Cookies, Sessions, & Local Storage

Keeping state with distributes systems

Session and State

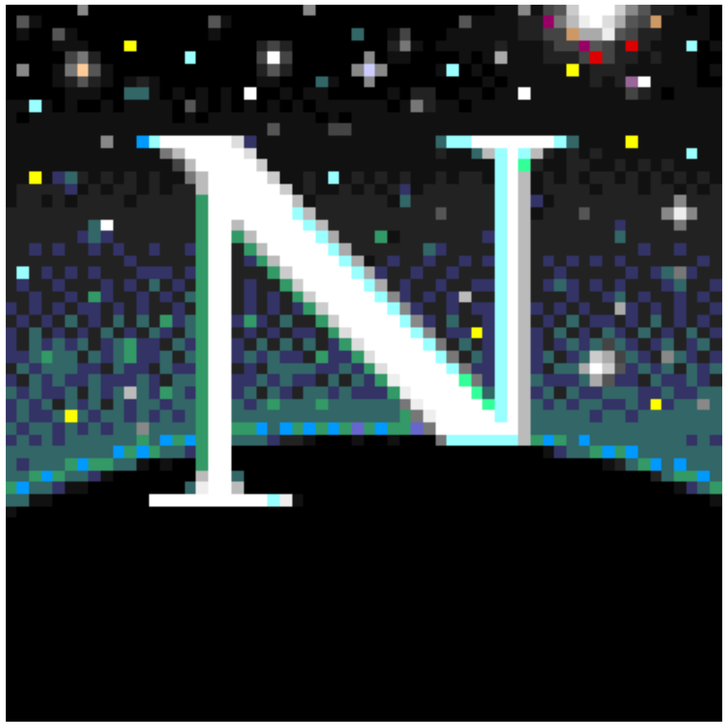
What's going on?

- Recall that the HTTP protocol is stateless.
- Each HTTP request is separate and isolated from any other ones.
- How does an application keep track of someone being logged in? User data?
- Options
  - HTTP Cookies
  - Shared Secret / Signed Tokens
  - Local Storage

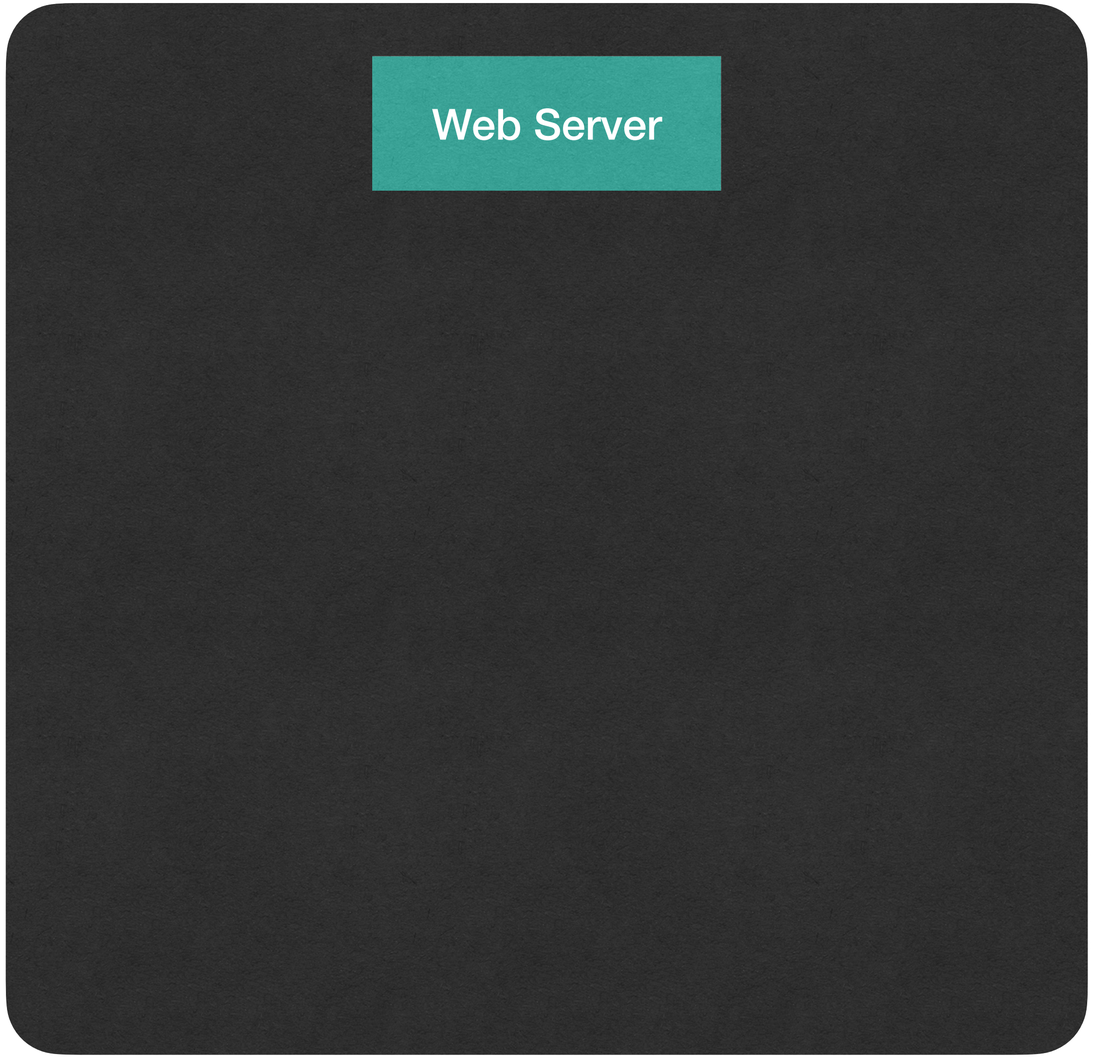
HTTP Cookies

History

- Cookies were introduced in 1994 with Netscape Navigator



Cookies Preserve State Between Requests



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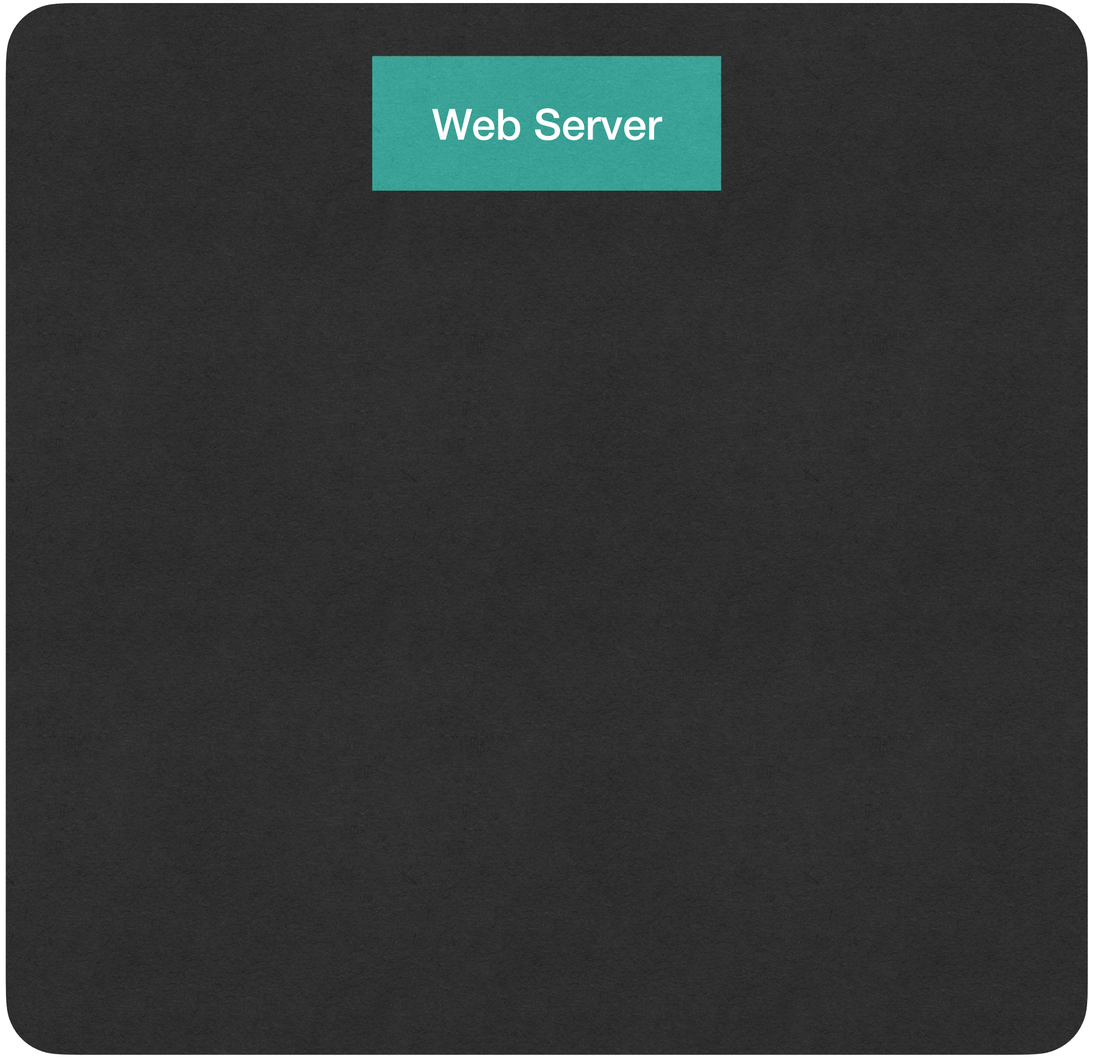

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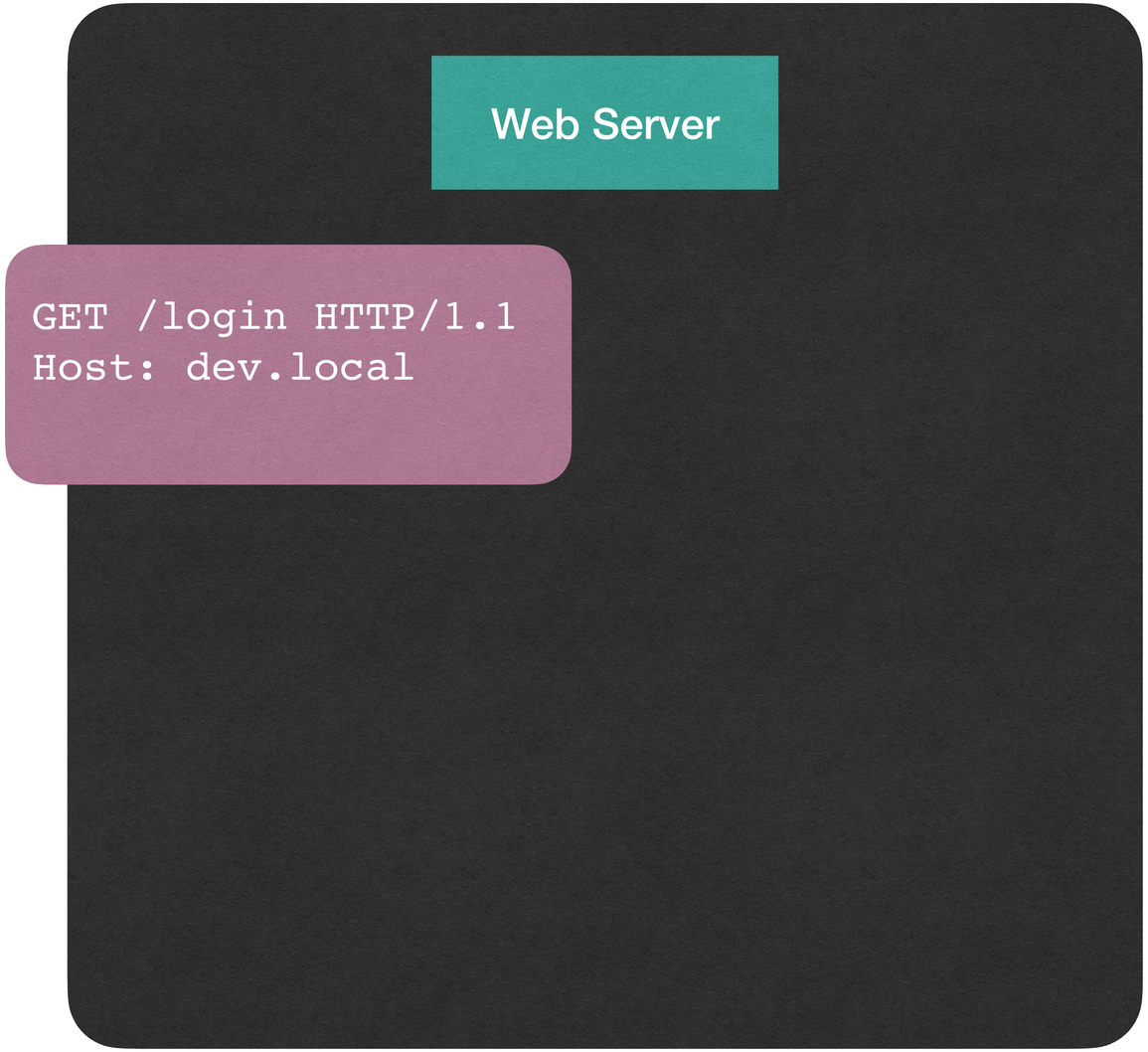

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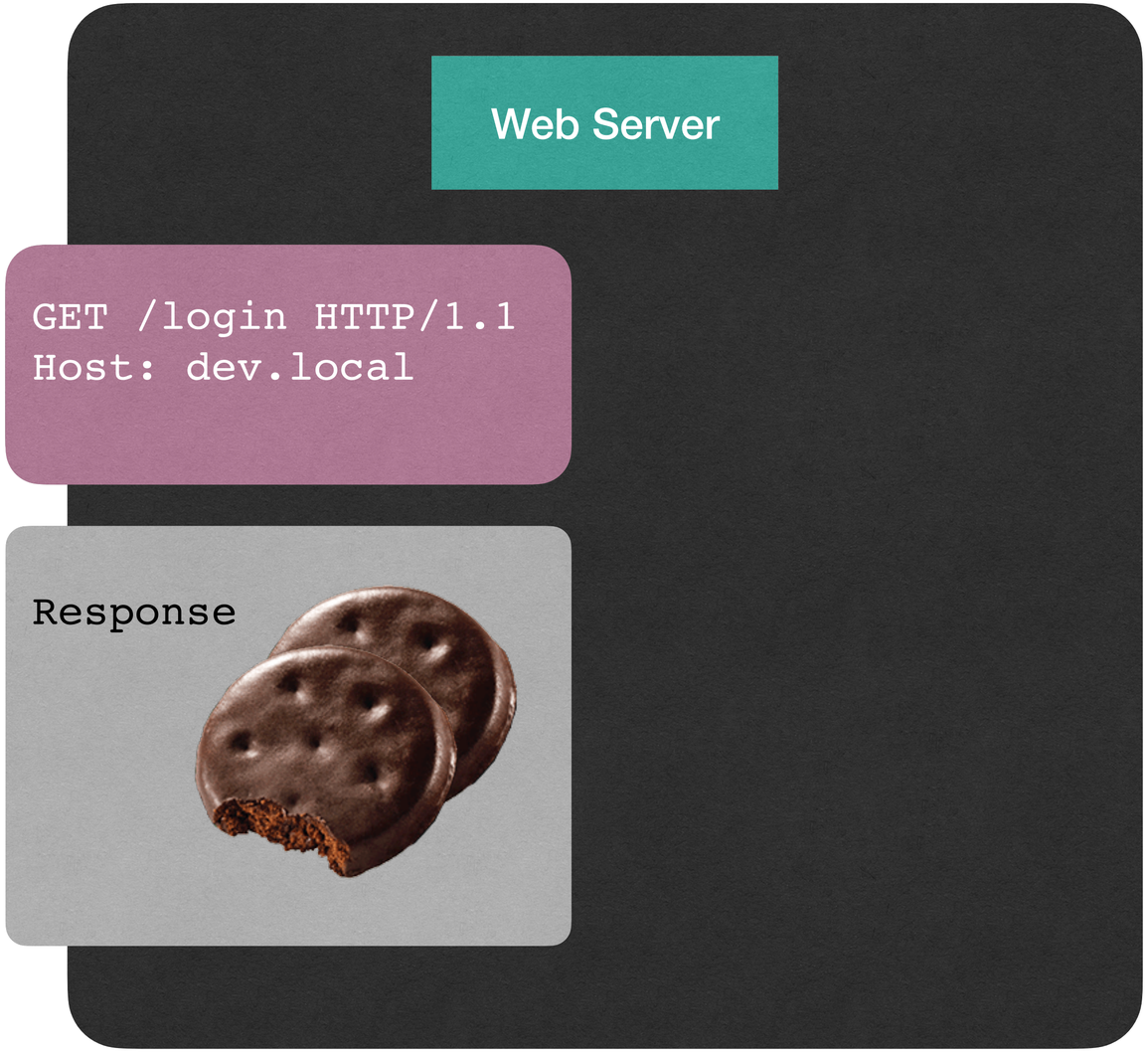

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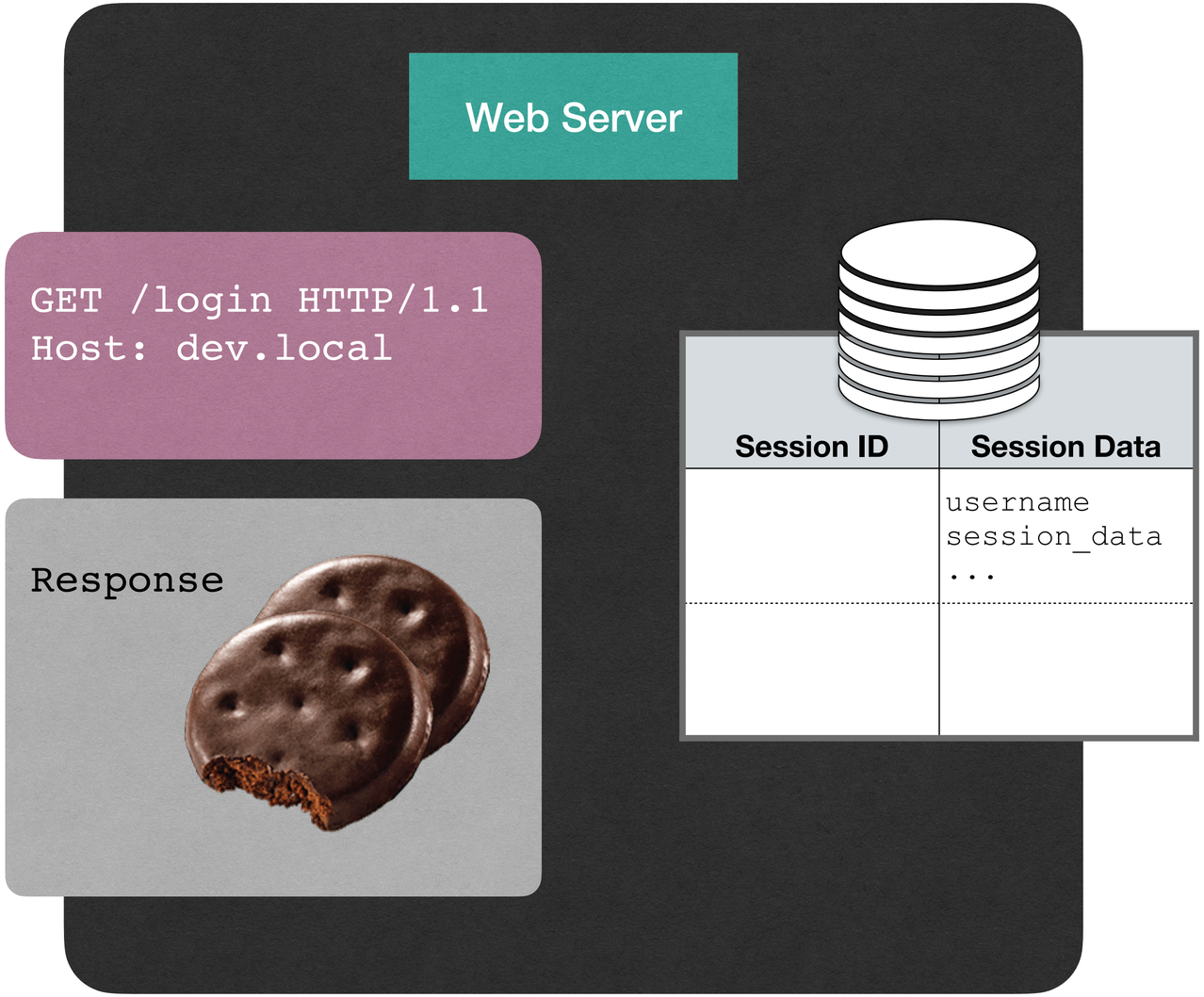

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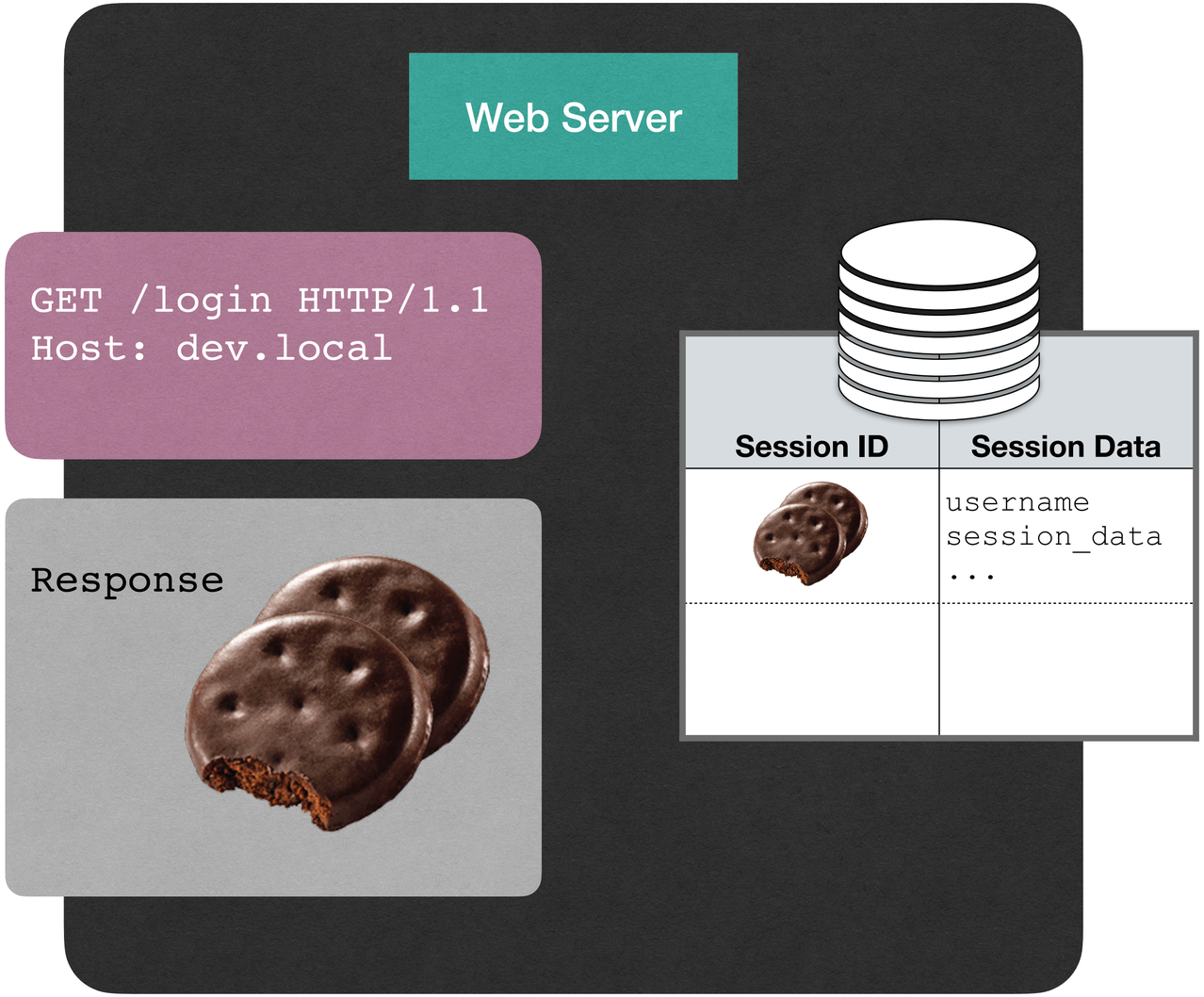

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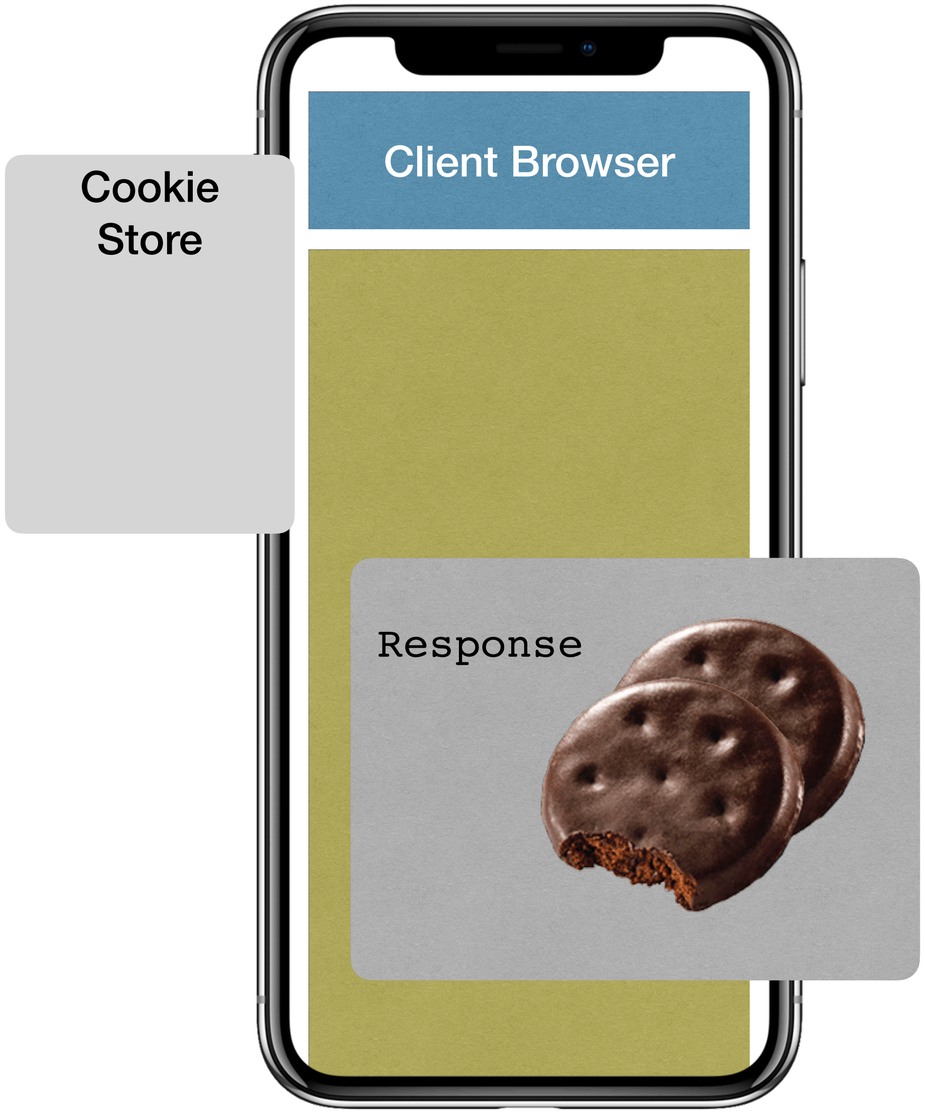

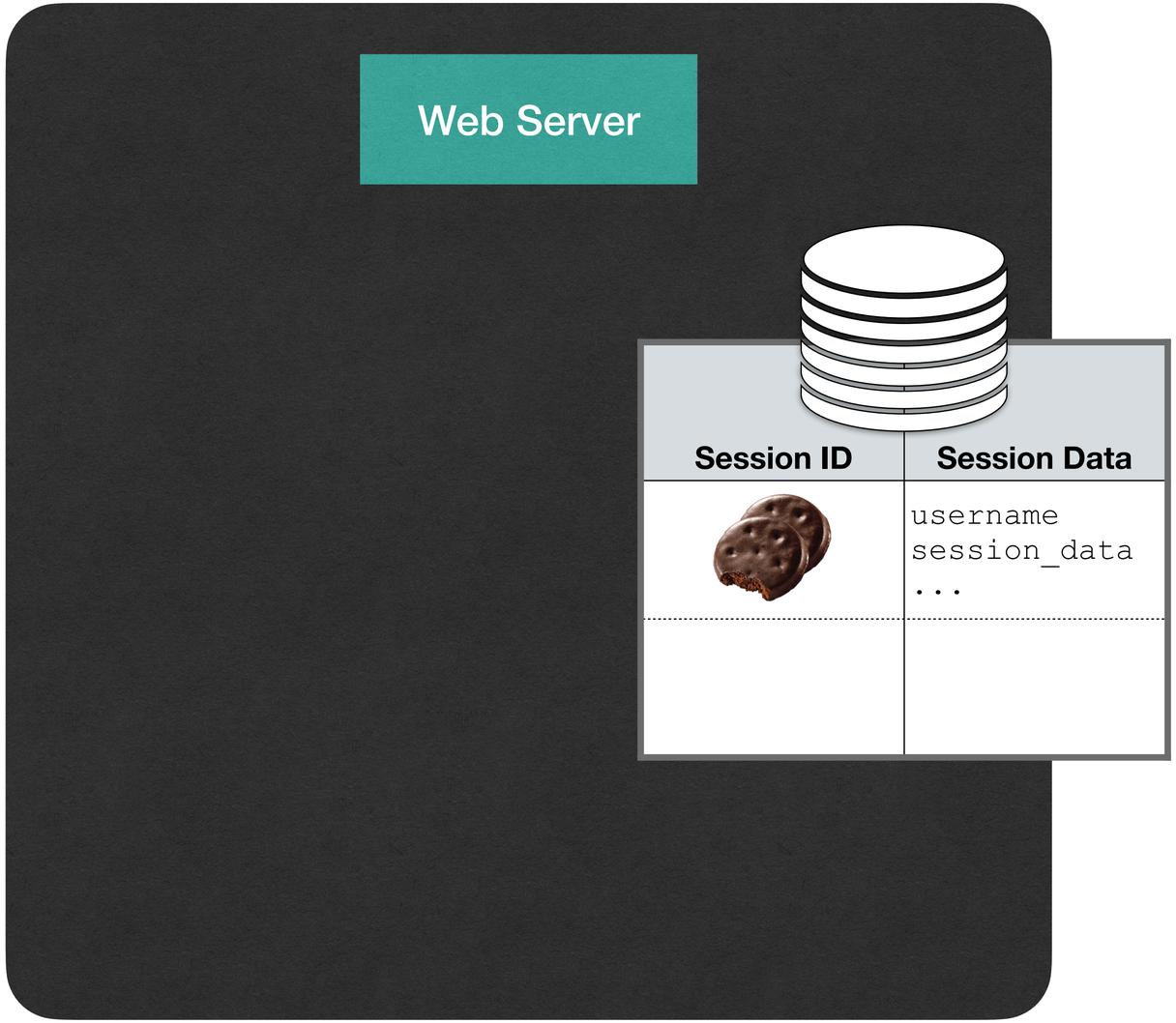

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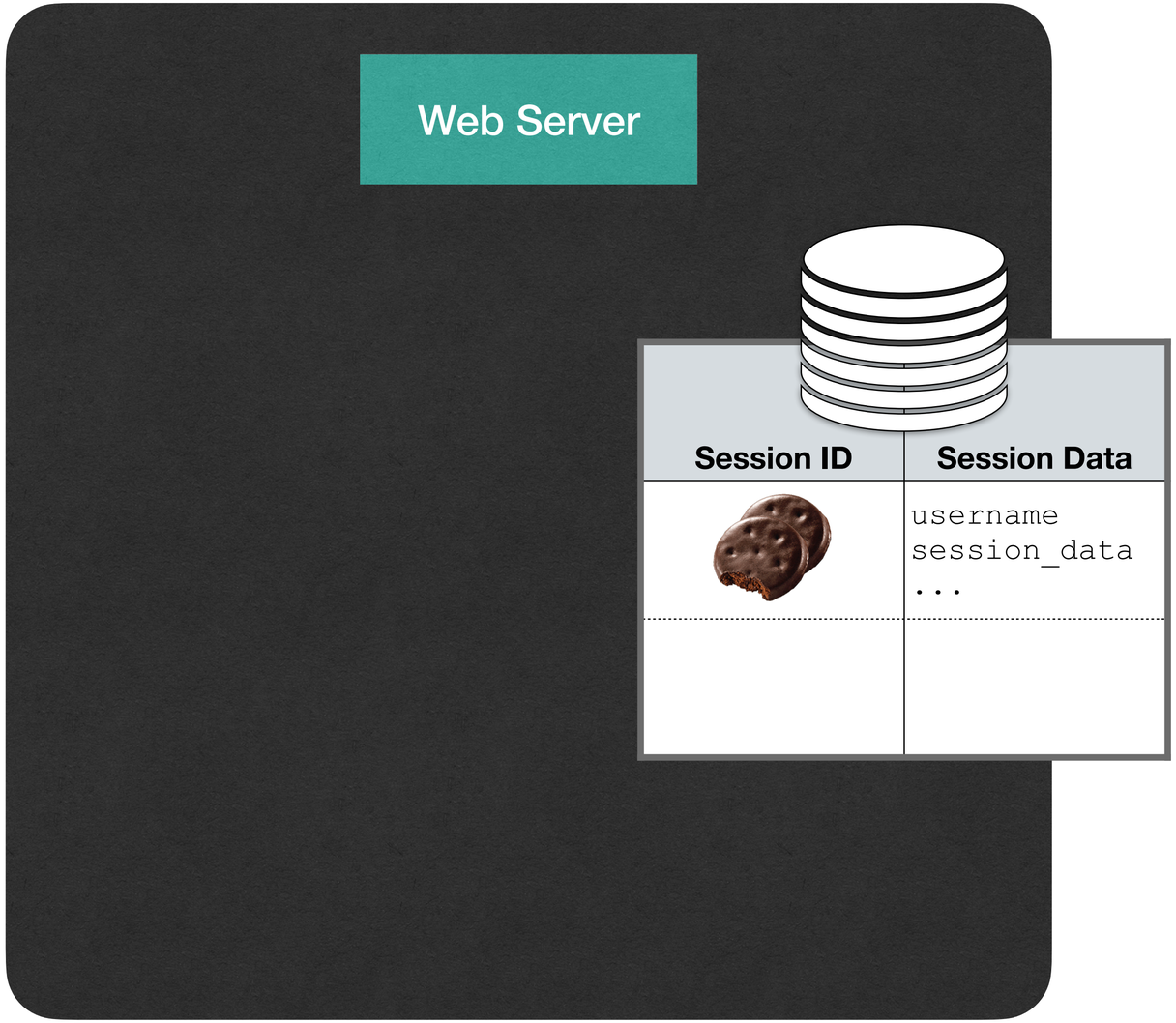

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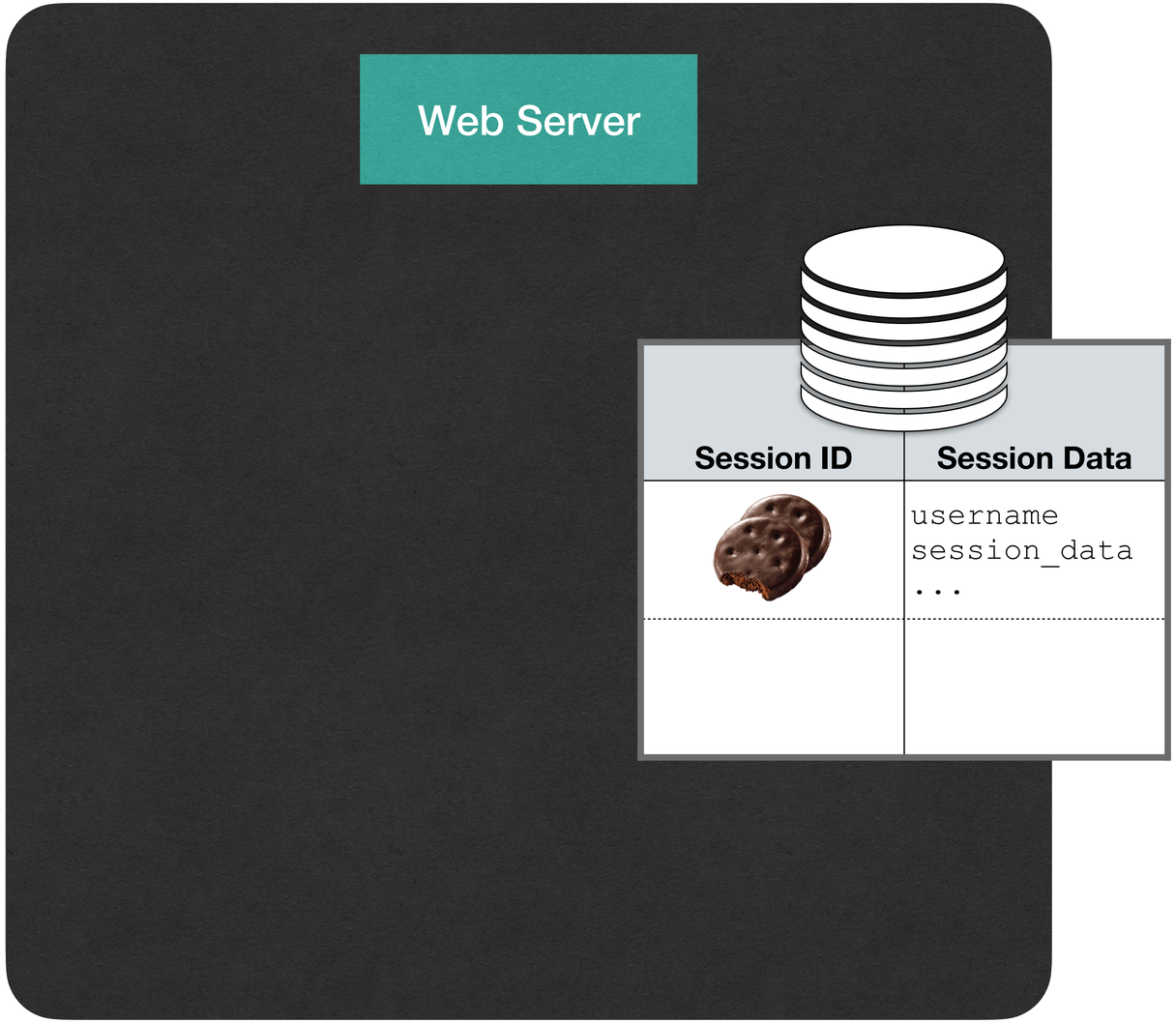

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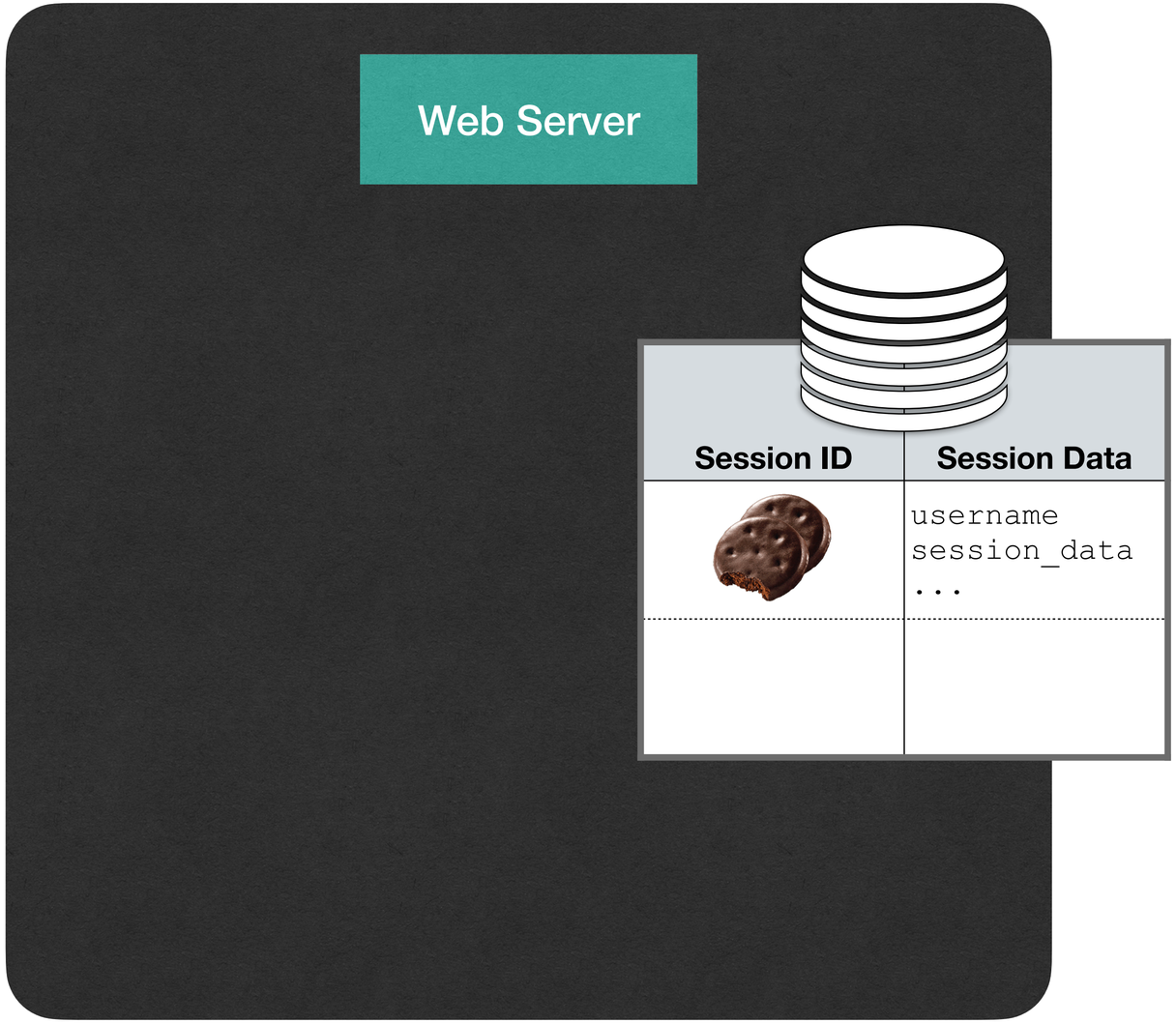

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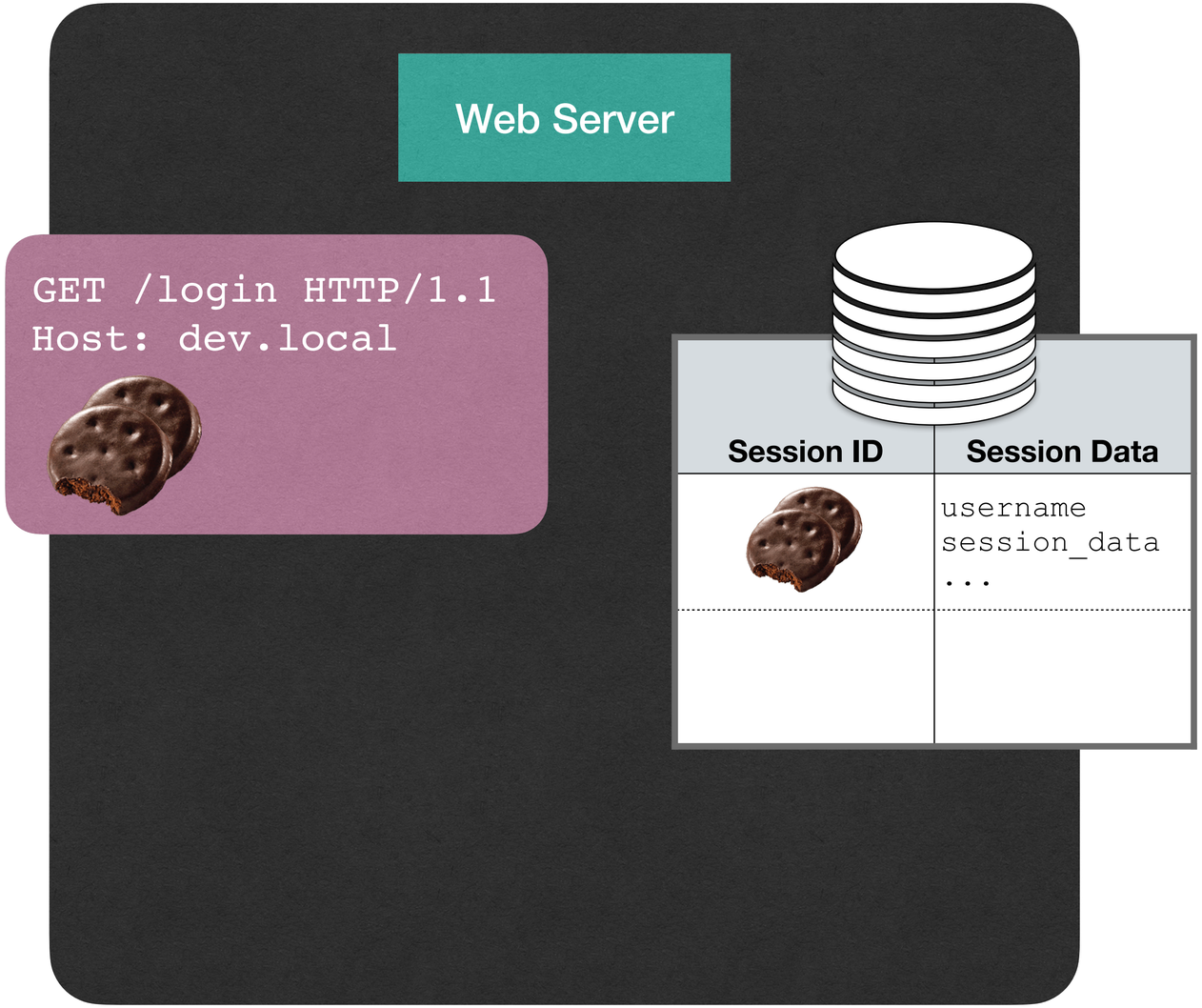

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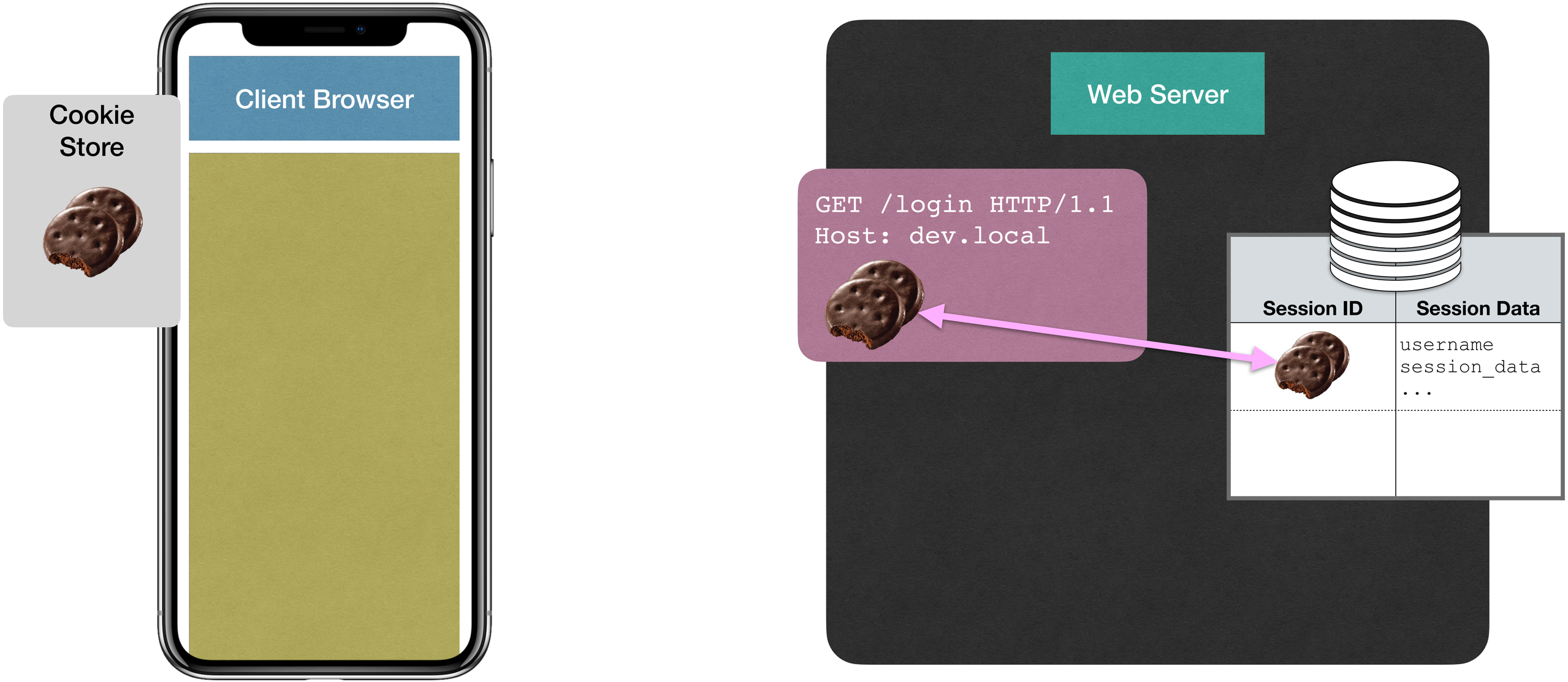

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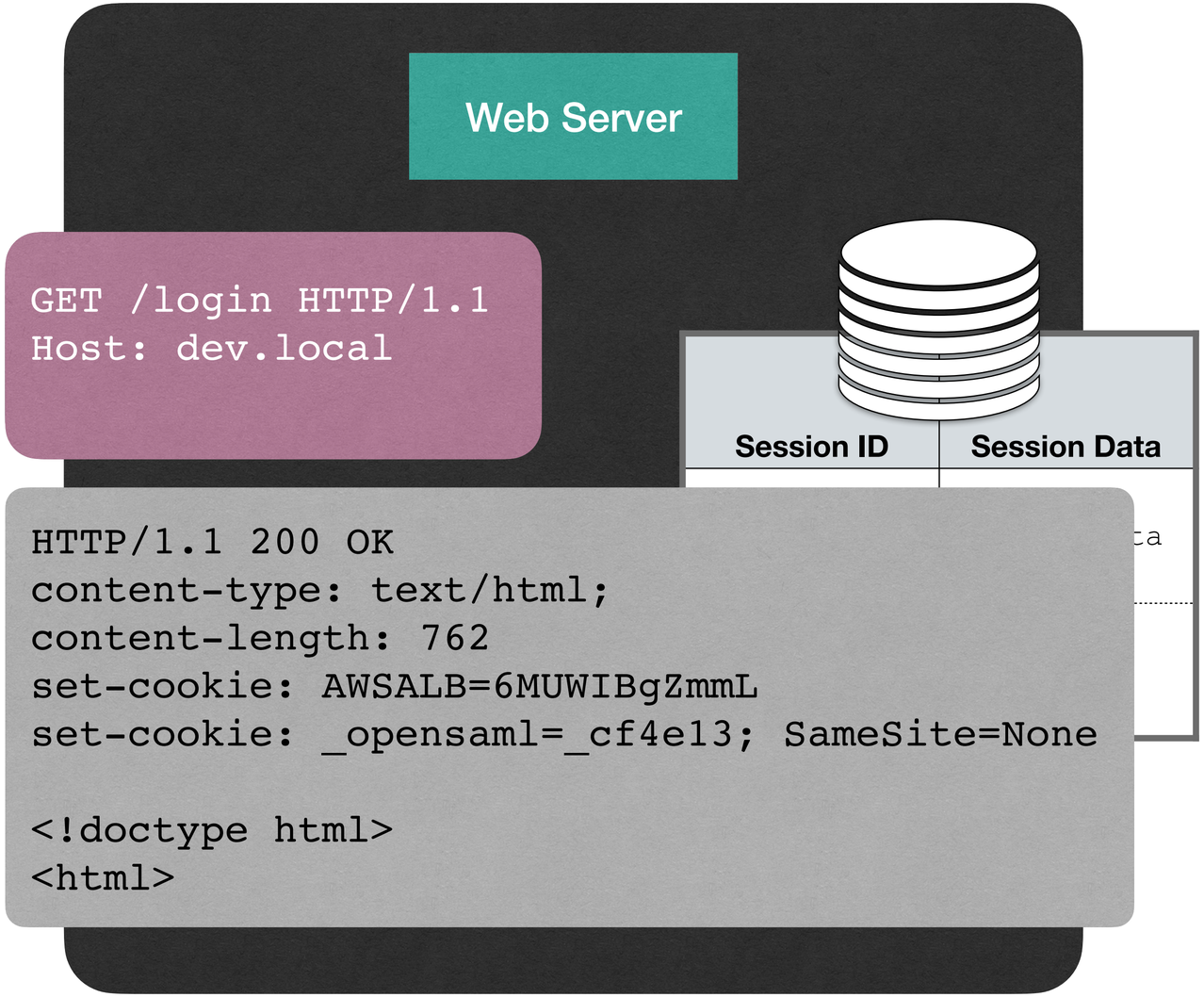

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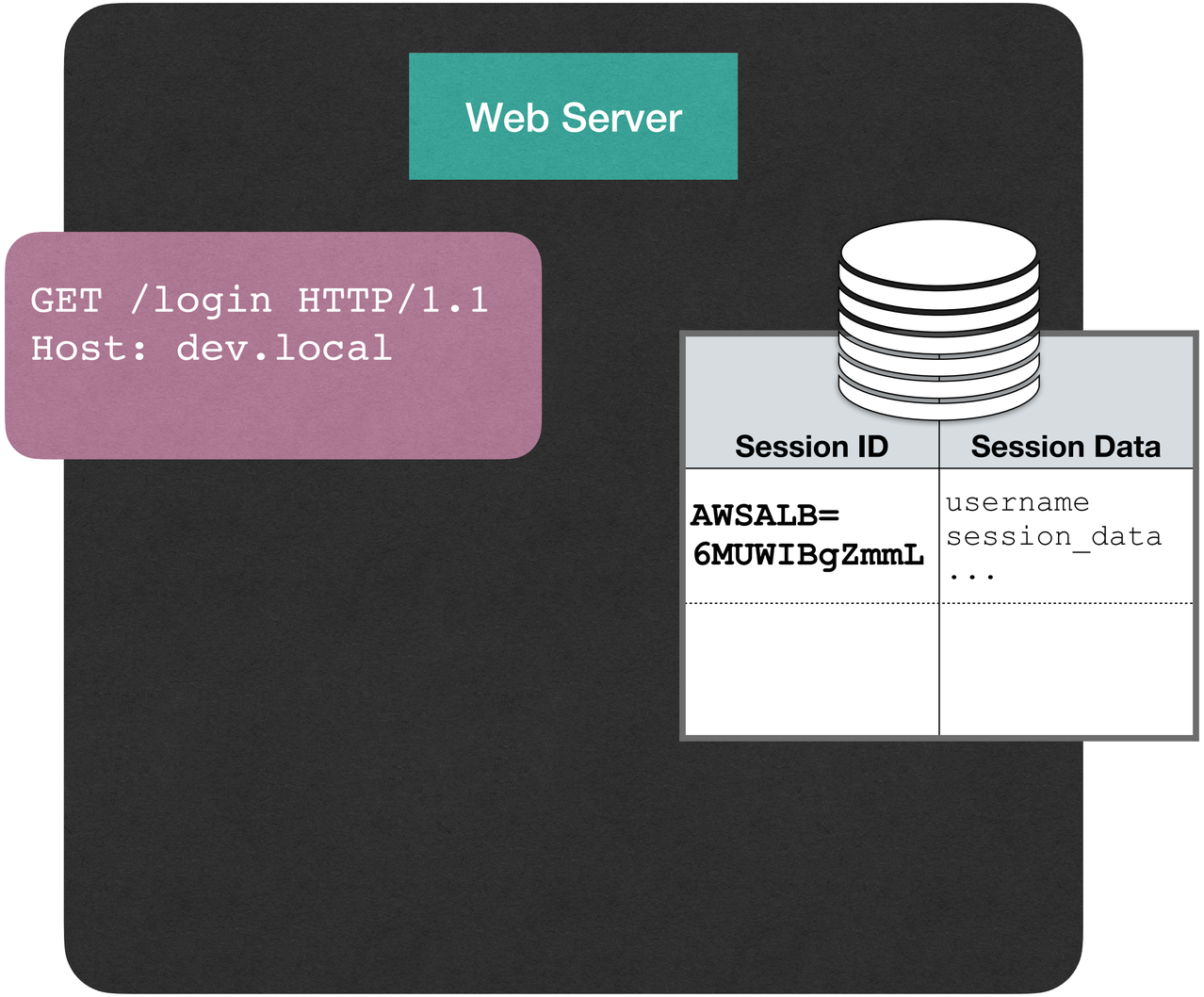


Cookies Preserve State Between Requests

```
HTTP/1.1 200 OK
content-type: text/html;
content-length: 762
set-cookie: AWSALB=6MUWIBgZmmL
set-cookie: _opensaml=_cf4e13; SameSite=None

<!doctype html>
<html>
```

HTTP Cookies

Odds and Ends

- A client cannot request a cookie
- Server decides whether to send a cookie back with a response or not
- Cookies are set with an HTTP response header of **`set-cookie`**
- Cookies can be set to expire at a given time, or when the browser is closed
- Browser enforce Cookie separation by domain
- Cookies can be sent and restricted to **`https`** requests
- Can be set to exclude from JavaScript access

HTTP Cookies

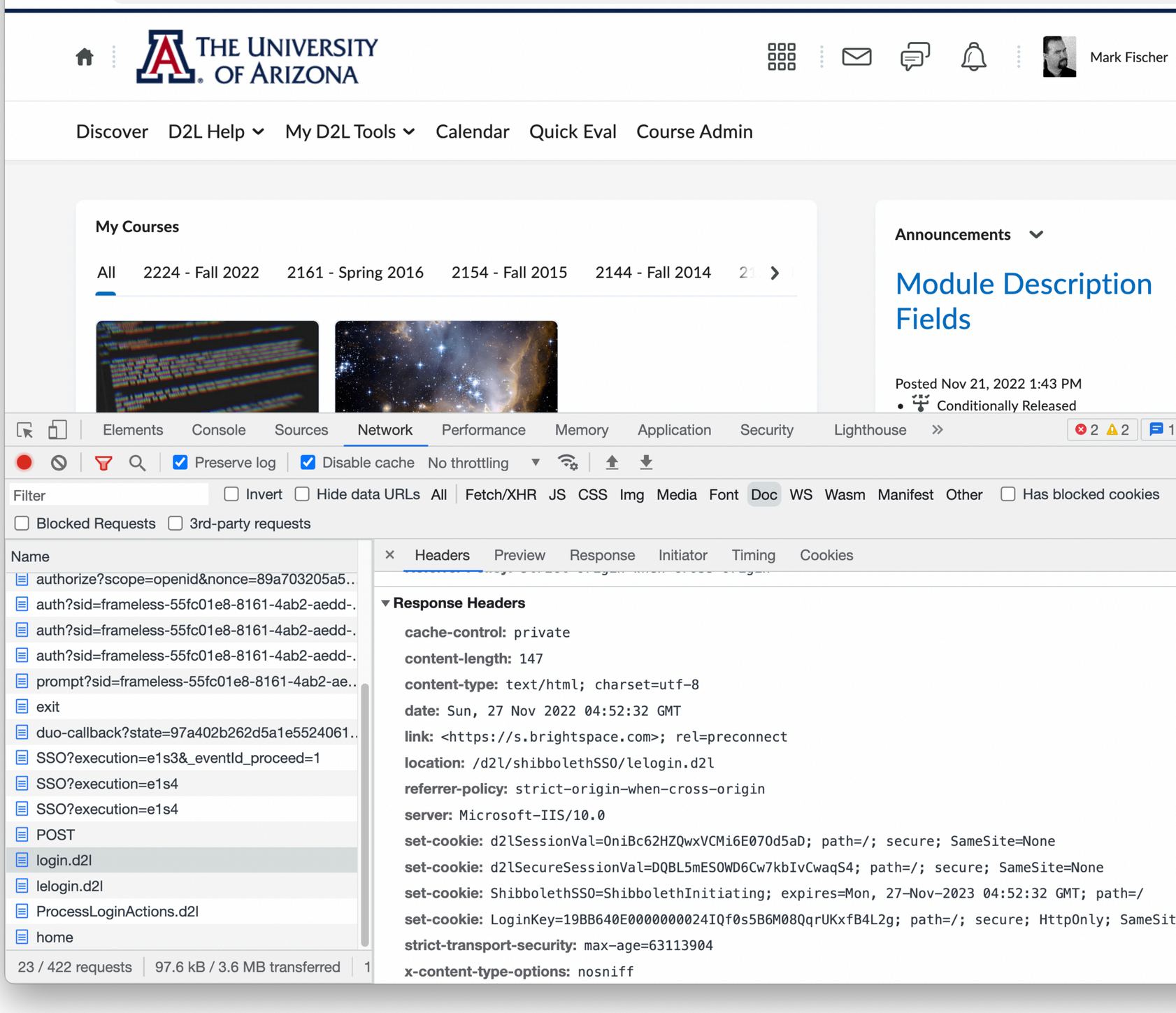
https://developer.mozilla.org/en-US/docs/Web/HTTP/Headers/Set-Cookie

```
Set-Cookie: <cookie-name>=<cookie-value>
Set-Cookie: <cookie-name>=<cookie-value>; Expires=<date>
Set-Cookie: <cookie-name>=<cookie-value>; Max-Age=<number>
Set-Cookie: <cookie-name>=<cookie-value>; Domain=<domain-value>
Set-Cookie: <cookie-name>=<cookie-value>; Path=<path-value>
Set-Cookie: <cookie-name>=<cookie-value>; Secure
Set-Cookie: <cookie-name>=<cookie-value>; HttpOnly

Set-Cookie: <cookie-name>=<cookie-value>; SameSite=Strict
Set-Cookie: <cookie-name>=<cookie-value>; SameSite=Lax
Set-Cookie: <cookie-name>=<cookie-value>; SameSite=None; Secure

// Multiple attributes are also possible, for example:
Set-Cookie: <cookie-name>=<cookie-value>; Domain=<domain-value>; Secure; HttpOnly
```

HTTP Cookies

D2L Login Example

- Used to track login to an application
- Used to track users across many visits
- Used to track users across many applications
- Used by 3rd party for data tracking



D2L Login Example

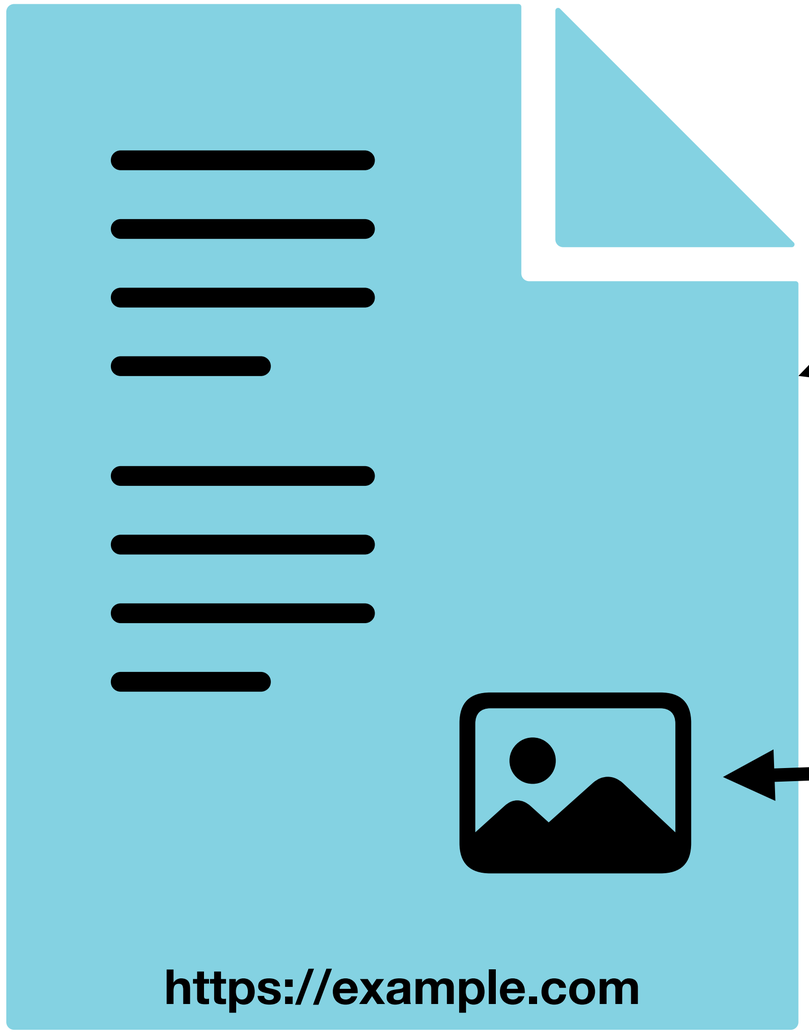
HTTP Cookies

Tracking Users Across Sessions

- Cookies can be set for the requested domain by any HTTP response.
- Cookies set by the domain of the parent Document are known as **first-party** cookies
- Cookies set by domains other than the parent Document are known as **third-party** cookies
  - The user/browser is the second-party
- Cookies are ***sent back to the originating domain*** on future requests to that domain

HTTP Cookies

Tracking Users Across Sessions



https://example.com

```
HTTP/1.1 200 OK
content-type: text/html;
content-length: 762
set-cookie: EXAMPLE_ID=6MUWIBgZmmL

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```
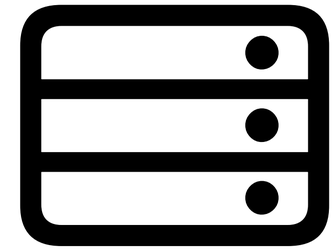
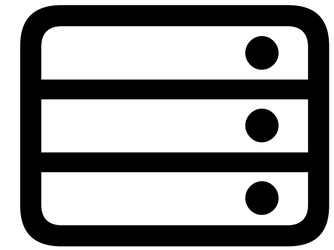

First-Party Cookie



example.com

```
HTTP/1.1 200 OK
content-type: image/jpeg;
content-length: 341762
set-cookie: TRACKER_ID=05737166221

<!doctype html>
<html>
...
```

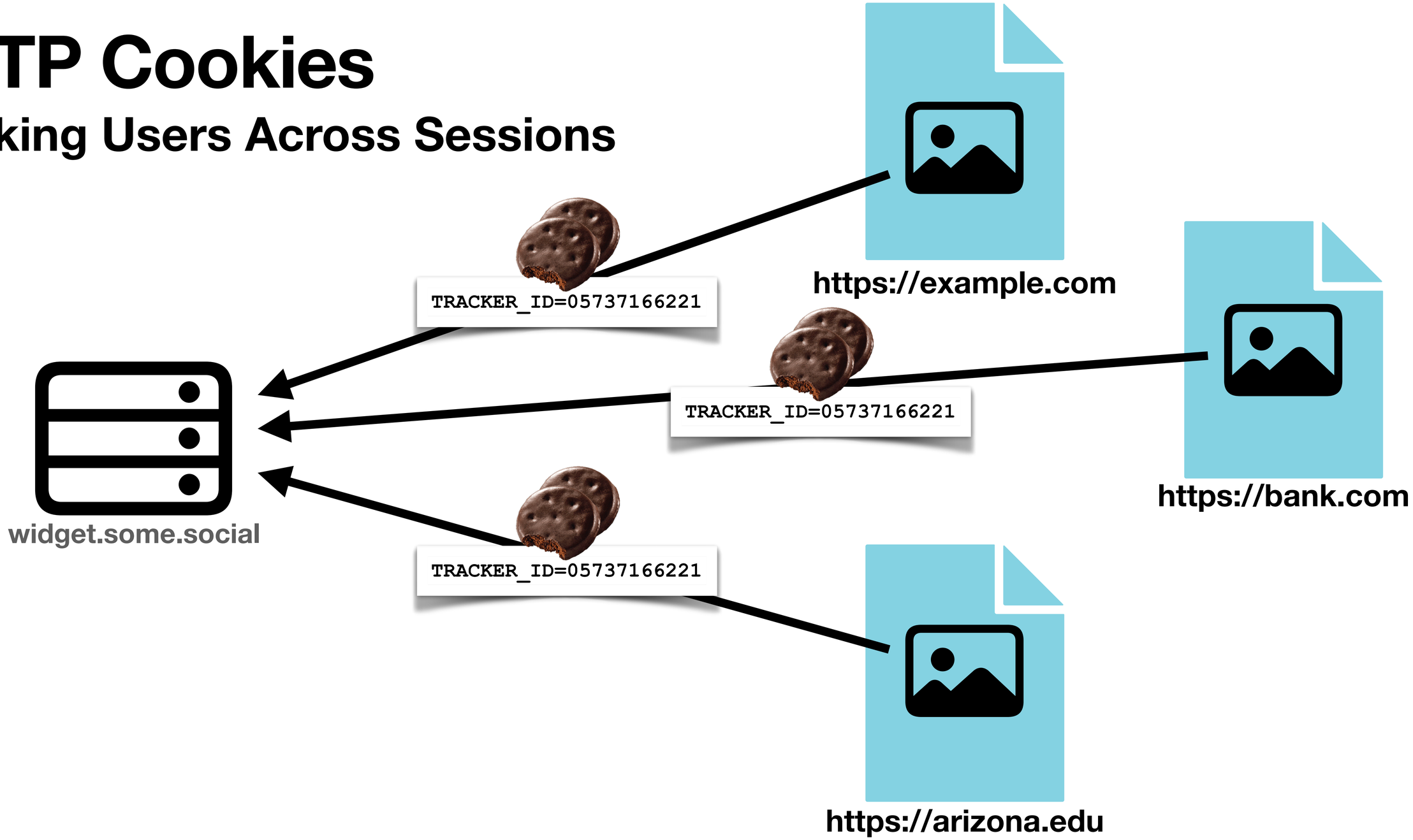
Third-Party Cookie



widget.some.social

HTTP Cookies

Tracking Users Across Sessions



HTTP Cookies

Tracking Users Across Sessions

- If a service can get it’s resources in to many web pages, say by offering free image hosting, that service can gain a great deal of information about what sites an individual user visits
  - User A visited example.com
  - User A then visited bank.com
- This correlated user data is very valuable

HTTP Cookies

Security

- Cookies are designed to be a trusted way for a host to know that the incoming request should be connected in some way to a previous request.
  - This is how state is shared across discrete independent requests
- If a bad actor can somehow gain access to a cookie value, they can impersonate the real user

HTTP Cookies

Security


```
GET /transfer_money HTTP/1.1
Host: example.com
cookie: SESSION_ID=12345
```

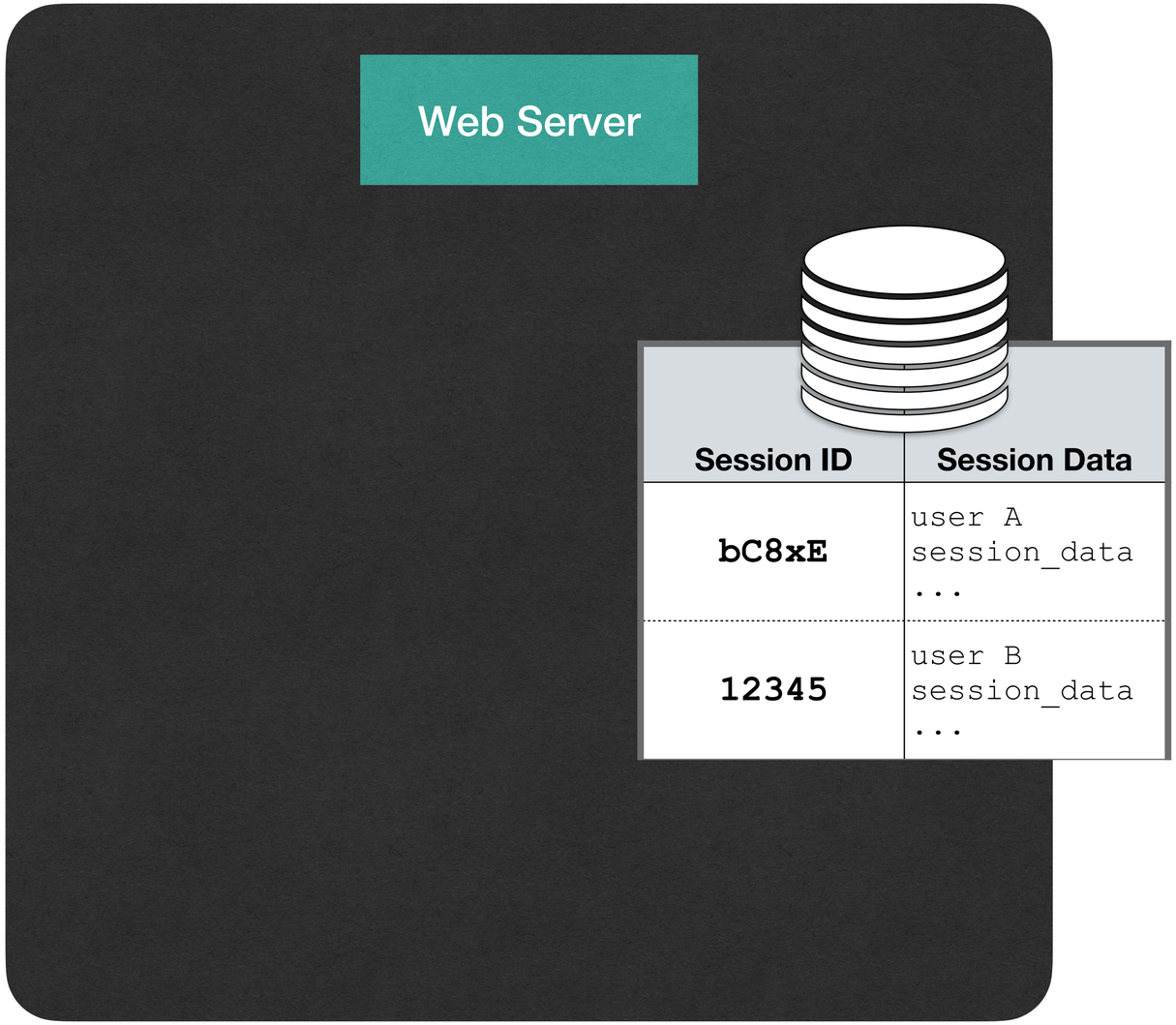
Web Server

Session ID	Session Data
bC8xE	user A session_data ...
12345	user B session_data ...

"OK, I know who you are. Welcome back User B."

HTTP Cookies

Security



HTTP Cookies

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Web Server

Session ID	Session Data
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HTTP Cookies

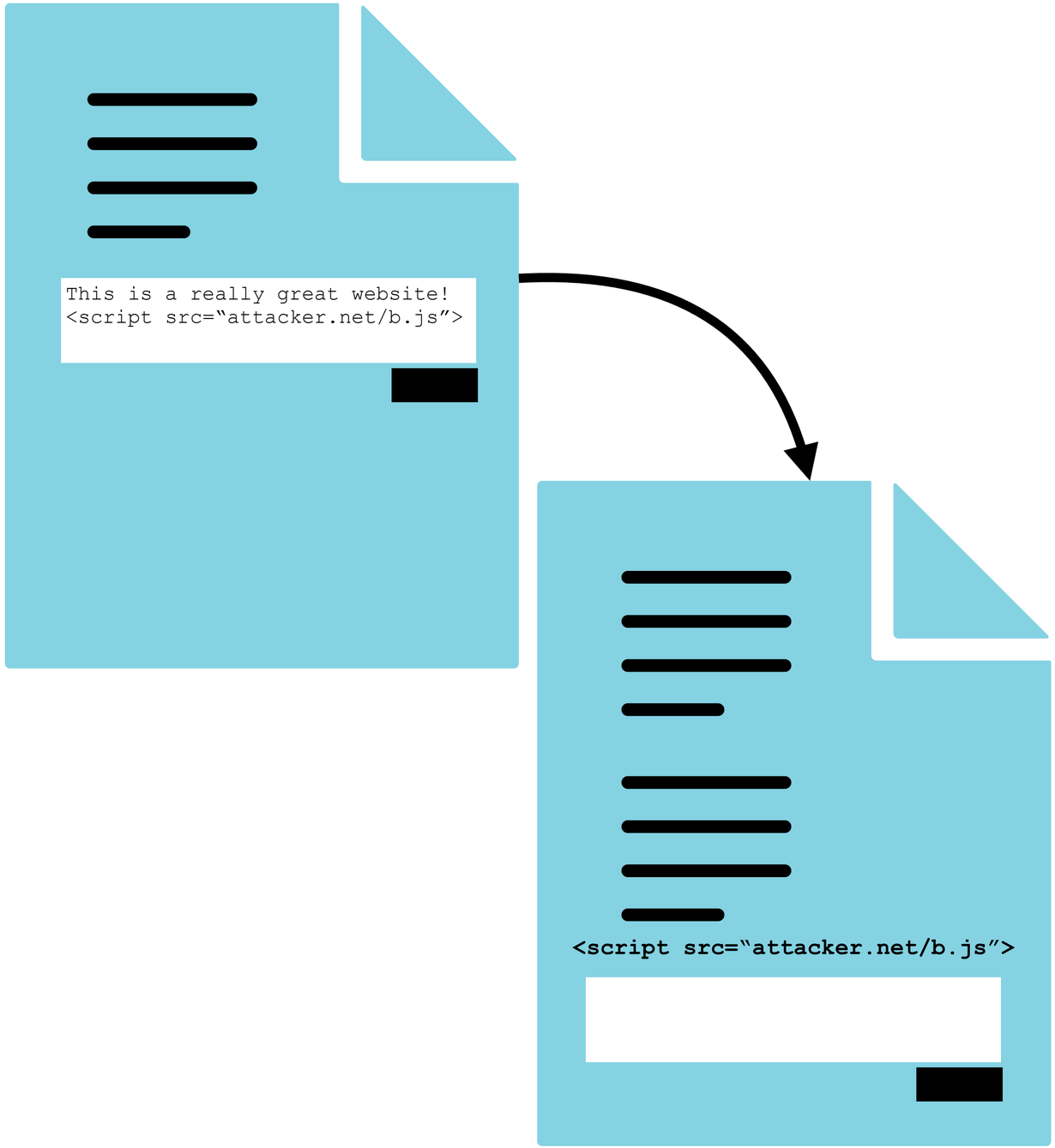
Security

- How does an attacker steal cookies?
- Physical access to devices
- Compromised software on user's devices
- Exploiting vulnerabilities in a Website to include attacker's JavaScript code along with authorized code

HTTP Cookies

Security

- Consider a poorly secured comment form
- If comments can be entered and displayed to others, and if the website does not properly sanitize input, an attacker can trick the website in to embedding the attacker's JavaScript code
- Attacker code can now read cookies from the main Document and send them to the Attacker



HTTP Cookies

XSS - Cross Site Scripting Attack

- How do you protect against?
- Set a cookie to only be accessible with HTTP requests

```
Set-Cookie: SESSION_ID=12345; HttpOnly
```

- Content Security Policies
  - https://developer.mozilla.org/en-US/docs/Web/HTTP/CSP
- https://cheatsheetseries.owasp.org/cheatsheets/Cross_Site_Scripting_Prevention_Cheat_Sheet.html