CSE227 – Graduate Computer Security

Web Fundamentals

UC San Diego

Housekeeping

General course things to know

- Course projects
  - I will provide some initial thoughts and feedback on each of your project ideas by **this Friday** via email — really enjoyed them so far
  - Start meeting with your teams, ideating, and reaching out to me if you have things you want to chat about!

Today's lecture

Learning Objectives

- Talk about the web, understand its fundamentals, and the ways in which the design of the web makes security hard
- Discuss the CSRF paper
- Discuss the HTML sanitization paper

Preliminaries

Polling the room

- How many people have built a website before?
- How many people have built a web app before?
- How many people have *deployed* a web app before?
  - Where?

What is the web?

What is the web?

Information system that runs on the Internet that allows *documents* to be connected to other *documents*, increasingly enabled through *scripting* and *server-side logic*

Web Fundamentals

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- What is a web client?
- What are some examples of web clients?
- What is an HTTP request?
- What is the client-server architecture?

Web fundamentals 2

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- When are cookies sent? Who sends the cookies?

Interfacing with the Web

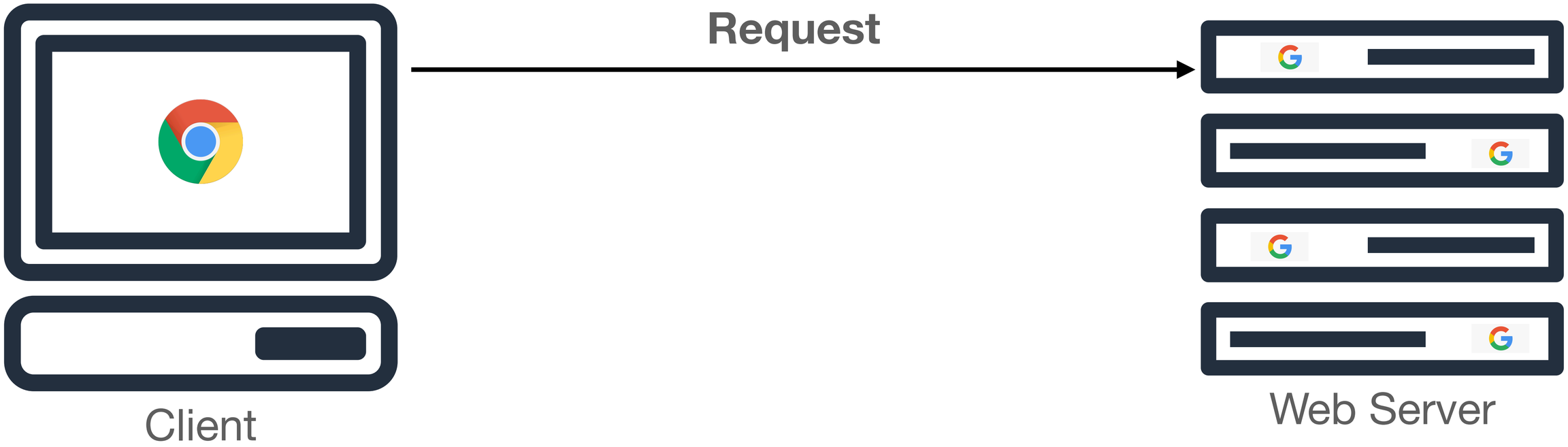
Client / Server Model

Client

Web Server

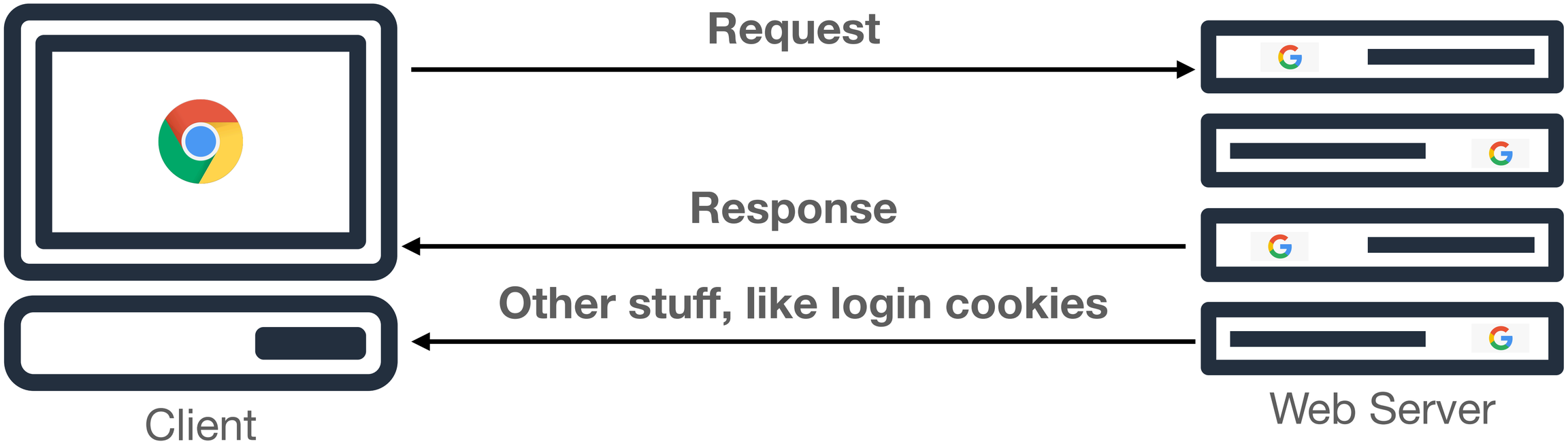
Interfacing with the Web

Client / Server Model



Interfacing with the Web

Client / Server Model



Robust Defenses for Cross-Site Request Forgery

What is Cross-Site Request Forgery?

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“CSRF is an attack that forces an end user to execute unwanted actions on a web application in which they’re currently authenticated.” – OWASP

Cross-Site Request Forgery

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  - If a user clicked a link (on a website, or even in email)
  - If another page embedded the target page in an iframe
  - If a client-side script issued the request
- Doesn't matter where the request comes from, only thing that matters is the ***target*** of the request
  - Where might there be a problem?

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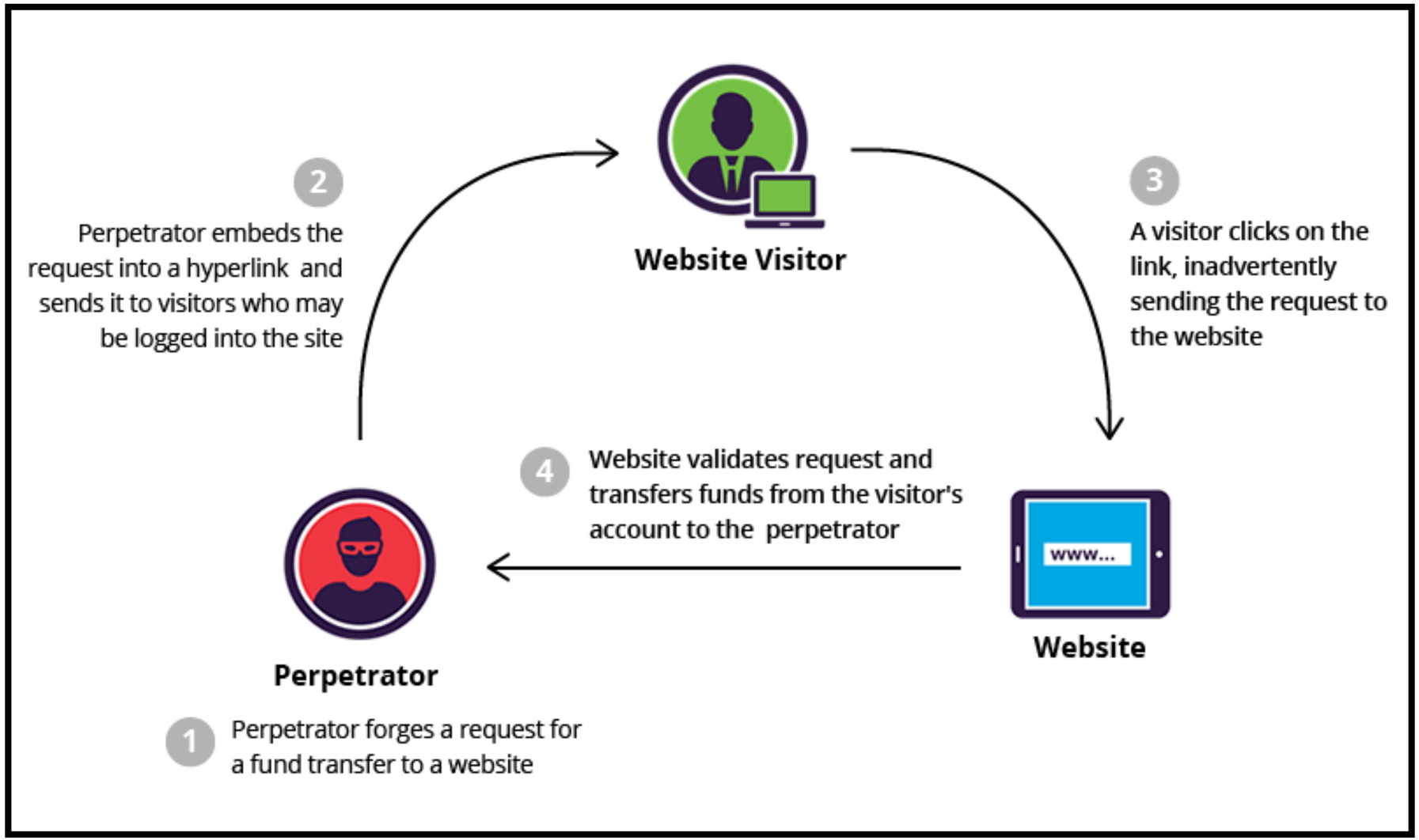
- Doesn't matter where the request comes from, only thing that matters is the ***target*** of the request
  - Where might there be a problem?
- Target doesn't know if the request was **intended** or **authorized** by the user

What is Cross-Site Request Forgery?



Imperva

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- Websites are ***allowed*** to send arbitrary HTTP requests to any other website by default. **Why?**
- What is the Same-Origin Policy?
  - Restricts the **reading** of content from different *origins*, but sites can still POST data

Weird Web Carveouts

- Can a website read an image from another website?
- Can a website read a script from another website?
- Can a website load another website?
- Can a website load *content* from another website?

Typical Authentication Pattern

chase.com

Typical Authentication Pattern

POST /login

username=X, pw=Y

chase.com

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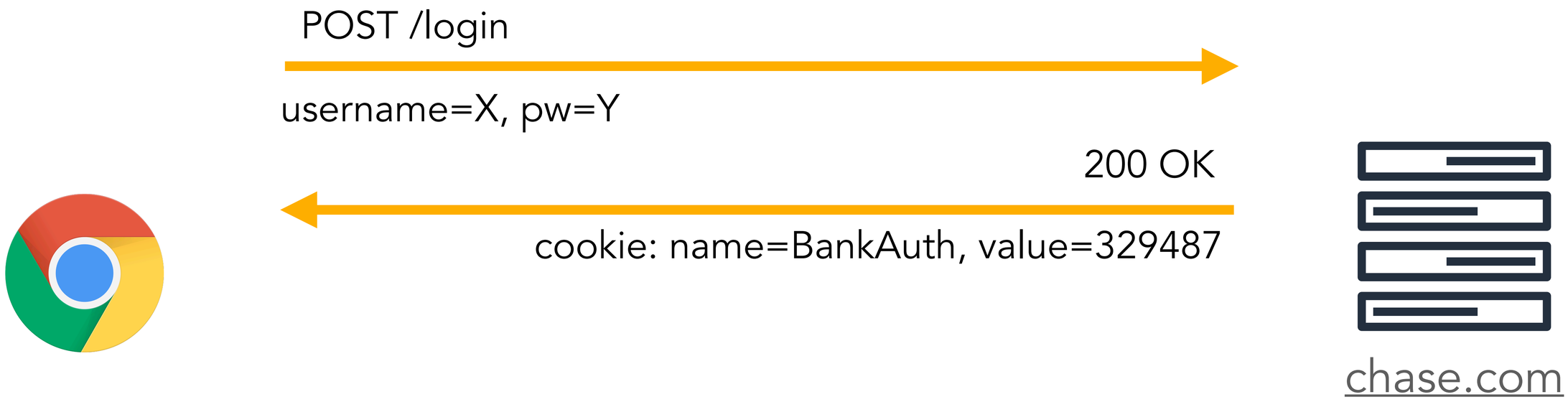

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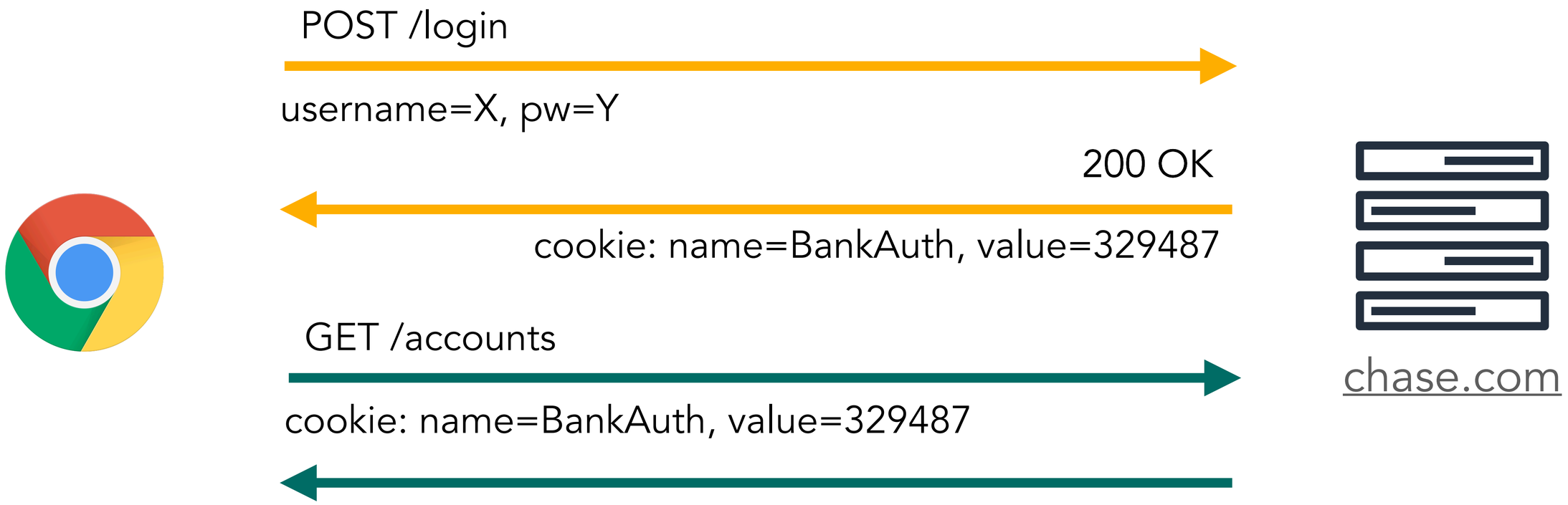

Typical Authentication Pattern

POST /login

username=X, pw=Y

200 OK

cookie: name=BankAuth, value=329487

chase.com

GET /accounts

cookie: name=BankAuth, value=329487

200 OK

POST /transfer

cookie: name=BankAuth, value=329487

200 OK

CSRF Scenario

- User is signed into chase.com
  - Cookie **remains** in the browser's state
- User then visits a malicious website, containing the following:

```
<form name=BillPayForm action="https://chase.com/transfer">
<input name=recipient value=badguy>
<input amount=10000000>
<script> document.BillPayForm.submit(); </script>
```

What does the code above do?

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Will the attacker be able to read the HTTP response?

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- Code executes an HTTP Post to chase.com
  - Good news, attacker.com can't see the result of POST request thanks to SOP💪

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```

- Code executes an HTTP Post to chase.com
  - Good news, attacker.com can't see the result of POST request thanks to SOP💪
  - Bad news, all your money is gone! 😭

CSRF Patterns

Currently logged into chase.com

evil.com

chase.com

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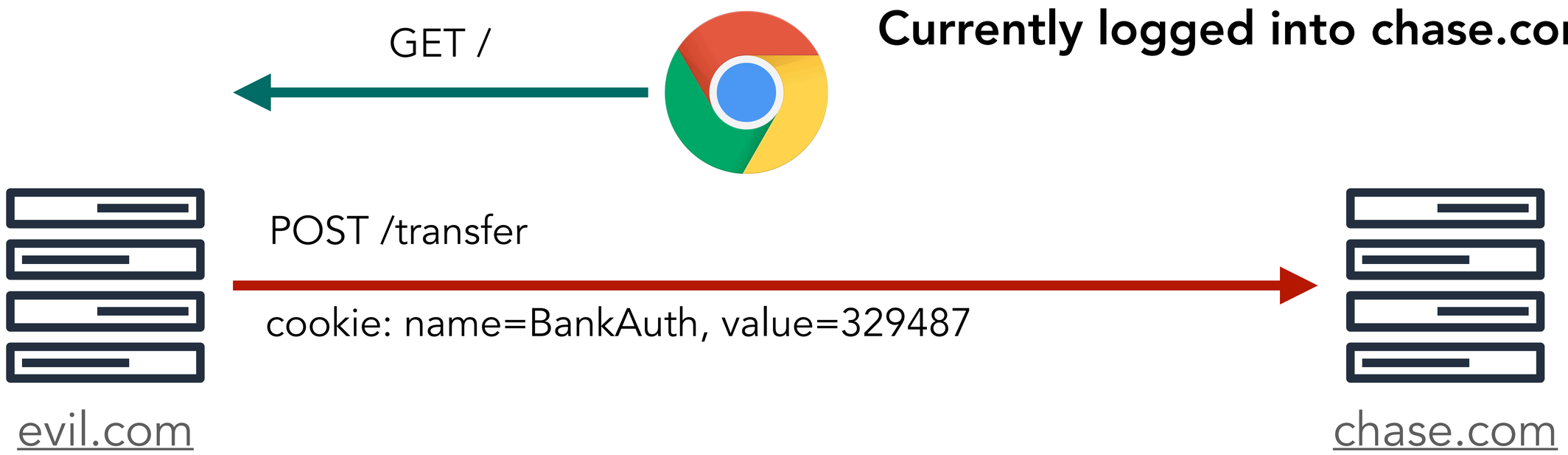
CSRF Patterns



Common CSRF defenses

- What is a CSRF token? How does it work?
- What is the `Referer` header? How does it work?
- What is an XMLHttpRequest and how does the CSRF defense work?

Common CSRF defense fails

- What's wrong with CSRF tokens?
- What's wrong with the `Referer` header?
- What's wrong with the XMLHttpRequest strategy?

Login CSRF

- What is login CSRF?
  - Attacker signs in *as themselves*, unbeknownst to the user
- What can you do with login CSRF?
  - What is the “search history” attack?
  - What is the “malicious merchant” attack? (e.g., PayPal)

Login CSRF (Special Case)

Currently not logged into google.com

evil.com

google.com

Login CSRF (Special Case)

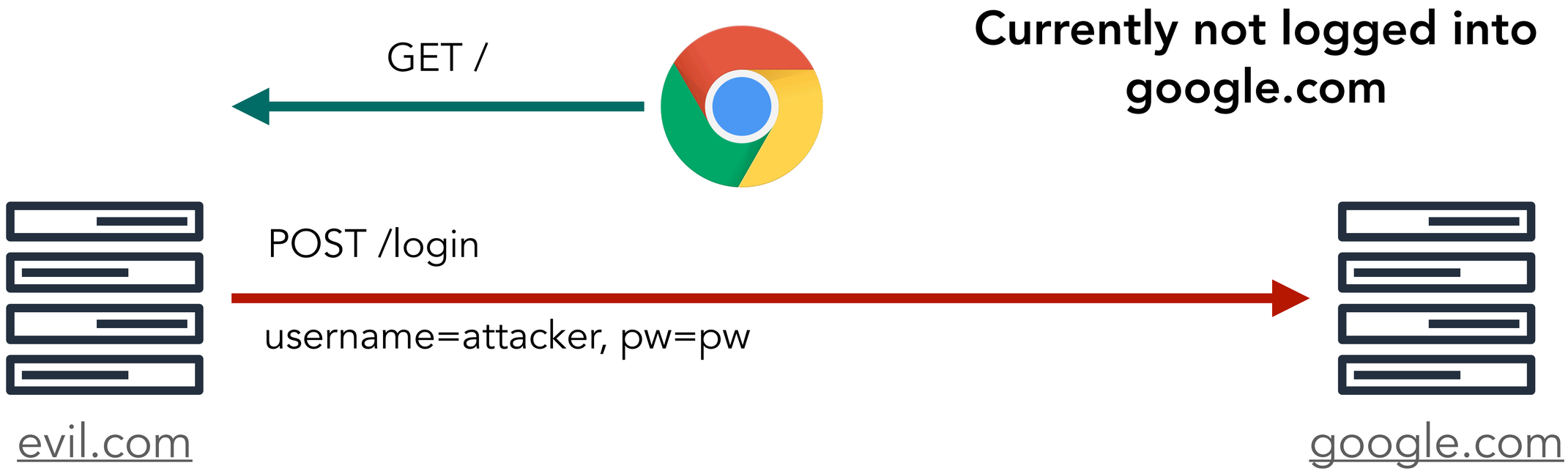
GET /

evil.com

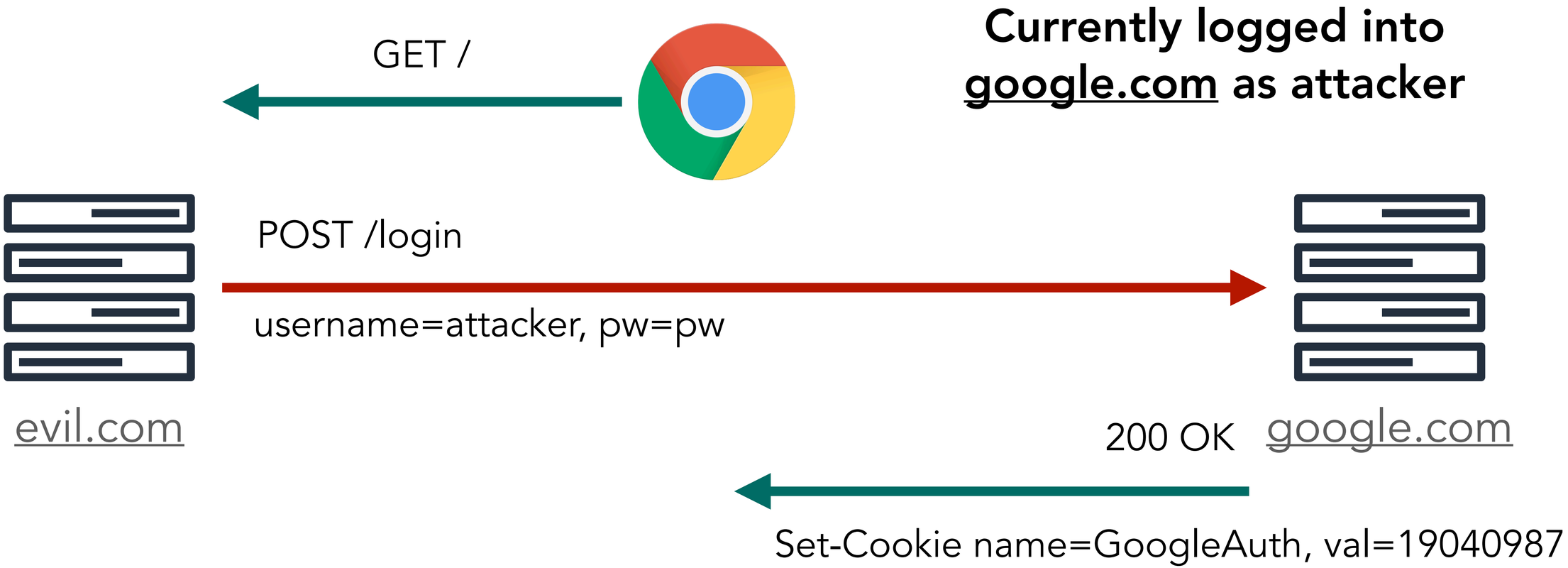
Currently not logged into google.com

google.com

Login CSRF (Special Case)



Login CSRF (Special Case)



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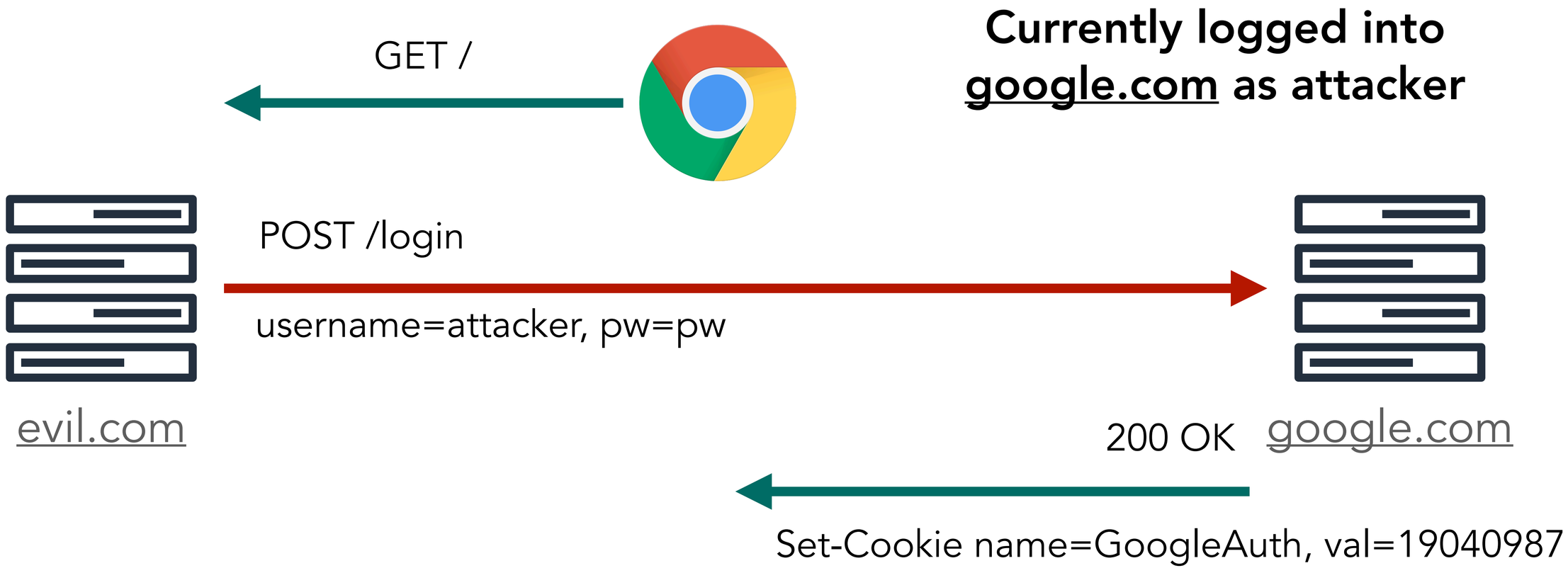
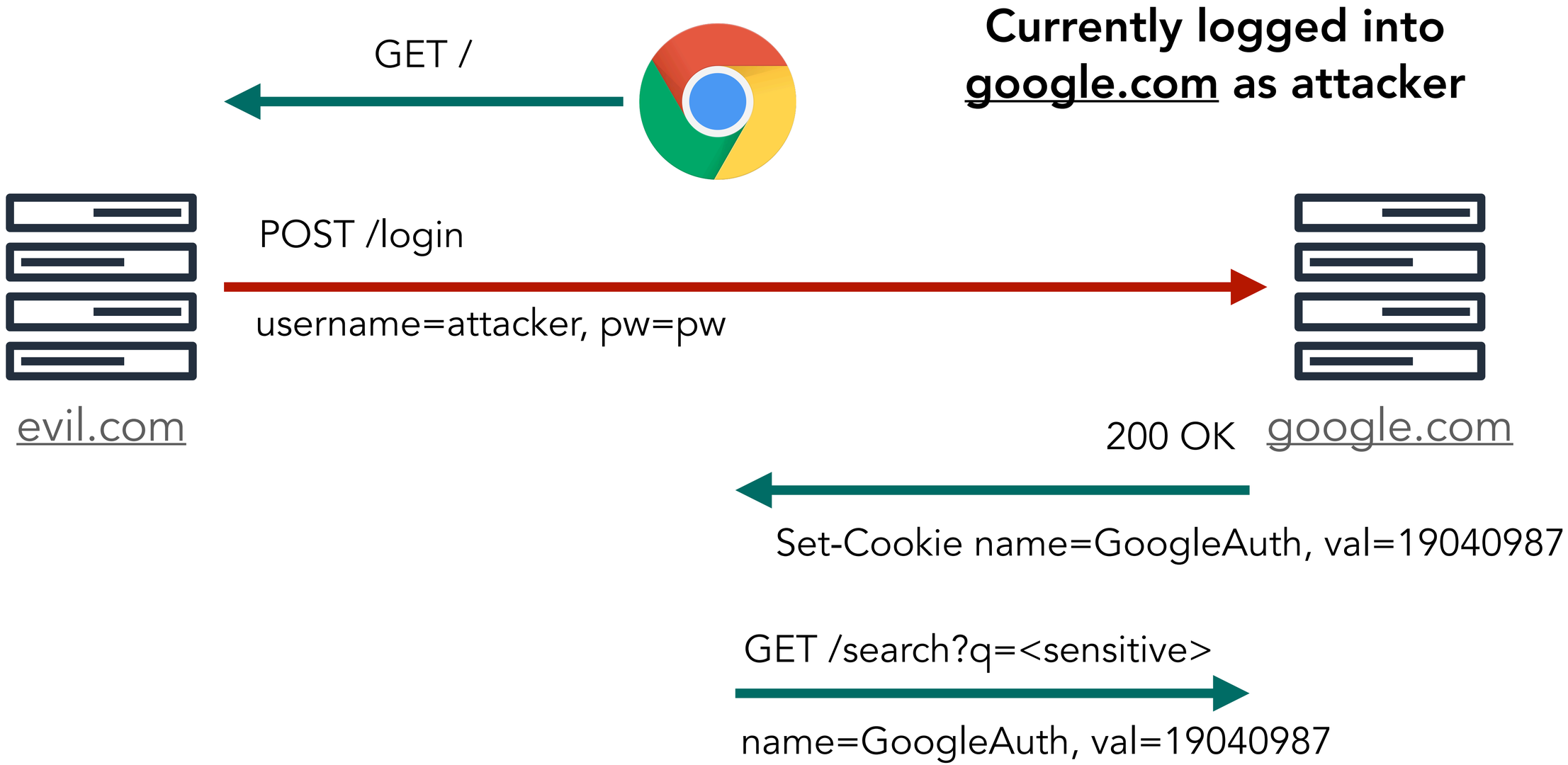


Why might an attacker want to do this?

Login CSRF (Special Case)



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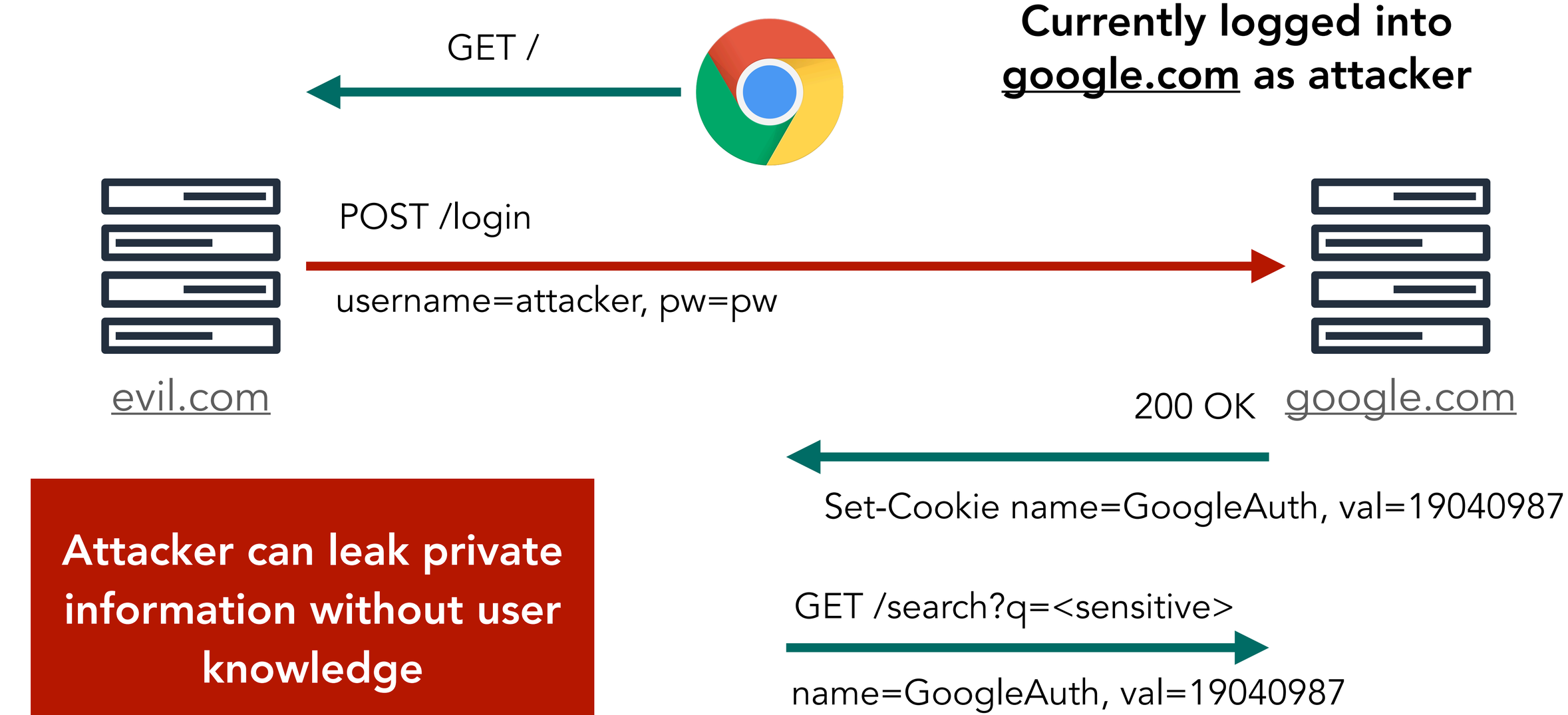

Attacker can leak private information without user knowledge

Defeating CSRF with the Referer header

- By default (usually), when the browser makes an HTTP request, it contains the *Referer*, aka the URL of the webpage that is making the request
  - Validation of the Referer header could easily defend against CSRF attacks
- People decry Referers because of privacy concerns. What part of the Referer contains these privacy issues?

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- Why does validation with the Referer header **not** work all the time?

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- People decry Referers because of privacy concerns. What part of the Referer contains these privacy issues?
- Why does validation with the Referer header **not** work all the time?
  - Fail-open: Allow requests where there is no Referer header
  - Fail-closed: Block requests where there is no Referer header

The Defense: Origin header

- What is the Origin header proposal in this paper?
  - Why does it help with the privacy concerns brought up before?
- What happens when the browser does not add an Origin header?
- Why do they think the Origin header will fix CSRF? Why do they think it'll be adopted?

The Defense: Origin header

Origin

Baseline Widely available

The HTTP `Origin` request header indicates the origin (scheme, hostname, and port) that *caused* the request. For example, if a user agent needs to request resources included in a page, or fetched by scripts that it executes, then the origin of the page may be included in the request.

Today's Defenses: SameSite Cookies

Set-Cookie

Baseline Widely available *

The HTTP `Set-Cookie` response header is used to send a cookie from the server to the user agent, so that the user agent can send it back to the server later. To send multiple cookies, multiple `Set-Cookie` headers should be sent in the same response.

`SameSite=<samesite-value>` Optional

Controls whether or not a cookie is sent with cross-site requests, providing some protection against cross-site request forgery attacks (CSRF).

SameSite Cookies

- Cookie option that prevents browser from sending a cookie along with cross-site requests
- **SameSite = Strict** Never send a cookie in a cross-site browsing context, even when following a regular link
- **SameSite = Lax** Session cookie is allowed when following a navigation link but blocks it in CSRF-prone request methods, like POST (default)
- **SameSite = None** Send cookies from any context
- Why might these strategies not always work?

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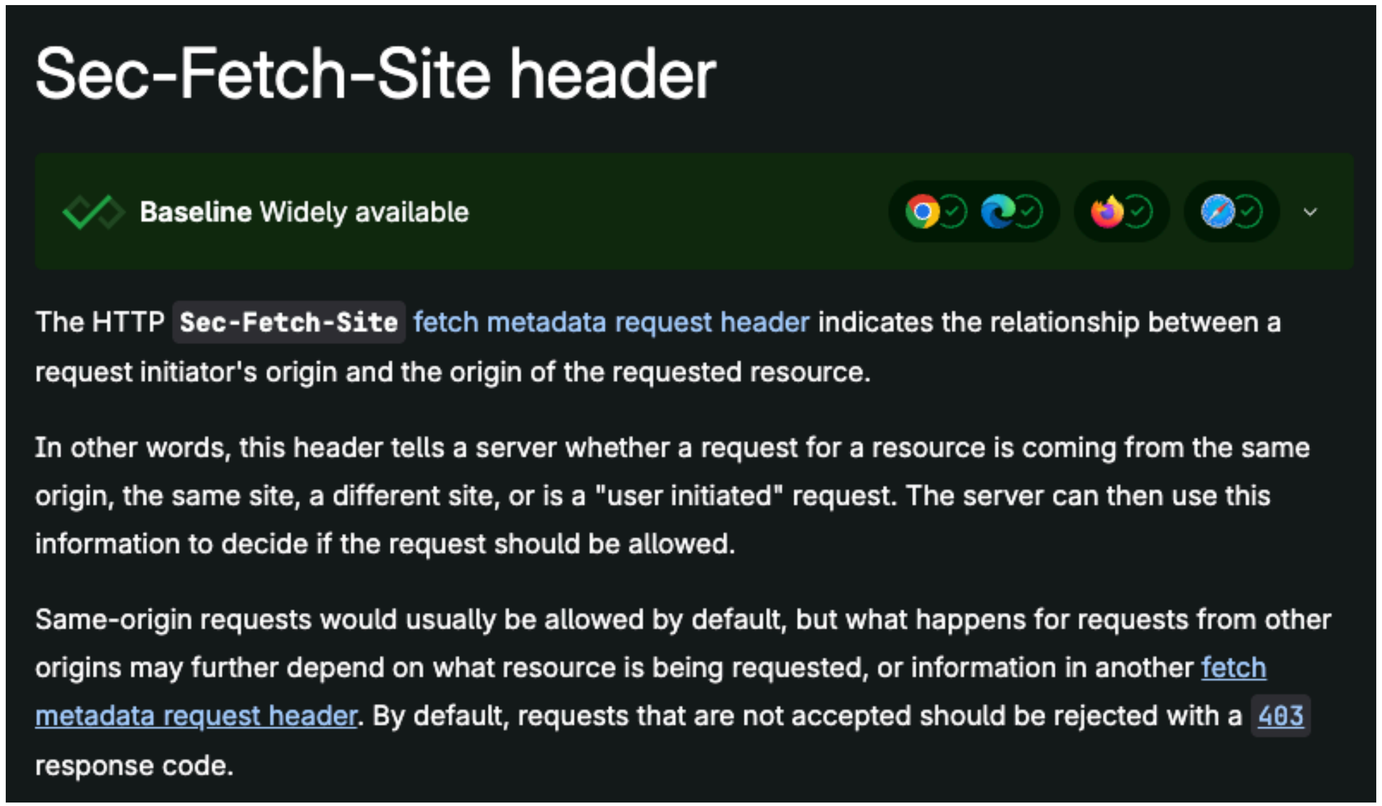
- **SameSite = None** Send cookies from any context
- Why might this not always work?
  - Server has to trust browser to implement correctly. And they might not.

CSRF Defenses Today

- Defense in depth — usually some combination of all three defenses
- New paradigm: Fetch metadata



https://developer.mozilla.org/en-US/docs/Web/HTTP/Reference/Headers/Sec-Fetch-Site

CSRF meta-questions

- How feasible is a CSRF attack? Will it work in practice?
- What software does the "Origin" proposal require you to *trust*?
  - Is this assumption always going to be true?
- How would you defend against a CSRF attack today? Is it that different from 2007, when this paper was written?
- What would you say is a **fundamental issue** that enables a CSRF attack?

CSRF meta-questions

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- What would you say is a **fundamental issue** that enables a CSRF attack?
  - Side-effects in the interface between the web server and web browser
  - *Feature*, not a bug

Paper meta-questions

- What did we think about the paper?
  - You can comment on the organization, the writing, the experiments, etc.
- What do you think about the solution presented in the paper?
- Why do you think this paper was so successful?