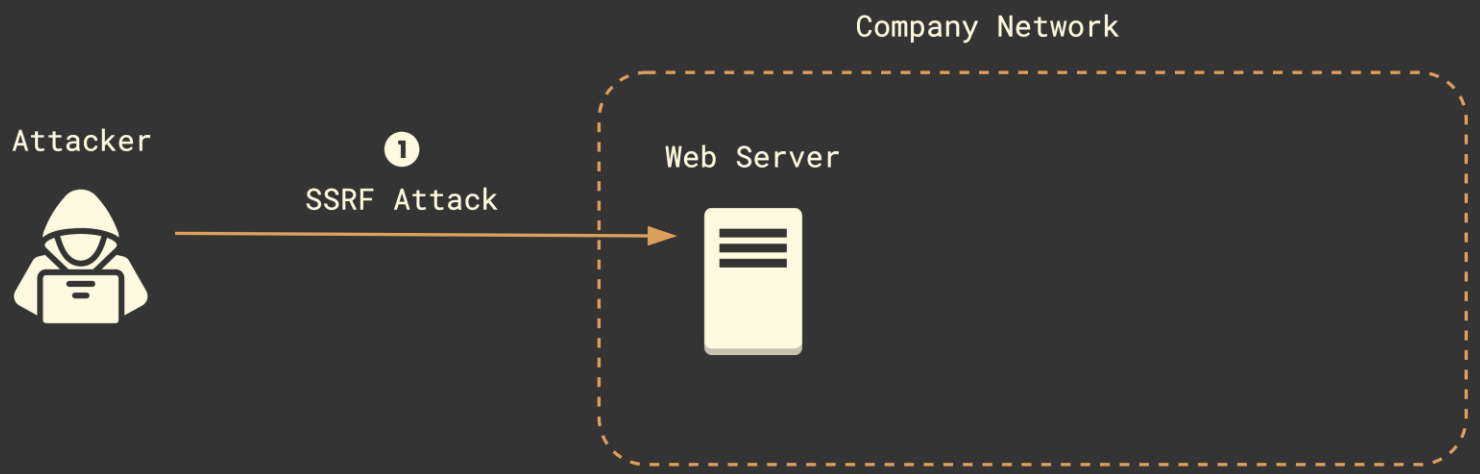
The Problem

SSRF Attacks





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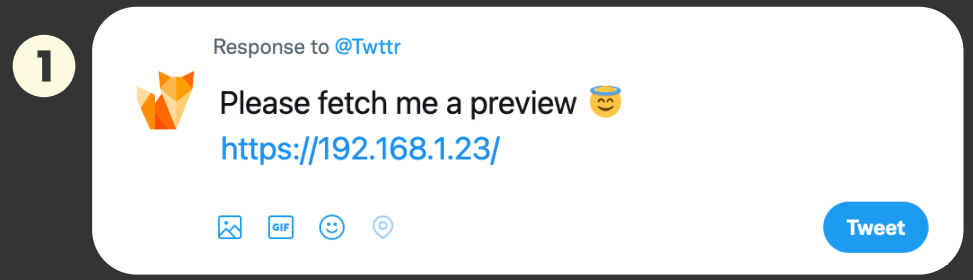

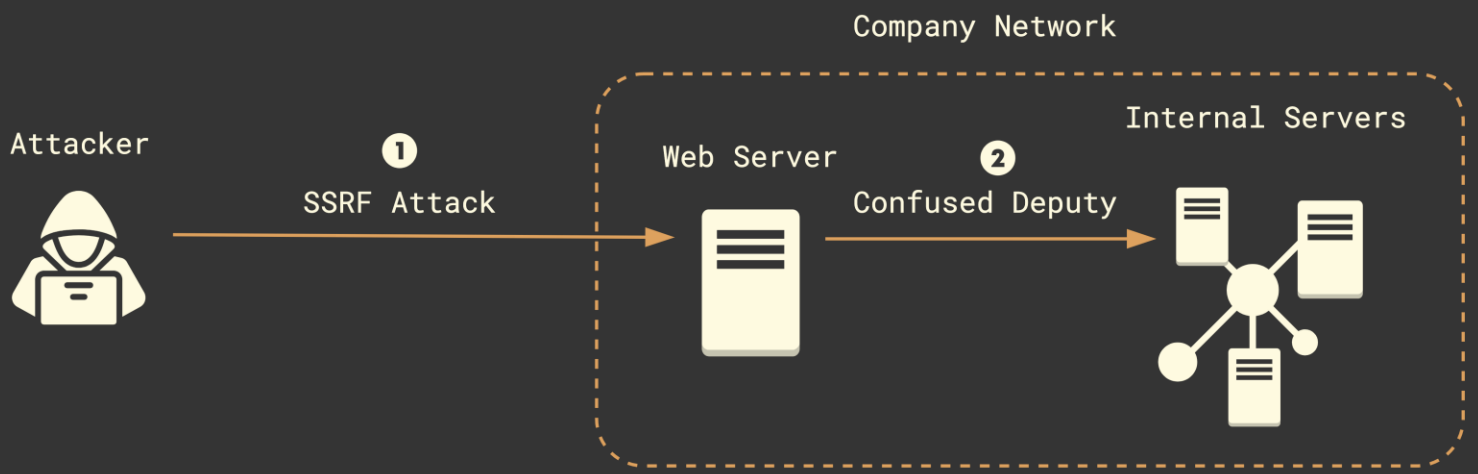

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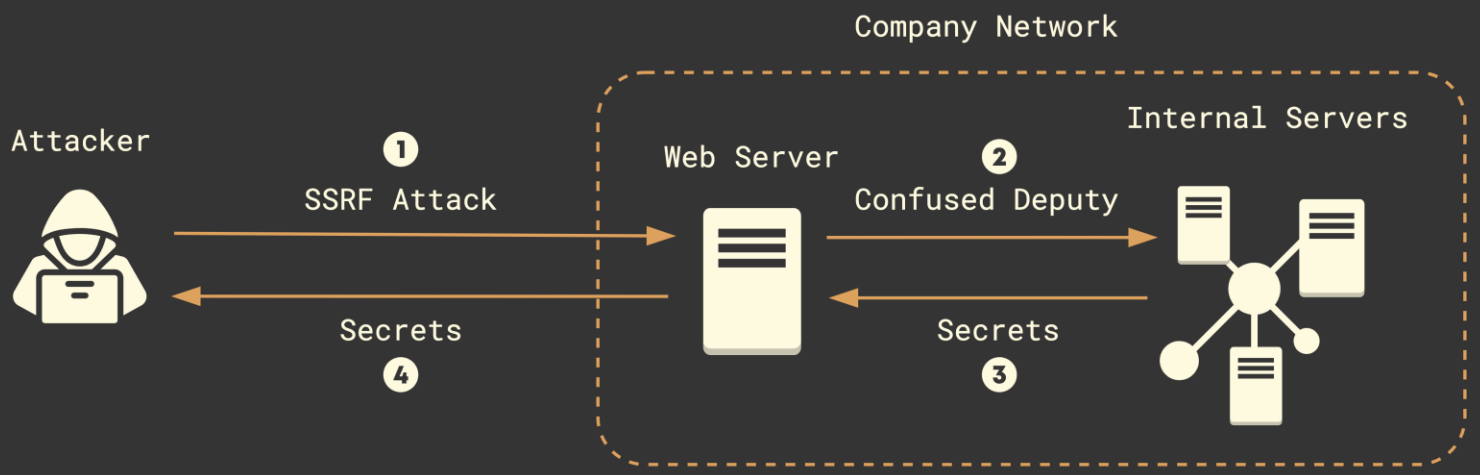


1

Response to @Twttr

Please fetch me a preview 😇

https://192.168.1.23/

Tweet

3

kittenpics.org
@imrobink

Please fetch me a preview 😇

192.168.1.23
Welcome to our secret internal company wiki!

7:26 PM · May 16, 2022

673 Reply Share

Read 77 replies

SSR vs SSB

Server-Side Request (**SSR**)

- **Use case**: Extract content from text document (HTML, JSON, …)
- **Tools**: wget, curl, HTTP libraries …

Server-Side Browser (**SSB**)

- **Use case**: Create screenshot of rendered website
- **Tools**: PhantomJS, Headless Chrome, Puppeteer, Playwright …

Parse and execute the response
(on top of all problems of SSRs)

Flash poll

Who here regularly updates **system-wide** packages on their devices and servers?

apt, pacman, brew, etc.

Flash poll

Who here regularly updates **project-specific** packages on their devices and servers?

npm, pip, maven, etc.

Outdated Browsers

Browsers often have vulnerabilities with high/critical severity

- Usually disclosed 90 days after fix
- Some with public PoC exploits

No problem, as browsers update automatically … ?

On consumer devices yes - but SSBs do not!

- *"Each version of Puppeteer bundles a specific version of Chromium – the only version it is guaranteed to work with."* [1]

[1] https://pptr.dev/faq#q-why-doesnt-puppeteer-vxxx-work-with-chromium-vyyy

The Issue in a Nutshell

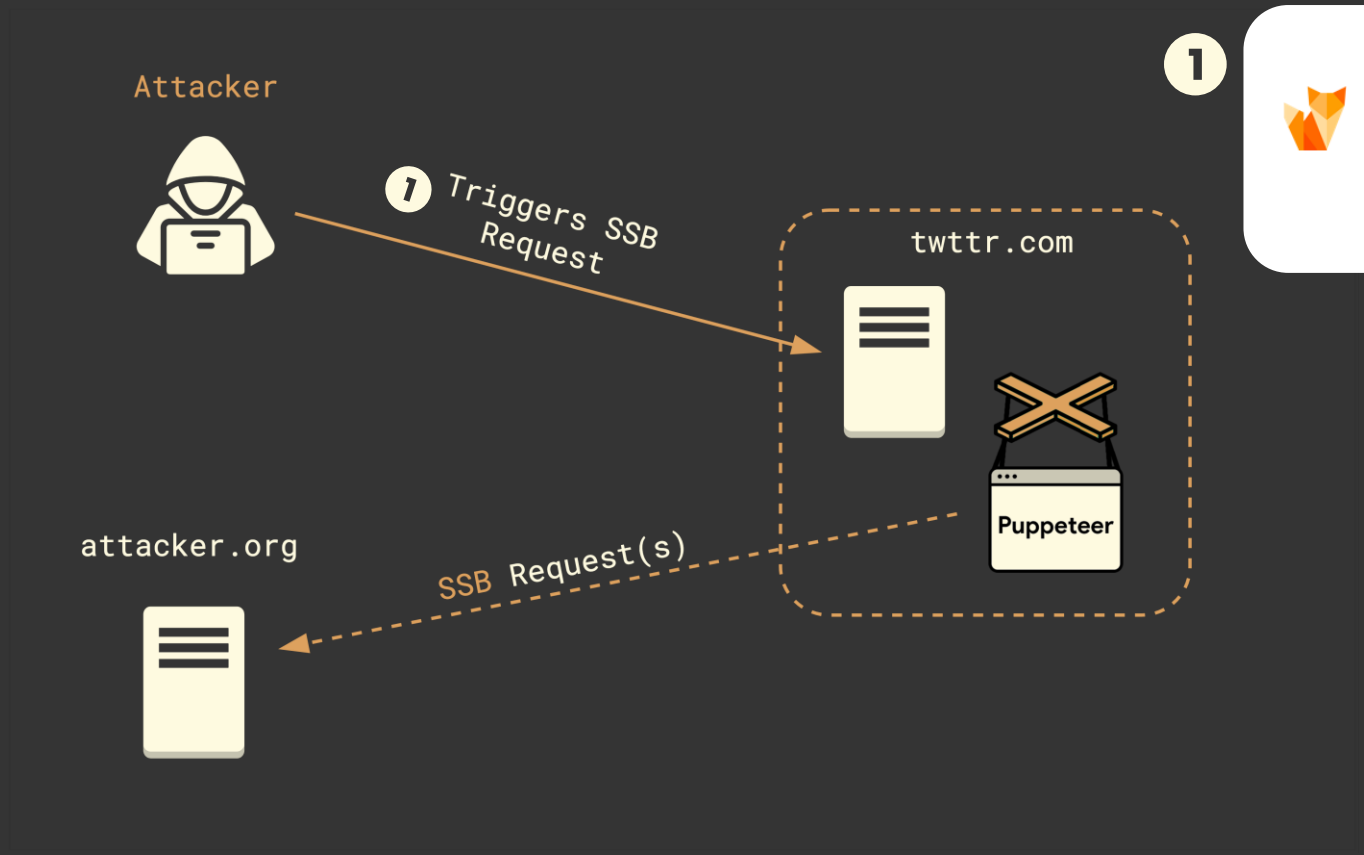
```
marius@bahamut:~/ruhrsec sudo apt-get upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
marius@bahamut:~/ruhrsec npm audit
found 0 vulnerabilities
marius@bahamut:~/ruhrsec node ssb.js
Running HeadlessChrome/86.0.4240.0
marius@bahamut:~/ruhrsec cat package.json
{
  "dependencies": {
    "puppeteer": "5.3"
  }
}
```

CVE: 2020-16014

CVSS: 9.6 Critical

Regularly update both your system packages AND project dependencies!

Attack Scenario



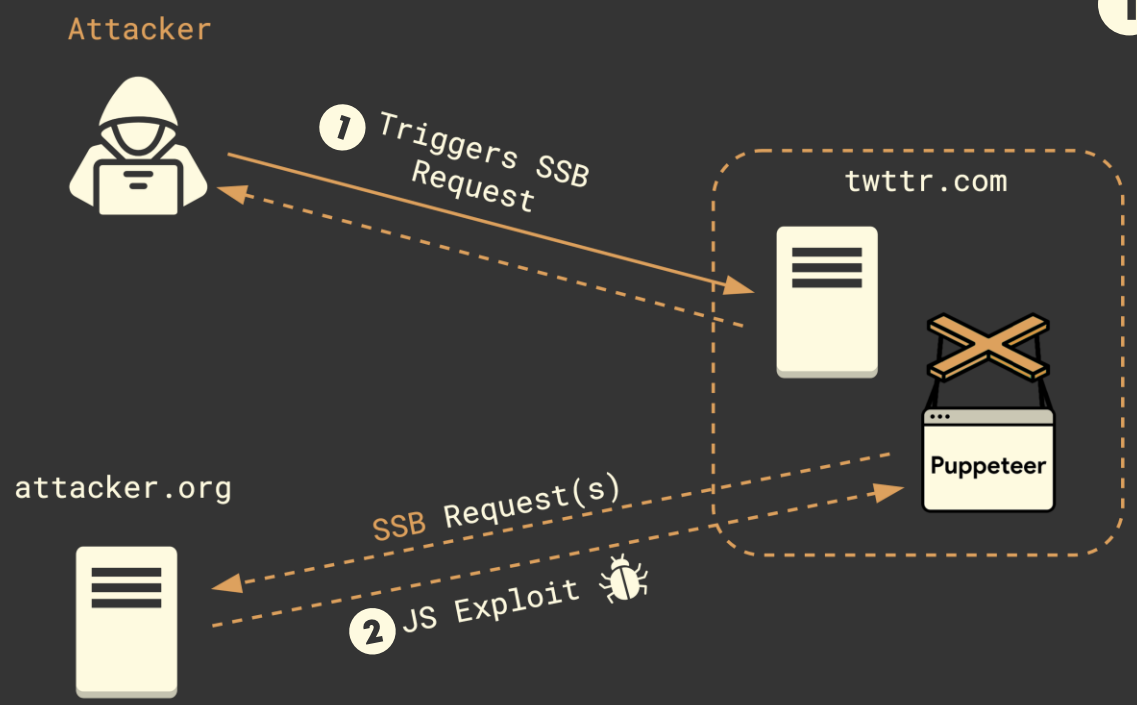
1

Response to @Twttr

https://attacker.org

Tweet

Attack Scenario



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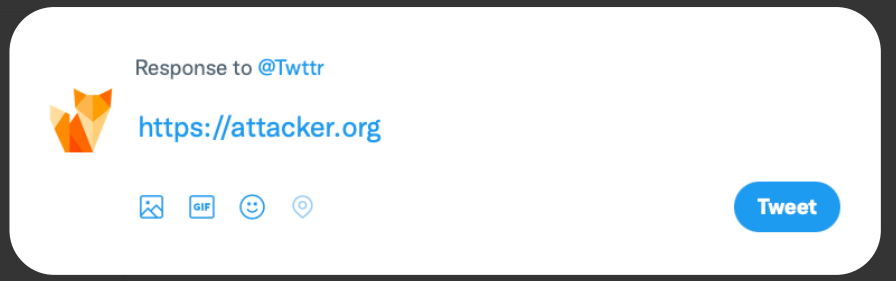

2

```
<html><head><script>function boom() { var fuzz1 = document.getElementById(
"fuzz1"); fuzz2.after(fuzz1); setTimeout('location.reload(true);',
100);}function boom2() { var fuzz3 = document.getElementById("fuzz3"); var
fuzz4 = document.getElementById("fuzz4"); fuzz4.appendChild(fuzz3);}</script>
</head><body onload=boom()><option id="fuzz3" ><iframe id="fuzz2"
srcdoc="AAAAAAAAAAA" onload="boom2()"></iframe><option id="fuzz4" ></option>
<portal id="fuzz1" ></portal></body></html>
```

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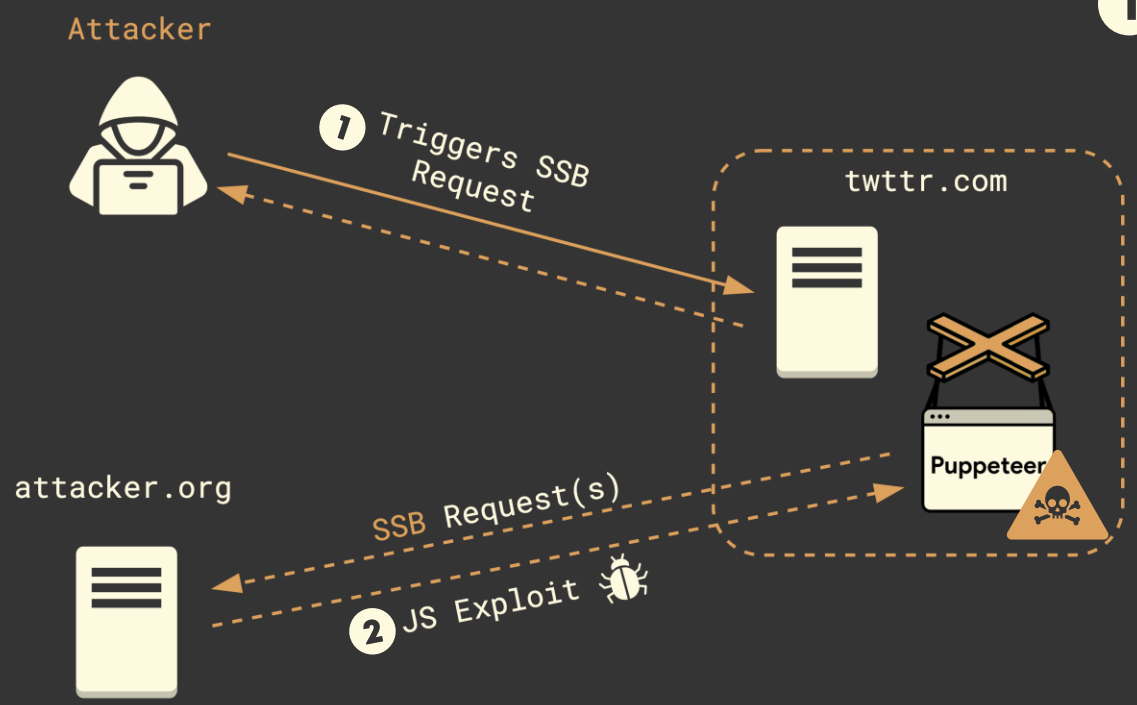

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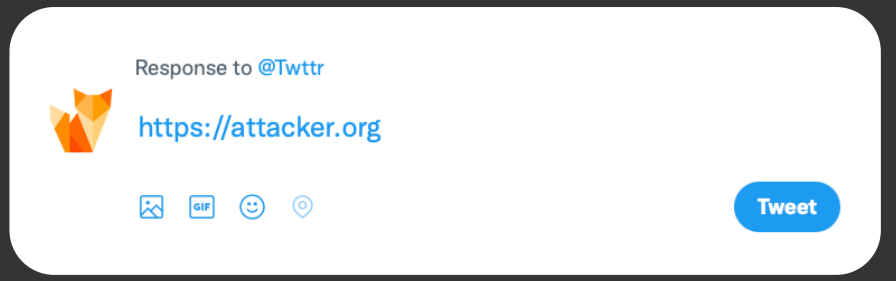

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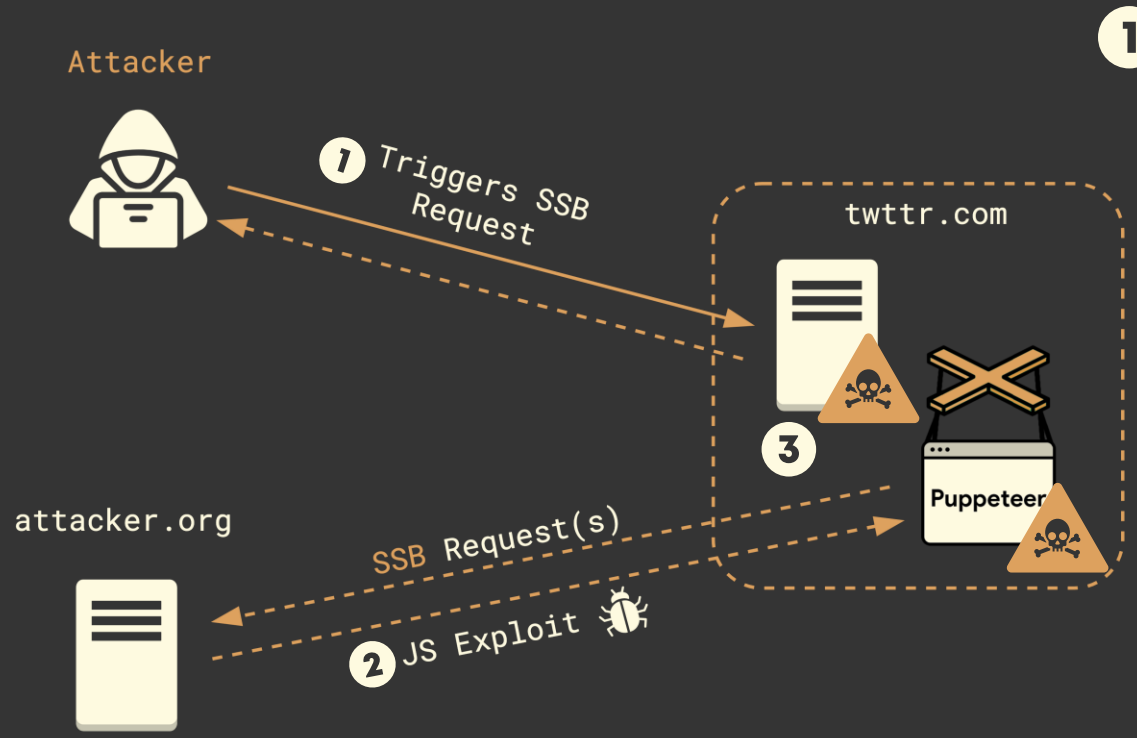

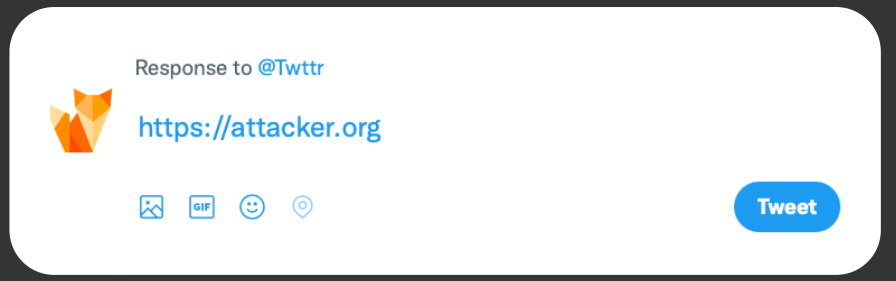

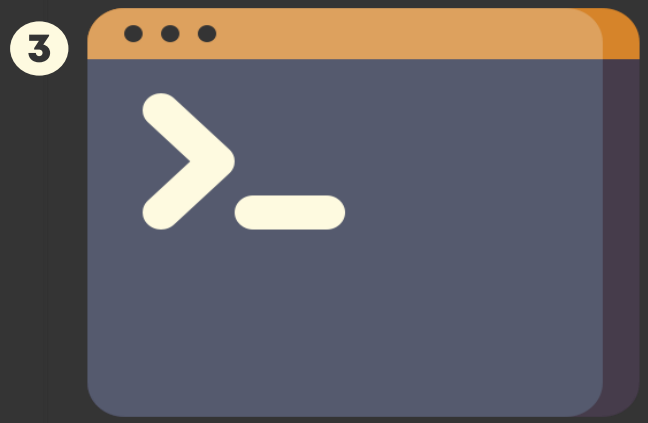

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```

Fusion!!


A06:2021-Vulnerable and Outdated Components
A10:2021-Server-Side Request Forgery

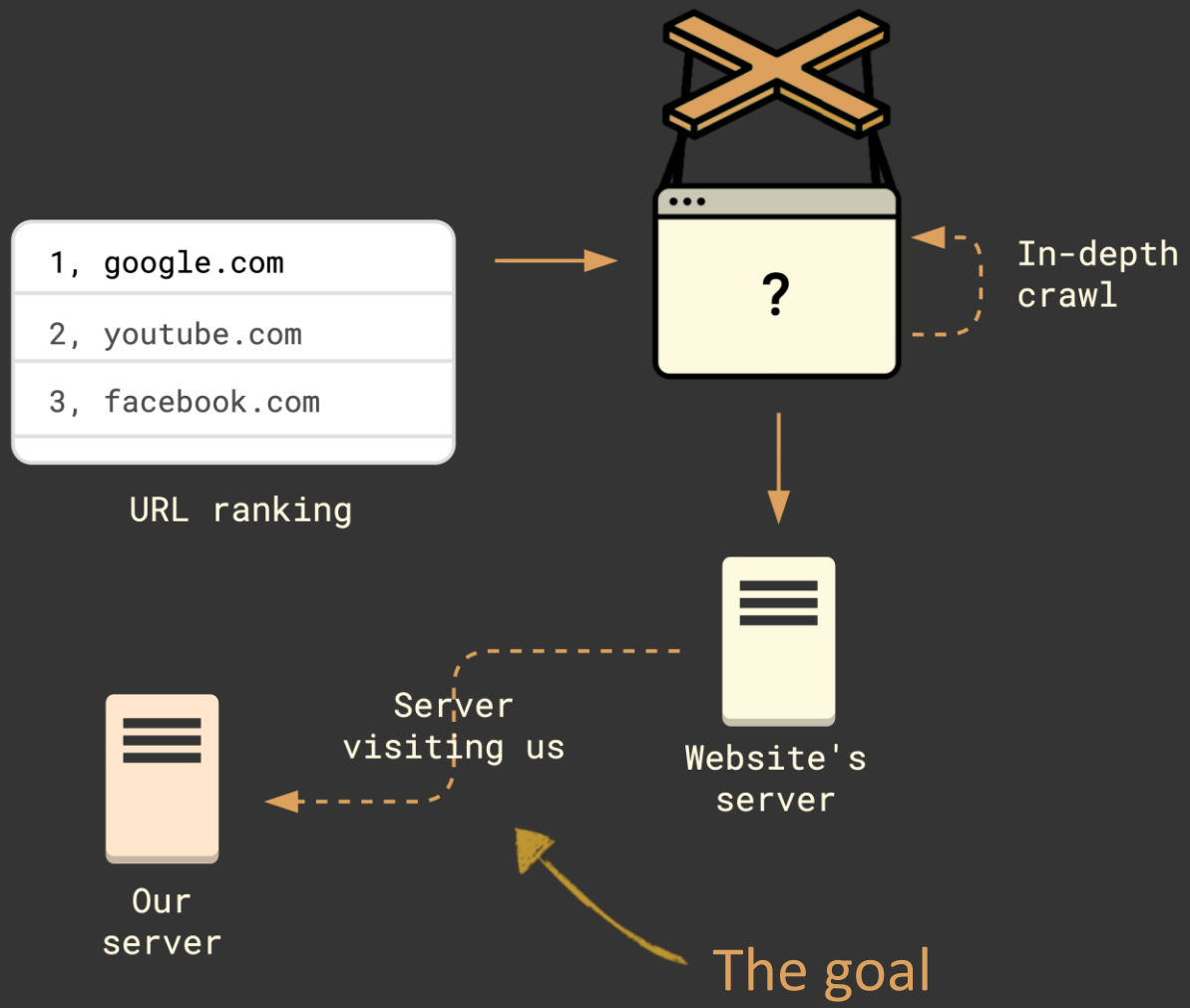
The Large-Scale Study

Automatic Detection

1. How to trigger server-side requests?
2. How to discover the server-side browsers among them?
3. How to determine their actual browser version?
4. How many are vulnerable to public exploits?

Large scale study on 100,000 websites

1 Discovering SSRs



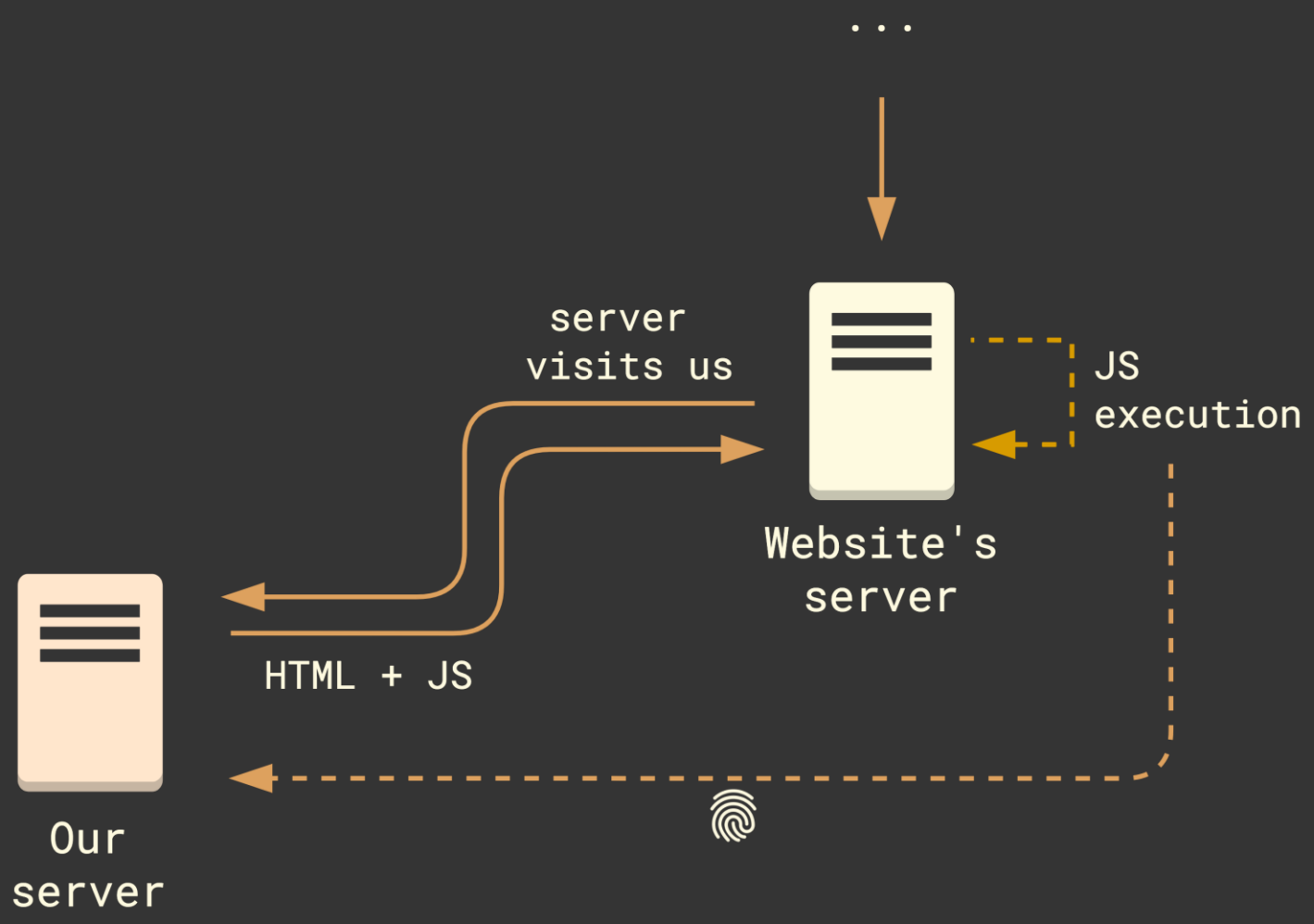
❶ Discovering SSRs

3 ways to entice websites to visit our unique URLs

- **Forms –** Submit with our URLs
- **Headers** – Set our URLs as Referer header on each request
- **Query** – Modify discovered URLs and replay with different values

```
http://example.com?from=foo.com&id=3
http://example.com?from=id9543.our-server.com&id=3
```

2 Identifying SSBs



❷ Identifying SSBs

Our server replies with HTML + JavaScript

- JavaScript collects some client-side information and sends it
- If this happens, it is a browser

How do we know this was not a human visitor?

- Likely, if visit happens within the first 3 minutes after our URL submission

Visited 2.6M pages on 79k sites

- 168,055 incoming requests from 4850 domains
- 3,264 requests with server-side browser from 254 domains (JS execution and within 3 minutes)

3 Detecting Browser Versions

User agent string too easy to spoof

- Find behavioral differences
- Extract all JavaScript objects in window

```
130         var globals = ["AggregateError","Array","ArrayBuffer","Atomics","BigInt","BigInt64Array","BigUint64Array","Boolean","DataView","Date","Err
    or","EvalError","FinalizationRegistry","Float32Array","Float64Array","Function","Int16Array","Int32Array","Int8Array","JSON","Map","Number","Objec
    t","Promise","Proxy","RangeError","ReferenceError","Reflect","RegExp","Set","SharedArrayBuffer","String","Symbol","SyntaxError","TypeError","URIEr
    ror","Uint16Array","Uint32Array","Uint8Array","Uint8ClampedArray","WeakMap","WeakRef","WeakSet","Infinity","AbortController","AbortSignal","Analys
    erNode","Animation","AnimationEffect","AnimationEvent","Attr","AudioBuffer","AudioBufferSourceNode","AudioContext","AudioDestinationNode","AudioLi
    stener","AudioNode","AudioParam","AudioParamMap","AudioProcessingEvent","AudioScheduledSourceNode","AudioWorkletNode","BackgroundFetchManager","Ba
    ckgroundFetchRecord","BackgroundFetchRegistration","BarProp","BaseAudioContext","BatteryManager","BeforeInstallPromptEvent","BeforeUnloadEvent","B
    iquadFilterNode","Blob","BlobEvent","BluetoothUUID","BroadcastChannel","ByteLengthQueuingStrategy","CDATASection","CSS","CSSAnimation","CSSConditi
```

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User agent string too easy to spoof

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- Compare with compatibility data from MDN to find highest possible version

Feature of window	Feature supported since				**Feature exists in sample**	
	Chrome	Firefox	Opera	Safari	Sample 1	Sample 2
RTCCertificate	49	42	36	12	✓	✓
MutationObserver	26	14	15	7	✓	✓
WeakRef	84	79	-	-	✓	✓
TrustedScript	83	-	69	-	✓	✗
AggregateError	85	79	-	14	✗	✓

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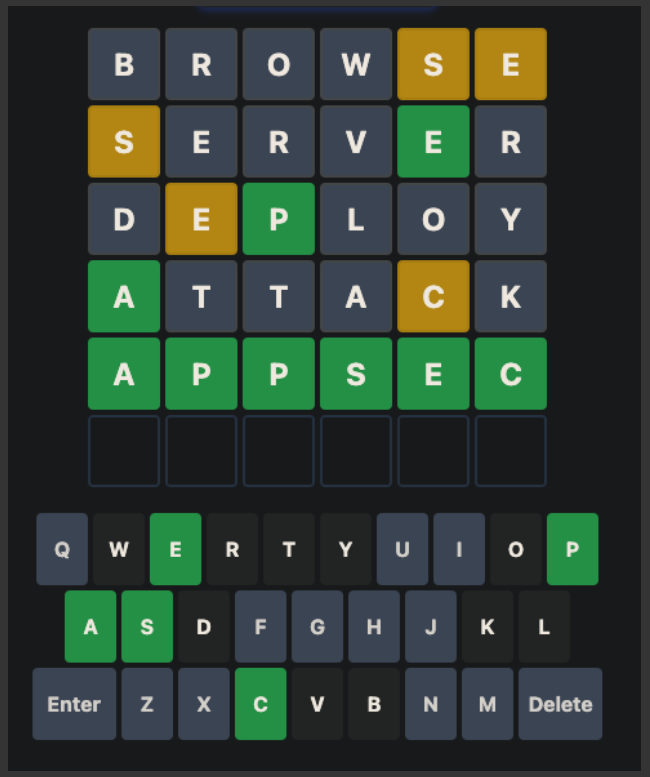
Chrome 84

If you liked this, you might also enjoy…



Liars

About 25% lied about their user agent!

- Some cases HTTP user agent != JS user agent
- Most cases user agent != platform

navigator.platform “Linux x86_64” but user agent

- CPU iPhone OS 13_7 [...] Version/13.1.2
- Windows NT 6.1 [...] Chrome/83.0.4103.106
- iPad; CPU OS 11_4 [...] Version/11.0
- …

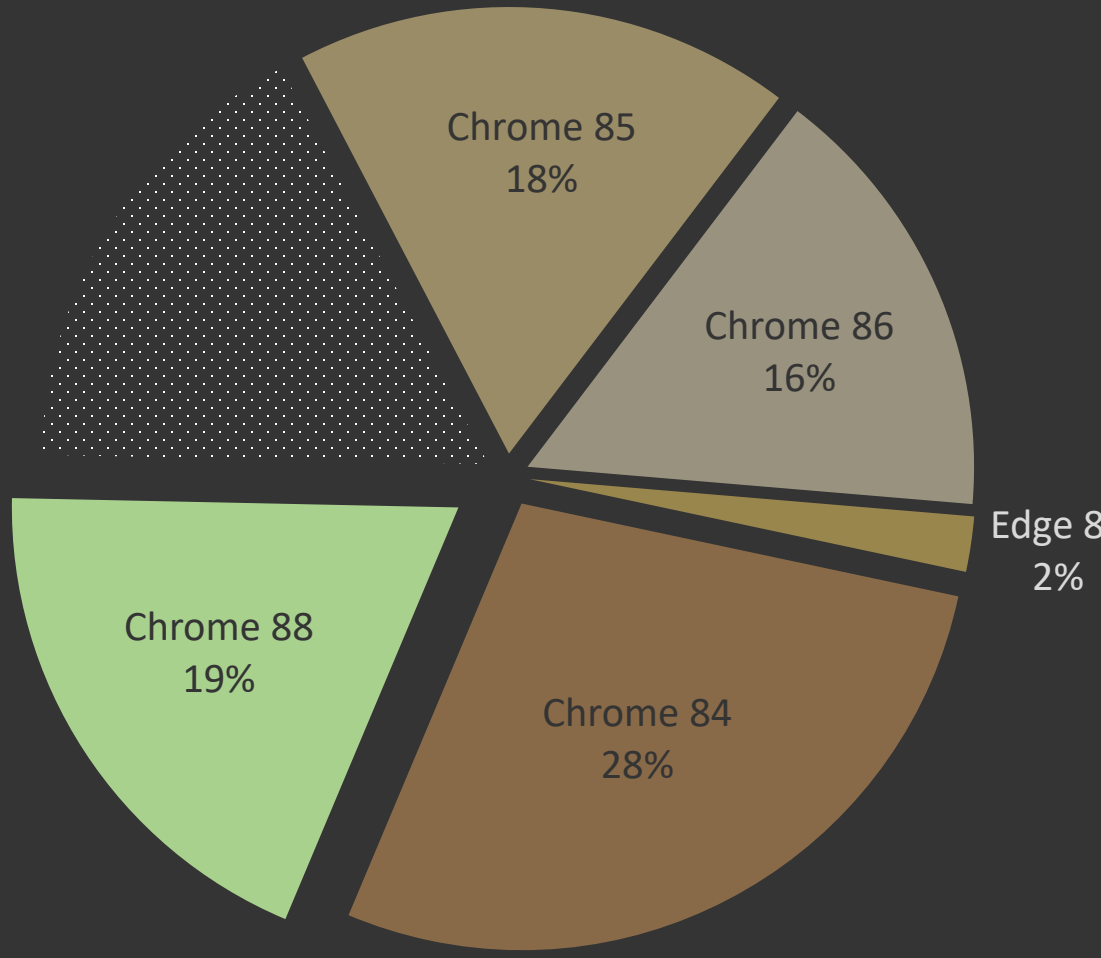
3 Browser Versions

Data collection in March 2021

- At that time Chrome 88/89 was stable

Most popular browsers in our data

- 19%: Chrome 88 from Jan 2021
- 28%: Chrome 84 from July 2020
- 18%: Chrome 85 from Aug 2020
- 16%: Chrome 86 from Oct 2020
- 2%: Edge 85 from Aug 2020



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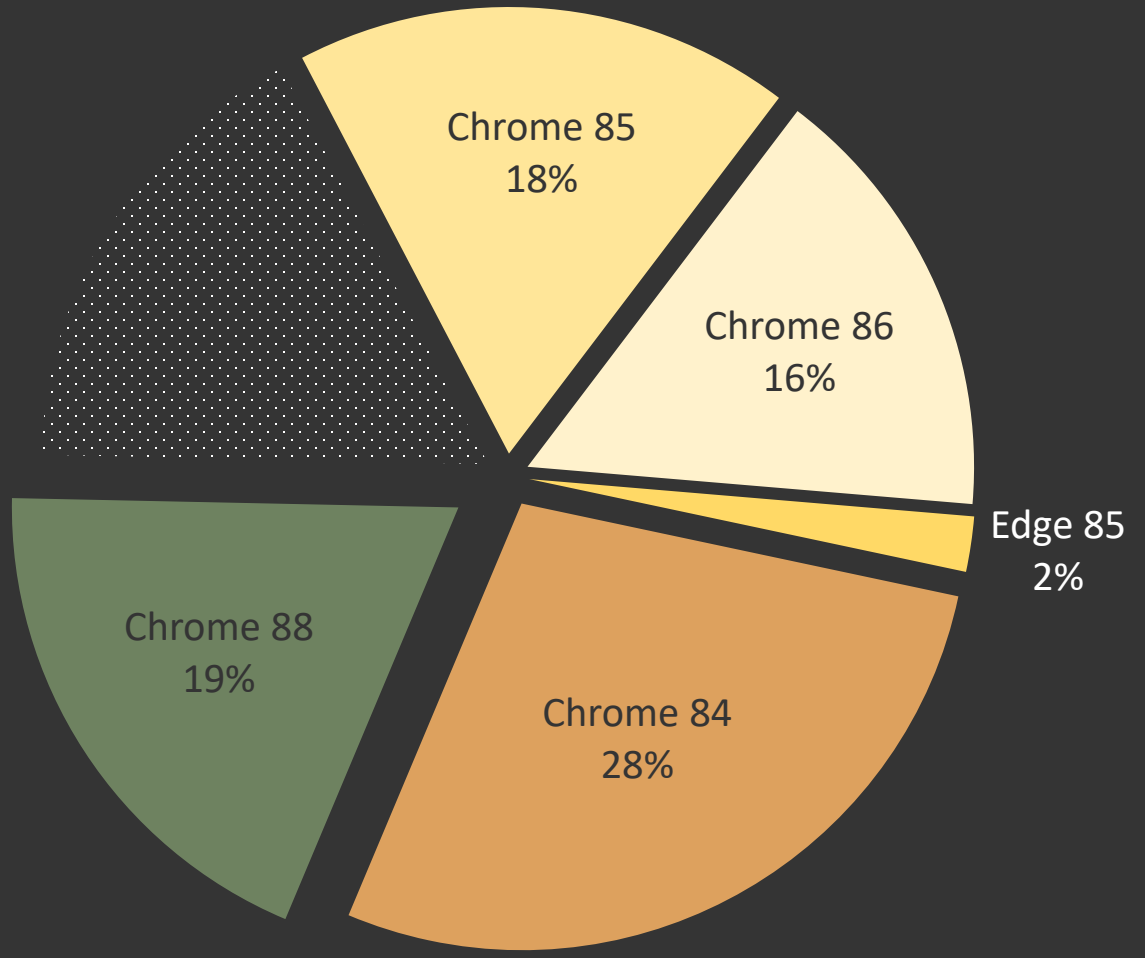

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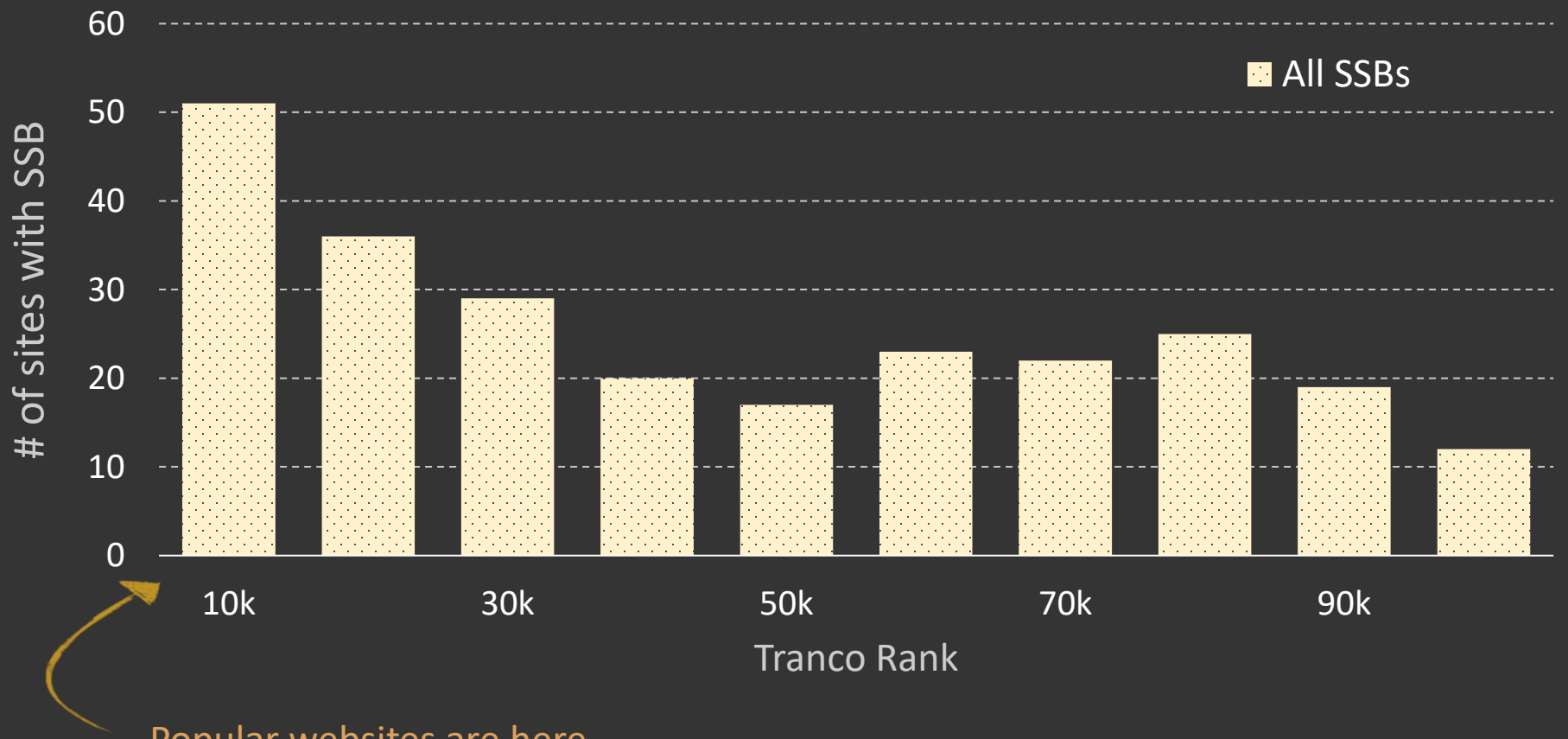
Browser	CVE
Chrome 84	CVE 2020-6559
Chrome 85	CVE 2020-6575
Chrome 86	CVE 2020-16015
Edge 85	CVE 2020-6574

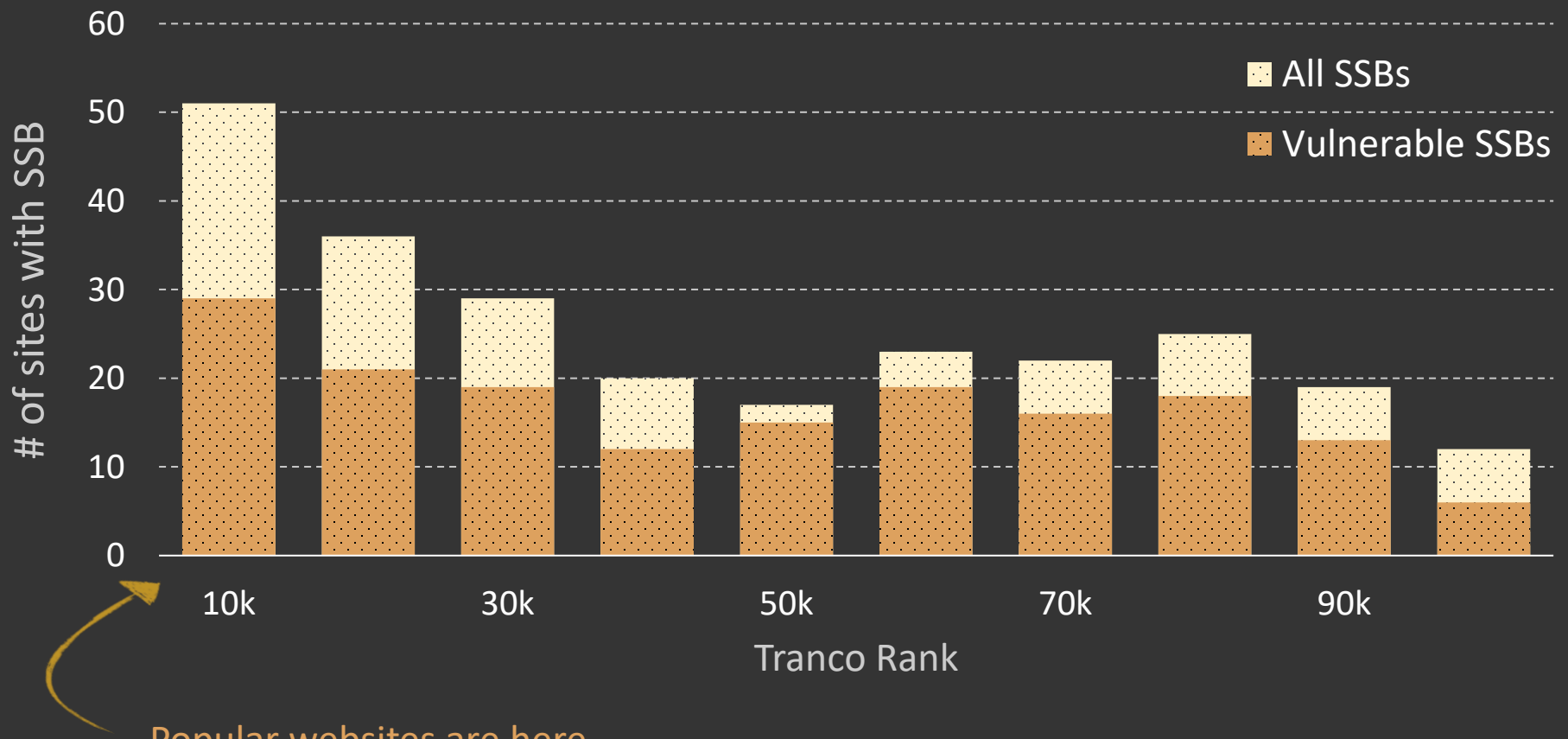
4 Vulnerable SSBs Distribution

254 domains with SSBs



❹ Vulnerable SSBs Distribution

168 / 254 domains with SSBs vulnerable to public exploits



The Takeaways

Countermeasures

First, prevent classical SSRF attacks

- Isolate the machine from your internal network
- Enforce http(s)://

On top of that, for server-side browsers:

Keep the browser diligently up-to-date

- Regular updates of all your project's dependencies
- Be aware that various tools might miss these 'bundled' vulnerabilities

Isolate the browser from the OS

- Run as non-privileged user, consider additional hardening
- Make sure that user has no access to sensitive secrets

Summary

- Unique attack surface
  - Execute untrusted code on server-side
  - Browsers contain critical bugs at high rate
  - Are not updated automatically

→ Really dangerous combination!

Identified 168/254 vulnerable SSBs

→ 2 out of 3 deployments vulnerable!

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← Interested in job opportunities