Hypertext Transfer Protocol (HTTP): Advanced Features

Péter Jeszenszky
Faculty of Informatics, University of Debrecen
jeszenszky.peter@inf.unideb.hu

Last modified: October 25, 2025

Contents

- Origin
- Cookies
- Web tracking
- Connection management

Safe Methods

- An HTTP method is **safe** if its application to a target resource is not expected to result in any state change on the origin server.
  - Thus, it has a read-only semantics.
  - Safe methods serve information retrieval purposes only and should not cause side effects on the server.
- Safe methods: GET, HEAD, OPTIONS, TRACE
- Unsafe methods: CONNECT, DELETE, POST, PUT
- In practice, a safe method (e.g., GET) may have a side effect on the server.
  - However, such side effects are harmless, such as logging, for which clients cannot be held accountable.

Origin (1)

- Origins are fundamental to security on the web.
- Two actors on the web that share an origin are assumed to trust each other.
- Actors with differing origins are considered potentially hostile versus each other, and should be isolated from each other.

Origin (2)

- The *HTML Standard* defines the concept of origin:
  - *HTML Living Standard – Loading web pages – Supporting concepts – Origins*
    https://html.spec.whatwg.org/multipage/browsers.html#origin
- See also:
  - *MDN Web Docs – Glossary – Origin*
    https://developer.mozilla.org/en-US/docs/Glossary/Origin

Origin (3)

- The origin of a resource is defined by the scheme, hostname, and port component of the URI used to access it.

Origin (4)

- For example, these are same origin:
  - http://example.com/index.html
  - http://example.com/docs/
  - http://example.com:80/
- For example, these are not same origin:
  - http://example.com/
  - http://www.example.com/
  - http://example.com:8080/
  - https://example.com/

Origin (5)

- Same origin policy:
  - A critical security mechanism that restricts how a document or script loaded by one origin can interact with a resource from another origin.
  - In general, it forbids code from one origin to access code from a different origin.
  - See:
    - *MDN Web Docs – Security on the web –Same-origin policy* https://developer.mozilla.org/en-US/docs/Web/Security/Same-origin_policy

Origin (6)

- Cross-Origin Resource Sharing (CORS):
  - A HTTP header-based mechanism that allows to control cross-origin access.
  - CORS is defined as part of the *Fetch Standard* of the WHATWG: https://fetch.spec.whatwg.org/
  - It allows a server to indicate any origins (domain, scheme, or port) other than its own from which a browser should permit loading resources.
  - It is based on the use of the `Origin` and `Access-Control-Allow-Origin` header fields.
  - See also:
    - *MDN Web Docs – HTTP guides – Cross-Origin Resource Sharing (CORS)* https://developer.mozilla.org/en-US/docs/Web/HTTP/CORS

Site (1)

- The site of a resource is a tuple consisting of the schema and the registrable domain of the host component of the URI.
- Note that the site and the origin of a resource are different concepts!
  - Compared to the origin, the site does not include the port.

Site (2)

- The *HTML Standard* defines the concept of the site of a resource:
  - *HTML Living Standard – Loading web pages – Supporting concepts – Origins – Sites*
    https://html.spec.whatwg.org/multipage/browsers.html#sites
- See also:
  - *MDN Web Docs – Glossary – Site*
    https://developer.mozilla.org/en-US/docs/Glossary/Site

Site (3)

- The registrable domain of a hostname is an entry in the Public Suffix List (e.g., `com`, `co.uk`, `hu`, `github.io`) and the label immediately preceding it.
  - See: *Public Suffix List* https://publicsuffix.org/list/
- For example, `ucl.ac.uk` is the registrable domain of https://www.ucl.ac.uk/, since `ac.uk` is a public suffix.

Site (4)

- For example, the following URIs are of the same site, although they have different origins:
  - https://example.com/
  - https://example.com:8080/
  - https://www.example.com/
- For example, the following URIs belong to different sites, they also have different origins:
  - https://example.com/
  - http://example.com/
  - https://eg.com/
  - https://example.org/
  - https://www.example.co.uk/

Cookies (1)

- ***Cookie***:
  - A name/value pair and associated metadata (attributes) sent by an origin server to a user agent using the `Set-Cookie` header field in a response.
    - An origin server can specify a scope for the cookie using the attributes.
  - In subsequent requests, the user agent returns the name/value pair to the origin server in the `Cookie` header field.

Cookies (2)

- Current specification:
  - Adam Barth. *HTTP State Management Mechanism.* RFC 6265, April 2011. https://www.rfc-editor.org/rfc/rfc6265
    - Defines the `Cookie` and `Set-Cookie` header fields.
- The specification intended to obsolete RFC 6264 is currently under development and has been published as an Internet-Draft.
  - See: https://datatracker.ietf.org/doc/draft-ietf-httpbis-rfc6265bis/
  - For example, it introduces the `SameSite` cookie attribute.

Cookies (3)

- Uses:
  - Session management
    - Shopping cart management
    - Authentication and authorization
  - Personalization
  - Web tracking (see the `Referer` header field)

Cookies (4)

- Information about cookies (cookie databases):
  - *CookieSearch* https://cookiesearch.org/
    - Example: YSC https://cookiesearch.org/cookies/?cookie-id=YSC
  - *Open Cookie Database* https://github.com/jkwakman/Open-Cookie-Database
    - Search form: https://jkwakman.github.io/Open-Cookie-Database/open-cookie-database.html

Cookies (5)

- Példa:
  - `curl --http1.1 --head https://www.w3.org/`

```
HTTP/1.1 200 OK
Date: Sun, 05 Oct 2025 13:39:51 GMT
Content-Type: text/html; charset=UTF-8
...
Set-Cookie: __cf_bm=VAdE4lj2Jfo8jwNG9tF...f29a9.L7FoS1dQ;
path=/; expires=Sun, 05-Oct-25 14:09:51 GMT; domain=.w3.org;
HttpOnly; Secure; SameSite=None
...
```

Cookies (6)

- An origin server can send multiple cookies in a response:
  - `curl --http1.1 --head https://www.youtube.com/`

```
HTTP/1.1 200 OK
Content-Type: text/html; charset=utf-8
...
Set-Cookie: YSC=XsDxGlmbJ3k; Domain=.youtube.com; Path=/; Secure;
HttpOnly; SameSite=none
Set-Cookie: __Secure-YEC=CgtQV2ZFckdHWDN5YyiBp...IBAREiEgEQ%3D%3D;
Domain=.youtube.com; Expires=Wed, 04-Nov-2026 13:41:35 GMT; Path=/;
Secure; HttpOnly; SameSite=lax
Set-Cookie: VISITOR_PRIVACY_METADATA=CgJIVRIcE...IBAREiEgEQ%3D%3D;
Domain=.youtube.com; Expires=Wed, 04-Nov-2026 13:41:36 GMT; Path=/;
Secure; HttpOnly; SameSite=none
Set-Cookie: VISITOR_INFO1_LIVE=; Domain=.youtube.com;
Expires=Mon, 09-Jan-2023 13:41:36 GMT; Path=/; Secure; HttpOnly;
SameSite=none
...
```

Cookies (7)

- When the user agent receives a `Set-Cookie` header, it stores the cookie together with its attributes.
- Subsequently, when the user agent makes an HTTP request, it includes the applicable, non-expired cookies in the `Cookie` header field.
  - It includes only the name/value pairs without the attributes!
- If the user agent receives a new cookie with the same name, `Domain` attribute, and `Path` attribute as a cookie that it has already stored, the existing cookie is replaced with the new cookie.

Cookies (8)

- Instructing curl to write cookies obtained to a file:
  - `curl --http1.1 https://www.youtube.com/ -c cookies.txt -v -o /dev/null`
  - See: https://curl.se/docs/http-cookies.html

Cookies (9)

- Sending back cookies with curl:
  - `curl --http1.1 https://www.youtube.com/ **-b cookies.txt** -v -o /dev/null`

```
GET / HTTP/1.1
Host: www.youtube.com
User-Agent: curl/7.81.0
Accept: */*
Cookie: VISITOR_PRIVACY_METADATA=CgJIVRIcE...IBAREiEgHg%3D%3D;
__Secure-YEC=Cgt0Wjc4W...IBAREiEgHg%3D%3D; YSC=J6CxOkFc5EE
```

Cookie Attributes (1)

- The specification defines the following attributes:
  - `Expires`
  - `Max-Age`
  - `Domain`
  - `Path`
  - `Secure`
  - `HttpOnly`
  - `SameSite`
- See: *Set-Cookie header (MDN)* https://developer.mozilla.org/en-US/docs/Web/HTTP/Reference/Headers/Set-Cookie

Cookie Attributes (2)

- Attributes indicating the maximum lifetime of the cookie:
  - **`Expires`**: specifies the date and time at which the cookie expires.
  - **`Max-Age`**: specifies the number of seconds until the cookie expires.
- A cookie with a `Max-Age` or `Expires` attribute is called a **persistent cookie**, because a user agent can retain the cookie over multiple sessions.
  - If a cookie has both the `Max-Age` and the `Expires` attribute, `Max-Age` has precedence over the `Expires` attribute.
- If a cookie has neither the `Max-Age` nor the `Expires` attribute, the user agent will retain it until the current session is over.
- Servers can delete cookies by sending the user agent a new cookie with an `Expires` attribute with a value in the past.

Cookie Attributes (3)

- **`Domain`**:
  - Specifies the servers to which the cookie will be sent.
    - For example, if the value of the attribute is `example.com`, the user agent will include the cookie in the `Cookie` header when making HTTP requests to `example.com` or `www.example.com`.
  - If the server omits the attribute, the user agent will return the cookie only to the origin server.
  - The user agent will reject cookies unless the attribute specifies a scope for the cookie that would include the origin server.
  - For security reasons, many user agents are configured to reject `Domain` attributes that correspond to “public suffixes” controlled by a public registry, such as `com`, `co.uk`, …
- **`Path`**:
  - Limits the scope of the cookie to a set of paths.
  - If the server omits the attribute, the user agent will use the “directory” of the request URI's path component as the default value.

Cookie Attributes (4)

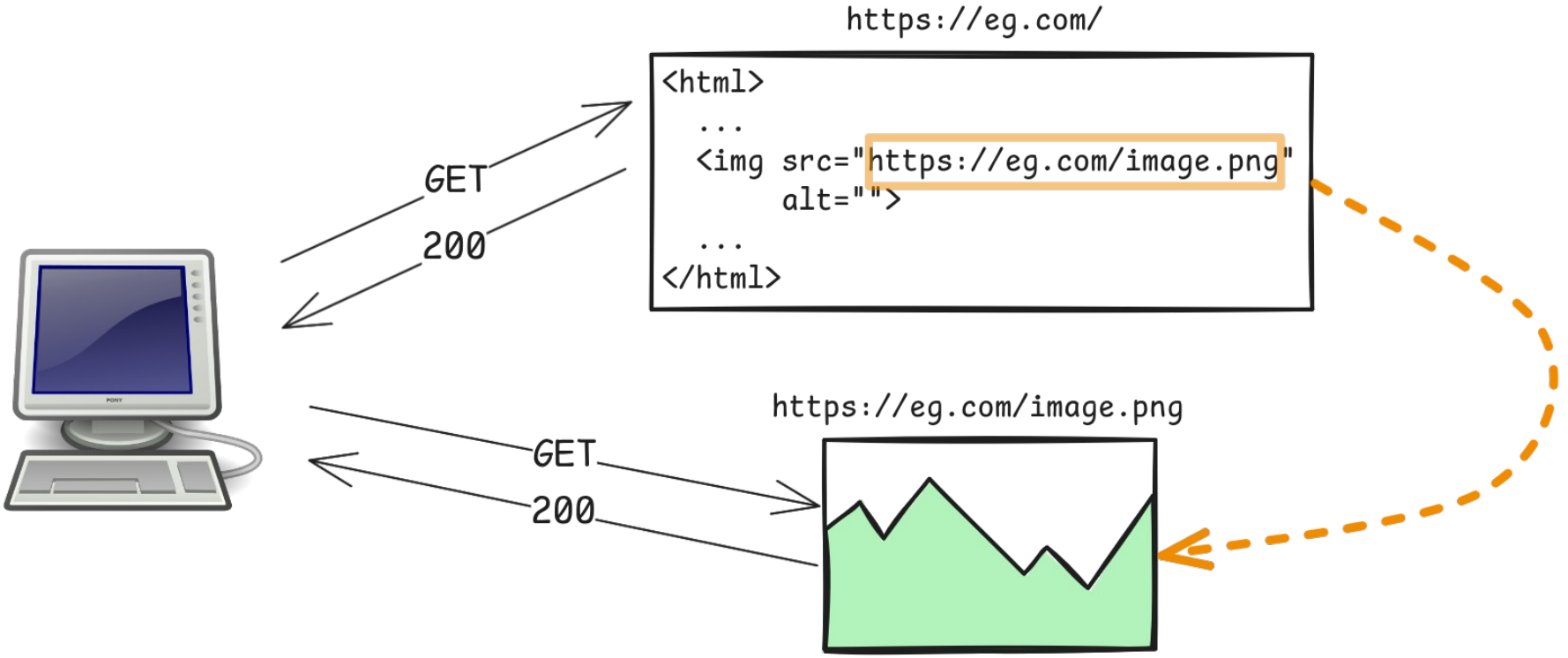
- **`Secure`**:
  - Limits the scope of the cookie to secure channels.
  - When a cookie has the `Secure` attribute, the user agent will include the cookie in an HTTP request only if the request is transmitted over a secure channel.
    - Because the cookie may contain sensitive information whose cleartext transmission poses a risk.
- **`HttpOnly`**:
  - Limits the scope of the cookie to HTTP requests.
  - Instructs the user agent not to make the cookie available to client-side APIs (e.g., JavaScript).

Cookie Attributes (5)

- **`SameSite`**:
  - Controls whether the cookie is included by the user agent in requests to resources from a different site than the cookie's sender, referred to as **cross-site requests**.
    - A request that is not a cross-site request is referred to as a **same-site request**.

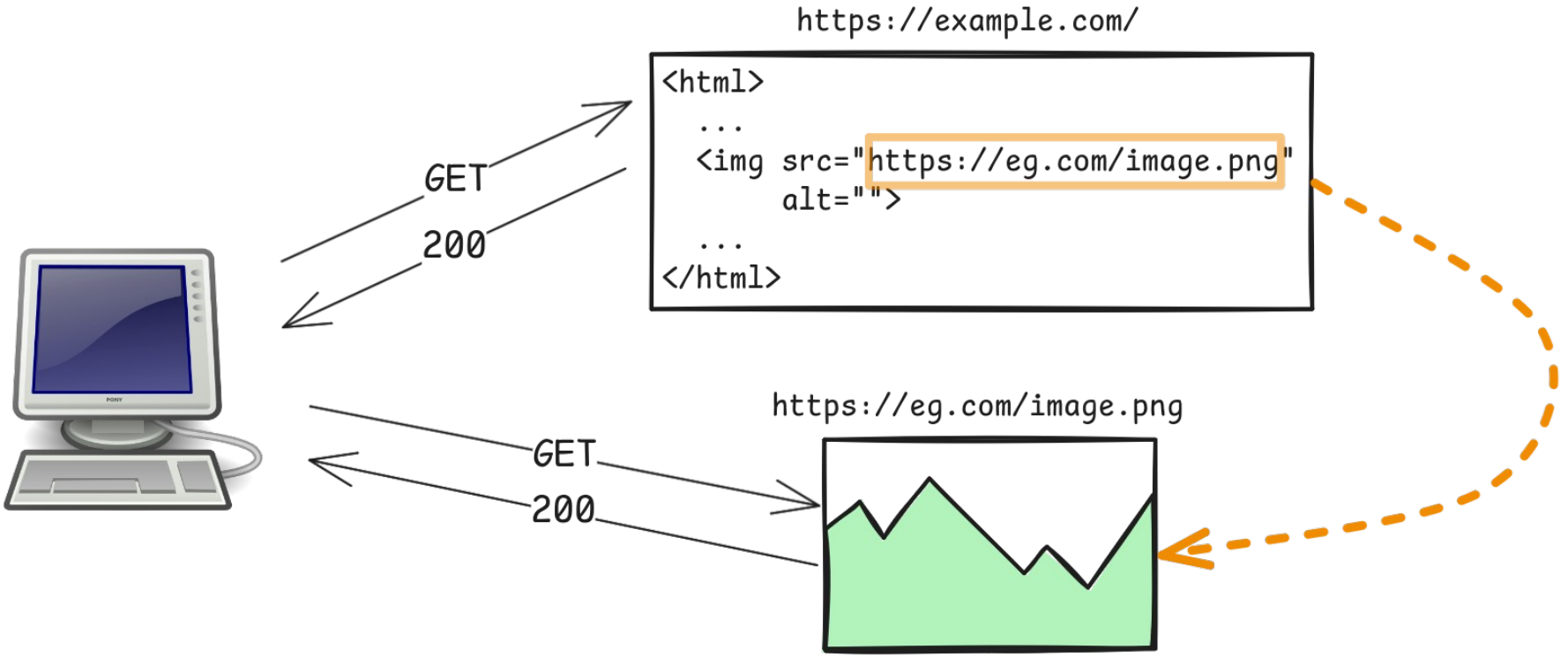
Cookie Attributes (6)

- **`SameSite`**: an example for same-site requests



Cookie Attributes (7)

- **`SameSite`**: an example for cross-site requests

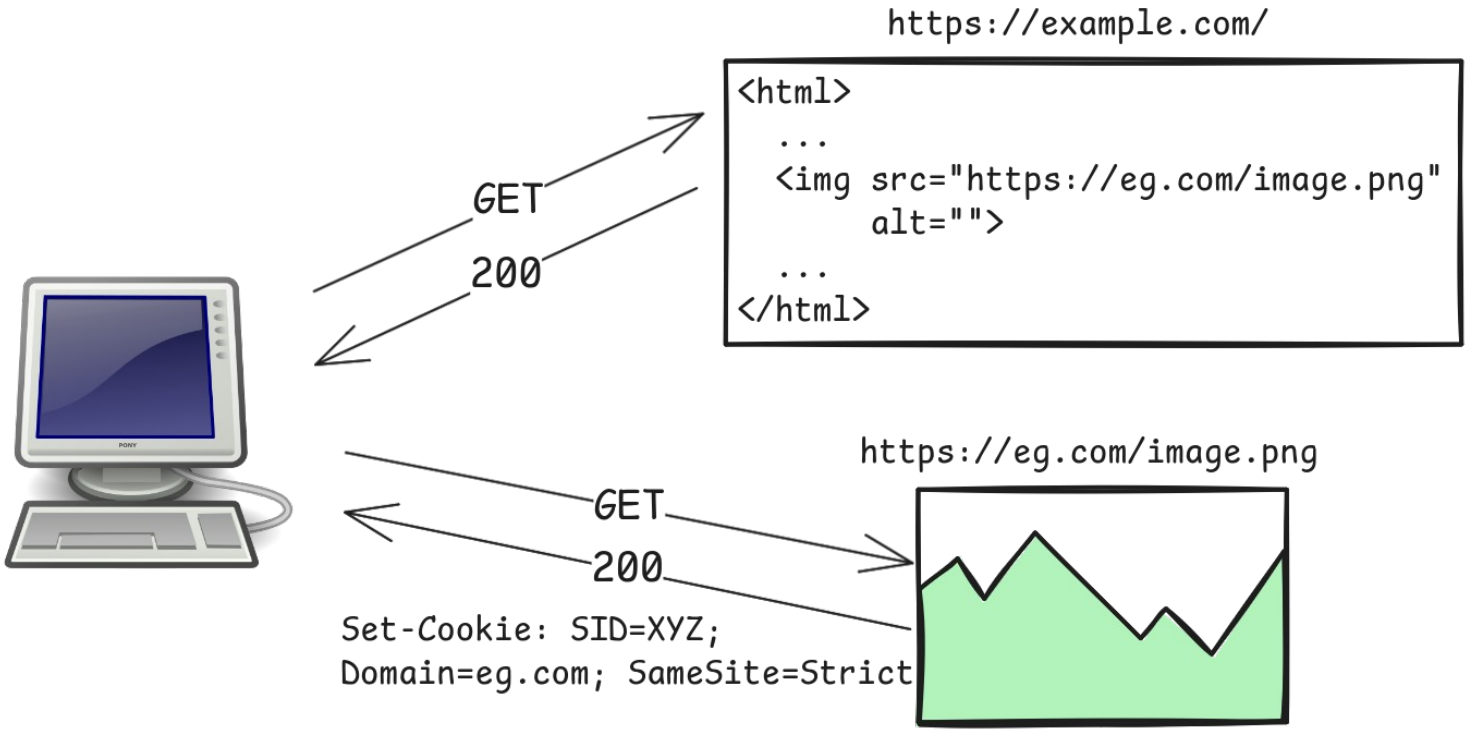


Cookie Attributes (8)

- **`SameSite`**:
  - Allowed attribute values:
    - **`Strict`**: The cookie is sent only in same-site requests.
    - **`Lax`**: The cookie is sent in same-site requests and cross-site requests satisfying both of the following conditions:
      - The request is a top-level navigation, i.e., the target URI is shown in the address bar of the browser.
      - The request's method is safe.
    - **`None`**: The cookie is sent both in same-site and cross-site requests.
  - `SameSite=Strict` may seem equivalent to omitting the Domain attribute; however, this is not the case.
    - The difference is that in the case of the `Domain` attribute, only the host component is considered, ignoring the scheme and the port.

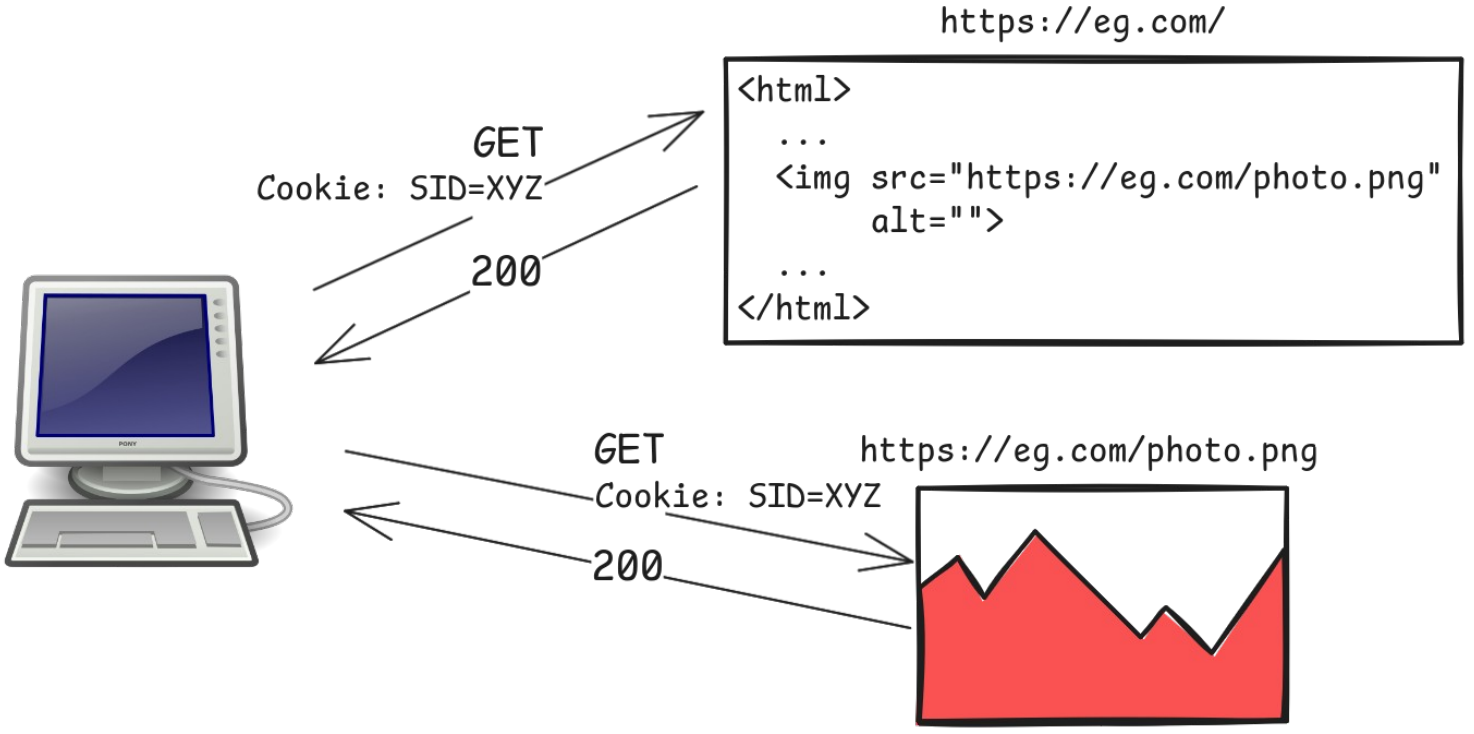
SameSite=Strict (1)

- The user agent gets a cookie from a server hosting an image, i.e., `https://eg.com/image.png`:



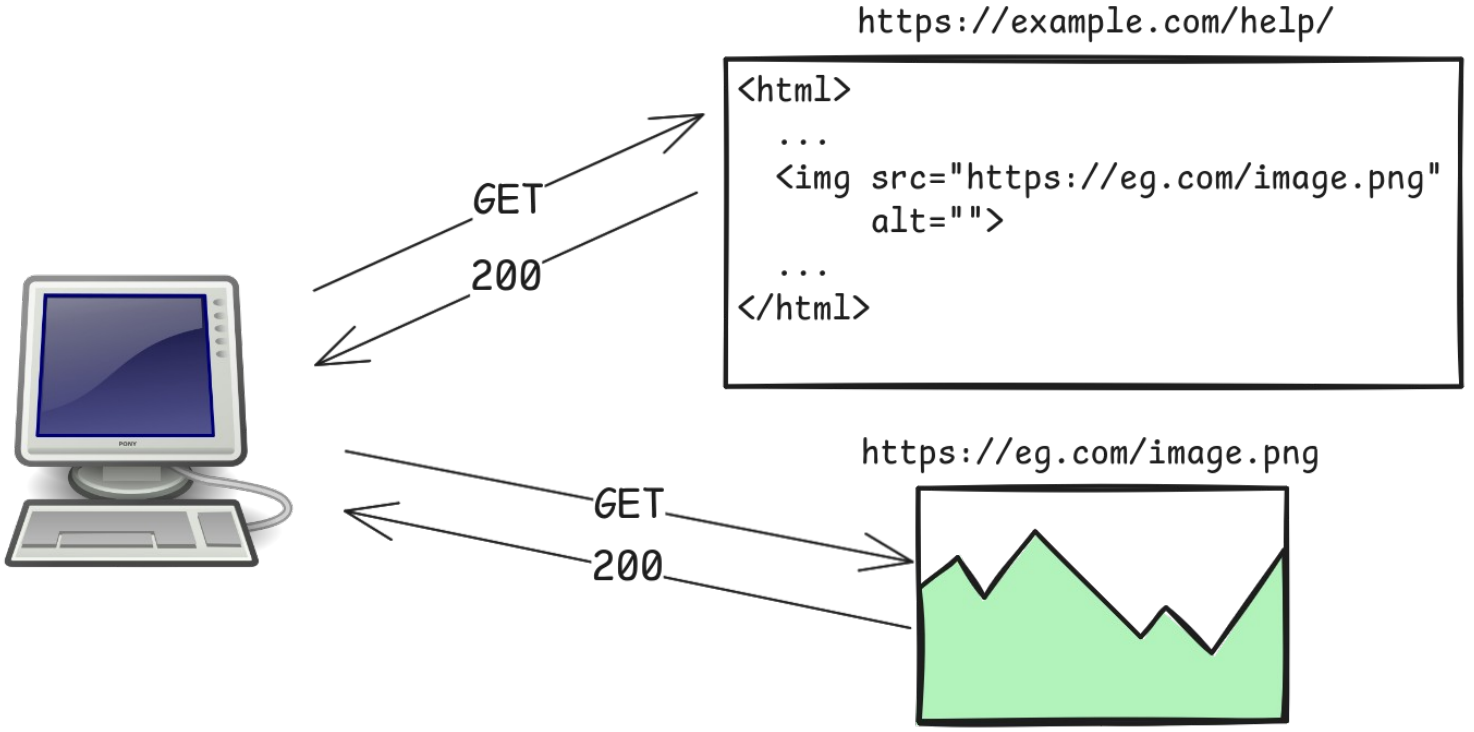
SameSite=Strict (2)

- The user agent sends back the cookie to the second server in same-site requests:



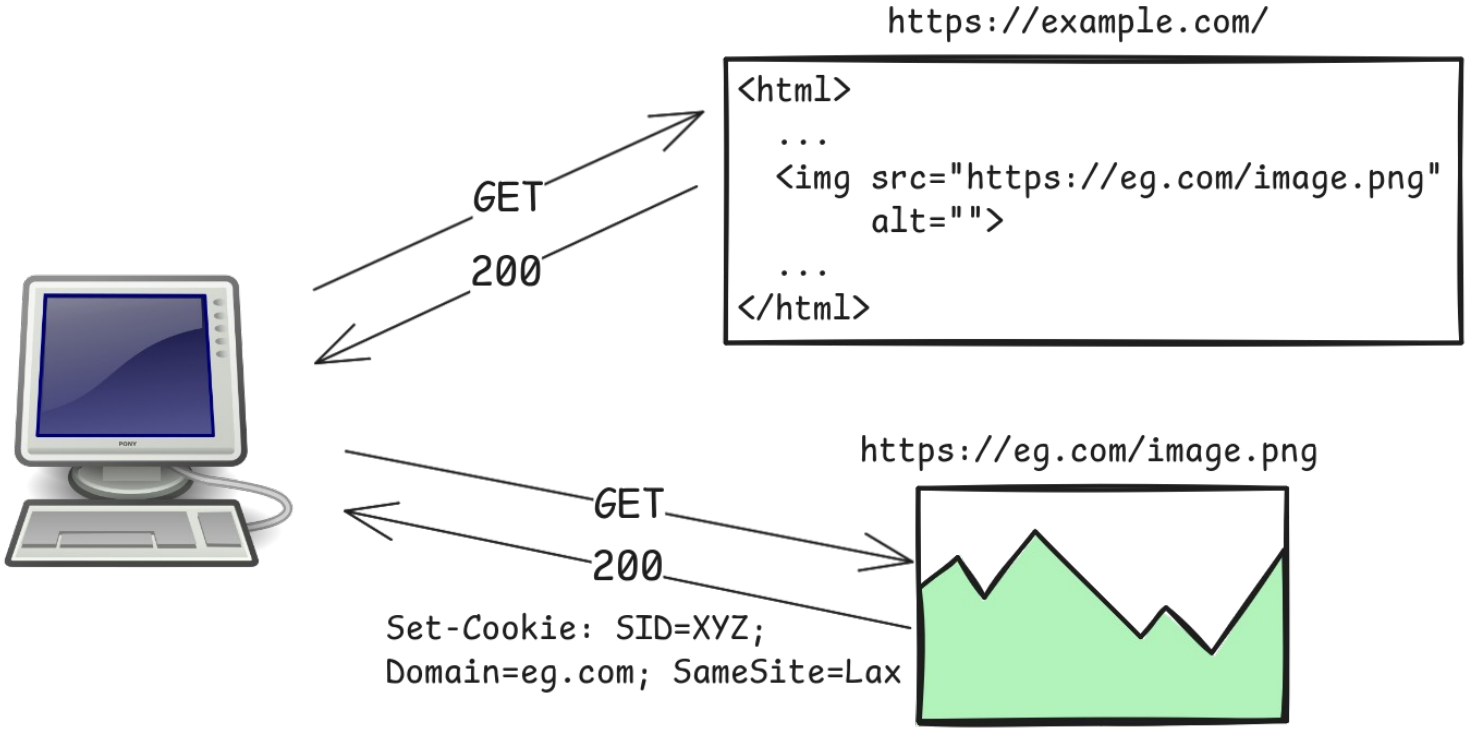
SameSite=Strict (3)

- However, the user agent does not include the cookie in cross-site requests:
  - Note that without the `SameSite` attribute the cookie would be sent!



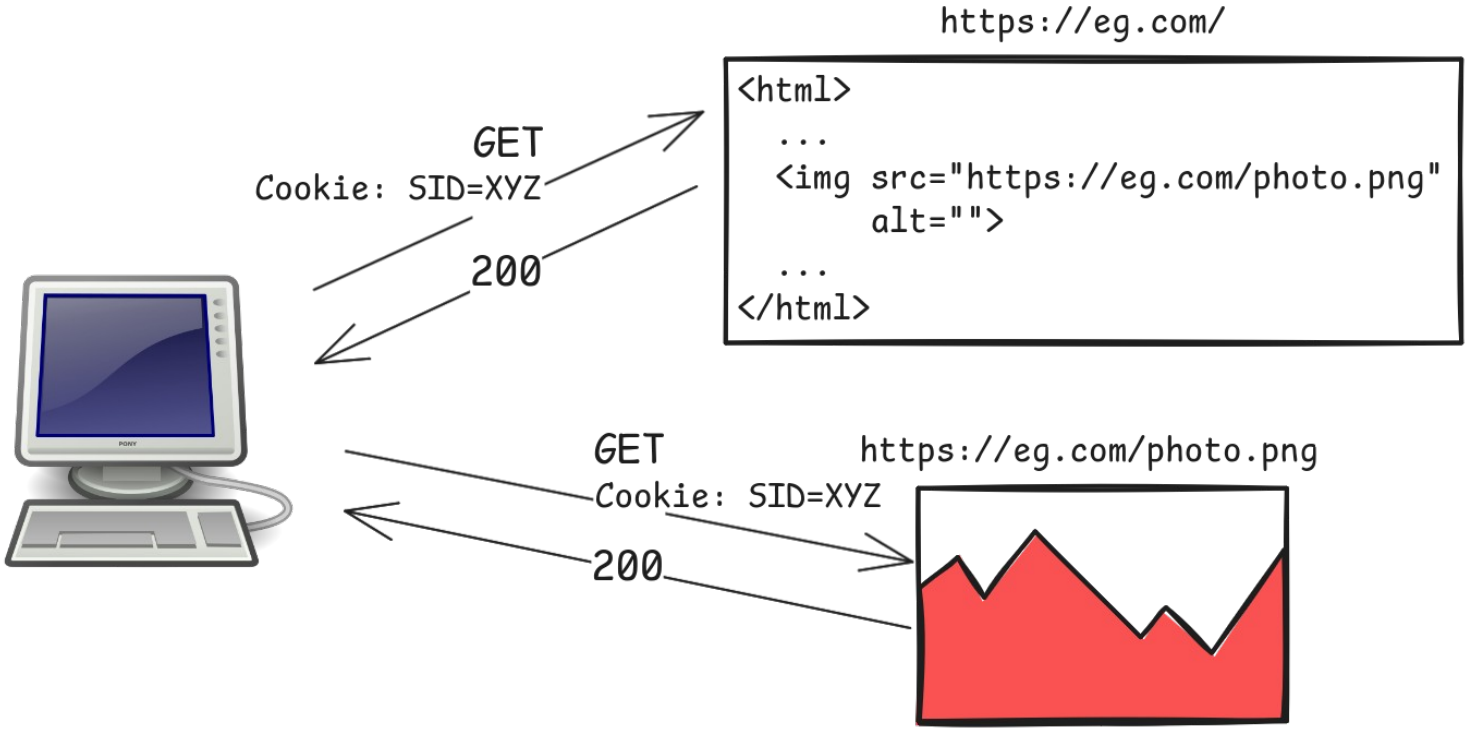
SameSite=Lax (1)

- The user agent gets a cookie from a server hosting an image, i.e., `https://eg.com/image.png`:



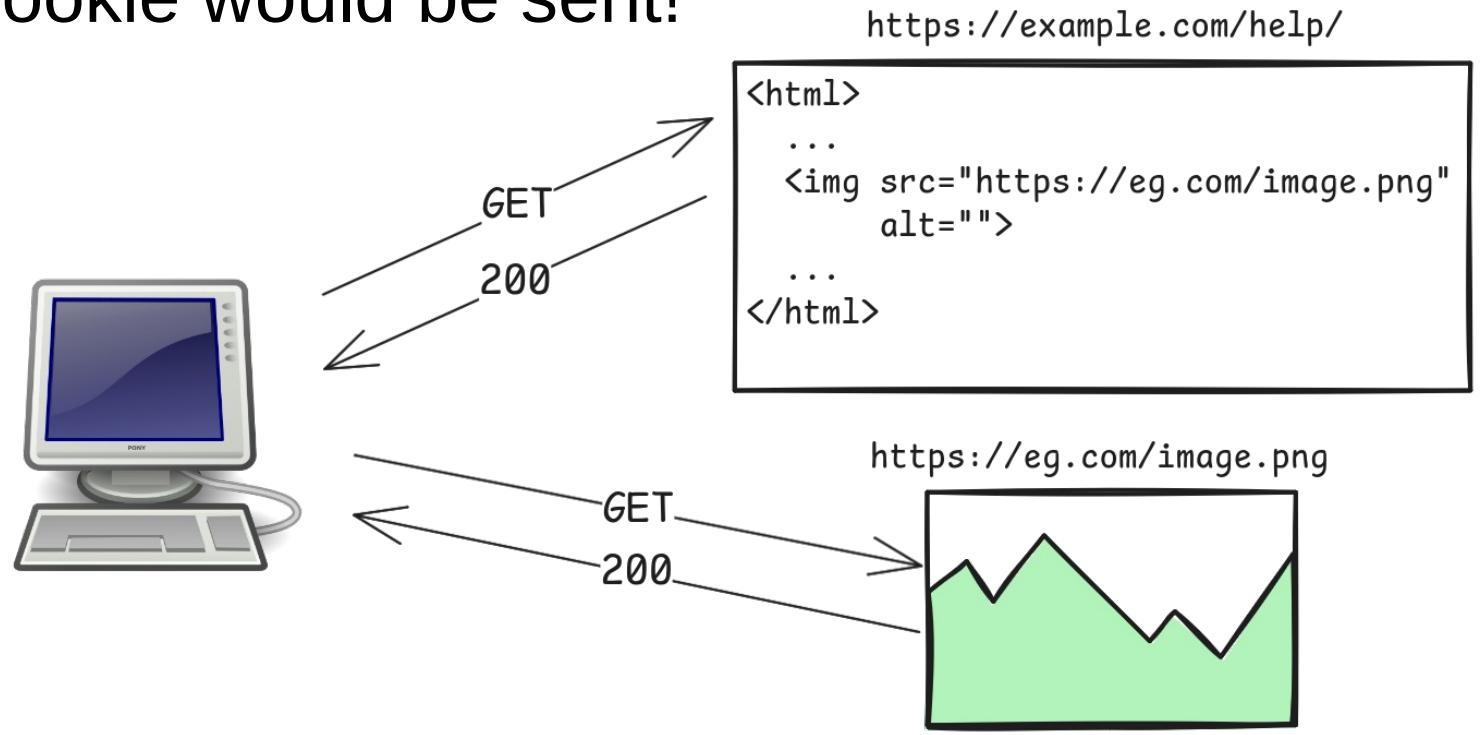
SameSite=Lax (2)

- The user agent sends back the cookie to the second server in same-site requests:



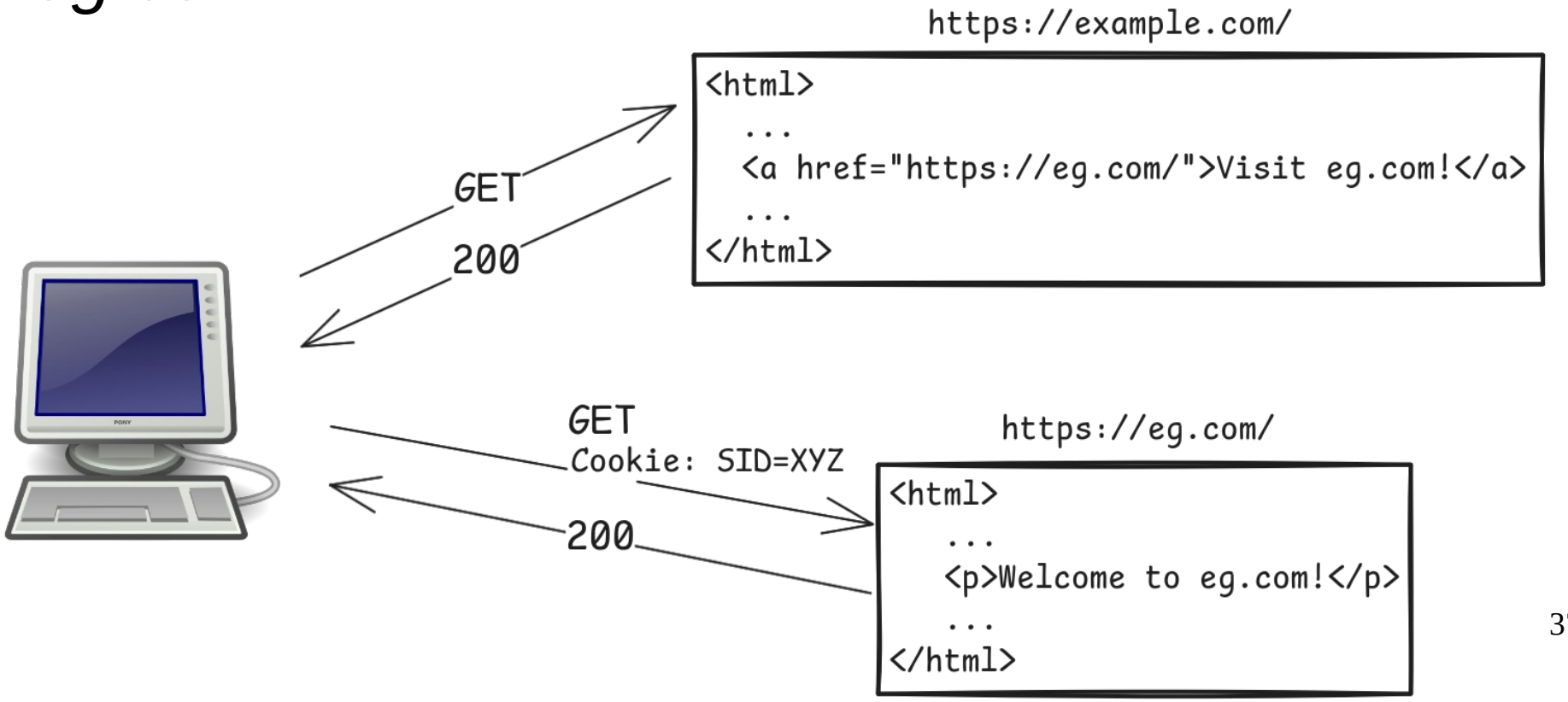
SameSite=Lax (3)

- The user agent does not include the cookie in cross-site requests that are not top-level navigations:
  - Note that without the `SameSite` attribute the cookie would be sent!



SameSite=Lax (4)

- However, the user agent includes the cookie in cross-site requests that are top-level navigations, e.g., when the user clicks on "*Visit eg.com!*":



Cookie Management (1)

- User agents:
  - Must remove all expired cookies from the cookie store.
  - When the current session is over, must remove all non-persistent cookies from the cookie store.
  - Should provide users with a mechanism for managing the cookies stored in the cookie store.
    - For example, let users delete all cookies received during a specified period or all the cookies related to a particular domain.
  - Should provide users with a mechanism for disabling cookies.

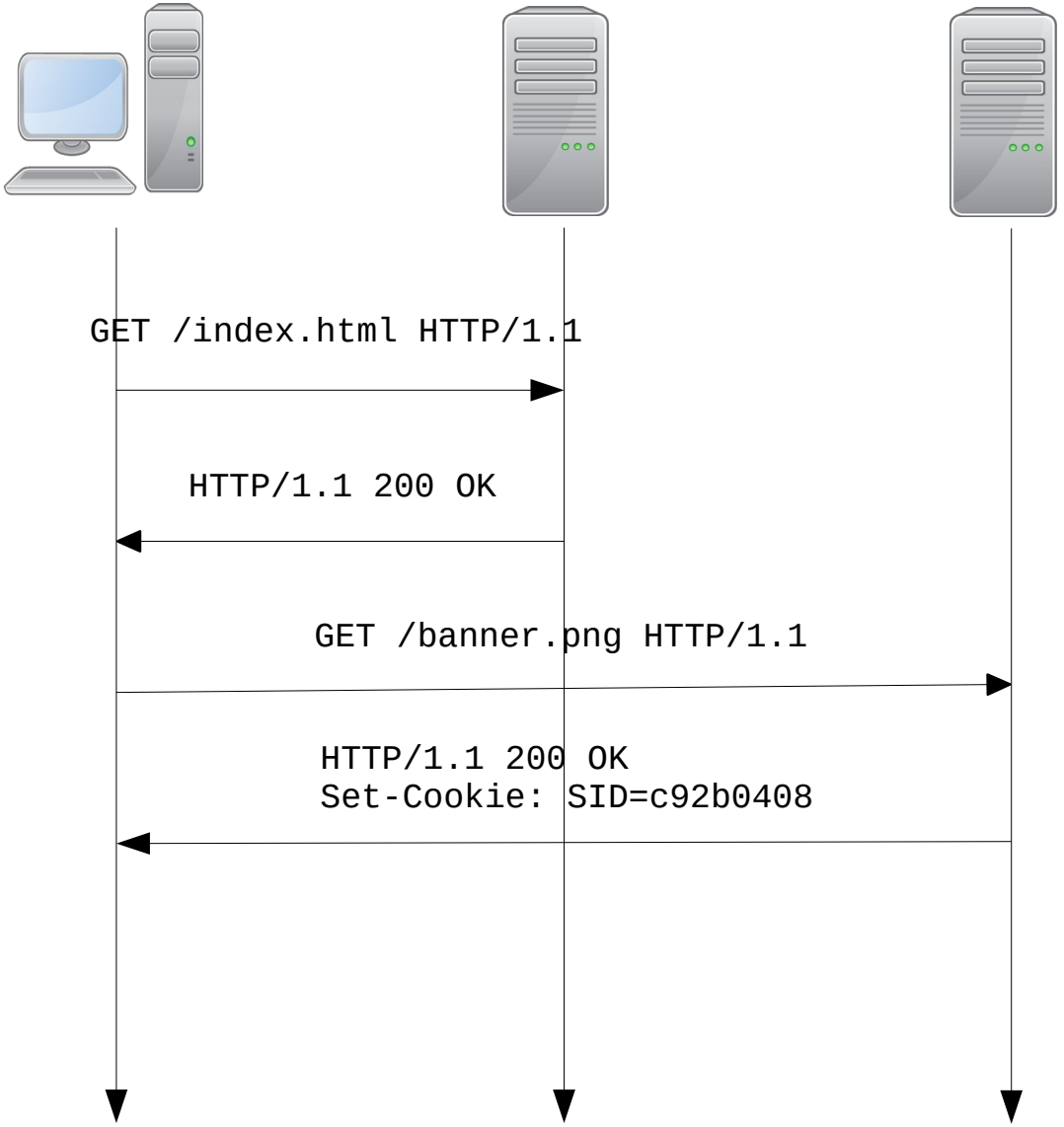
Cookie Management (2)

- User agents have limits on the number and size of cookies that they can store.
- The specification recommends the following minimum capabilities:
  - At least 4096 bytes per cookie.
  - At least 50 cookies per domain.
  - At least 3000 cookies total.

Cookies: Privacy and Security Concerns (1)

- Cookies are often criticized for letting servers track users.
- Particularly problematic are so-called **third-party cookies**.
  - In rendering an HTML document, a user agent often requests resources from other servers.
  - These third-party servers can use cookies to track the user even if the user never visits the server directly.
  - Third-party cookies are also known as cross-site cookies.

Cookies: Privacy and Security Concerns (2)



Cookies: Privacy and Security Concerns (3)

- Unless sent over a secure channel (such as TLS), the information in the `Cookie` and `Set-Cookie` headers is transmitted in cleartext.
  - All sensitive information conveyed in these headers is exposed to an eavesdropper and a malicious intermediary could alter it.
- Servers should encrypt and sign the contents of cookies when transmitting them to the user agent (even when sending the cookies over a secure channel).
- When using cookies over a secure channel, servers should set the `Secure` attribute for every cookie.

Cookies: Privacy and Security Concerns (4)

- The current EU regulations:
  - **2002/58/EC**: *Directive on privacy and electronic communications* (12 July 2002) (“ePrivacy Directive”) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002L0058
  - **2009/136/EC**: *Directive 2009/136/EC of the European Parliament and of the Council* (25 November 2009) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0136
    - It is referred to as the ePrivacy Directive amendment.
    - See the modification of the paragraph 3 of Article 5 of Directive 2002/58/EC.
    - It states that storing cookies on the user's computer requires informed consent from the user.
  - Article 29 Data Protection Working Party: *Opinion 04/2012 on Cookie Consent Exemption* (7 June 2012) https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2012/wp194_en.pdf

Cookies: Privacy and Security Concerns (5)

- See also:
  - *Cookies, the GDPR, and the ePrivacy Directive* https://gdpr.eu/cookies/
  - *Third-party cookies (MDN)* https://developer.mozilla.org/en-US/docs/Web/Privacy/Third-party_cookies

Web Tracking (1)

- A possible definition:
  - Tracking is the collection of data regarding a particular user's activity across multiple distinct contexts and the retention, use, or sharing of data derived from that activity outside the context in which it occurred.
  - A context is a set of resources that are controlled by the same party or jointly controlled by a set of parties.
- Source: https://www.w3.org/TR/tracking-dnt/#dfn-tracking

Web Tracking (2)

- Can be based on the following:
  - IP address
  - Cookies
  - The `ETag` header field
  - Device fingerprint (operating system, screen resolution, installed fonts, …)
    - See:
      - *Am I Unique*? https://amiunique.org/
      - *Cover Your Tracks* https://coveryourtracks.eff.org/
  - …

Web Tracking (3)

- Example for browser fingerprinting:
  - FingerprintJS (written in: TypeScript, license: Business Source License 1.1) https://github.com/fingerprintjs/fingerprintjs
    - A source-available (however, not open source), client-side, browser fingerprinting library that queries browser attributes and computes a hashed visitor identifier from them.
    - Unlike cookies and local storage, a fingerprint stays the same in incognito/private mode and even when browser data is purged.
    - Demonstration:
      - Visit the following page in Google Chrome, then also open it in an incognito window: https://fingerprintjs.github.io/fingerprintjs
      - Now repeat the experiment in Firefox.

Web Tracking (4)

- Statistics about trackers:
  - *Ghostery WhoTracks.me* https://www.ghostery.com/whotracksme
    - *Trackers Rank* https://www.ghostery.com/whotracksme/trackers
    - *Ghostery Tracker Database* https://github.com/ghostery/trackerdb
- Further information:
  - *BrowserLeaks.com* https://www.browserleaks.com/

The Referer Header Field (1)

- Allows the user agent to specify a URI reference for the resource from which the target URI was obtained.
  - See: https://developer.mozilla.org/en-US/docs/Web/HTTP/Headers/Referer
- Example:
  - `Referer: https://www.w3.org/`
- It has the potential to reveal information about the browsing history of the user, which is a privacy concern.

The Referer Header Field (2)

- A user agent should not send a `Referer` header field if the referring resource was accessed with a secure protocol and the request-target has an origin differing from that of the referring resource unless the referring resource explicitly allows `Referer` to be sent.
- A user agent must not send a `Referer` header field in an unsecured HTTP request if the referring resource was accessed with a secure protocol.

Controlling the Use of the Referer Header Field (1)

- The mechanism provided by HTML:
  - *HTML Living Standard – Link type `"noreferrer"`*

    https://html.spec.whatwg.org/multipage/semantics.html#link-type-noreferrer
    - The `rel="noreferrer"` attribute of the a element.
    - Example:
      - `<a href="https://example.com/" rel="noreferrer">Click here</a>`
    - Browser support: https://caniuse.com/rel-noreferrer

Controlling the Use of the Referer Header Field (2)

- *Referrer Policy* (W3C Candidate Recommendation, 26 January 2017) https://www.w3.org/TR/referrer-policy/
  - Provides a mechanism by which document authors can define a policy for clients on the sending of the `Referer` header field.
  - Example:
    - `Referrer-Policy: no-referrer`
    - `<meta name="referrer" content="no-referrer"/>`
    - `<a href="https://example.com/" referrerpolicy="no-referrer">Click here</a>`
  - Browser support: https://caniuse.com/referrer-policy

Controlling the Use of the Referer Header Field (3)

- *Referrer Policy* (continued):
  - Available options: https://developer.mozilla.org/en-US/docs/Web/HTTP/Headers/Referrer-Policy
  - The default is `strict-origin-when-cross-origin`, that is also used by Firefox and Chrome, currently.
    - See:
      - *Firefox 87 trims HTTP Referrers by default to protect user privacy* https://blog.mozilla.org/security/2021/03/22/firefox-87-trims-http-referrers-by-default-to-protect-user-privacy/
      - *A new default Referrer-Policy for Chrome – strict-origin-when-cross-origin* https://developer.chrome.com/blog/referrer-policy-new-chrome-default/
  - Further information: *Referer and Referrer-Policy best practices* https://web.dev/articles/referrer-best-practices

Protection Against Tracking (1)

- Disabling the sending of the `Referer` header field:
  - **Firefox**: see the `network.http.sendRefererHeader` option (`about:config`) https://wiki.mozilla.org/Security/Referrer
  - **Chromium, Google Chrome**: not possible (?)
  - **Opera**: not possible (?)
  - **Chromium-based Microsoft Edge**: not possible (?)

Protection Against Tracking (2)

- Disabling the acceptance of third-party cookies:
  - In major web browsers (i.e., Chromium, Google Chrome, Chromium-based Microsoft Edge, Firefox, Opera) users can choose to block third-party cookies in private browsing/incognito mode or block third-party cookies in general.
  - Since blocking third-party cookies can break sites, users can make exceptions by allowing the use of third-party cookies for specific sites.

Protection Against Tracking (3)

- Disabling the acceptance of third-party cookies:
  - **Firefox**: see the `network.cookie.cookieBehavior` option (`about:config`)
    - See also: *Third-party cookies and Firefox tracking protection – Disable third-party cookies* https://support.mozilla.org/en-US/kb/third-party-cookies-firefox-tracking-protection#w_disable-third-party-cookies
  - **Chromium**, **Google Chrome**: see the *Block third-party cookies* option (`chrome://settings/privacy`)
  - **Opera**: see the *Block third-party cookies* option (`opera://settings/cookies`)
  - **Chromium-based Microsoft Edge**: see the *Block third-party cookies* option (`edge://settings/content/cookies`)

Protection Against Tracking (4)

- Private browsing/incognito mode:
  - Many modern web browsers provide a privacy feature called private browsing.
  - In private browsing mode when the current session is over browsing information (such as browsing history, cookies, and cached content) is automatically erased.

Protection Against Tracking (5)

- Private browsing/incognito mode: (continued)
  - **Firefox:**
    - *Private Browsing – Use Firefox without saving history* https://support.mozilla.org/en-US/kb/private-browsing-use-firefox-without-history
  - **Chromium**, **Google Chrome**:
    - *How private browsing works* https://support.google.com/chrome/?p=incognito
  - **Opera**:
    - *Opera Help – Security and privacy – Private window* https://help.opera.com/en/latest/security-and-privacy/#privateWindow
  - **Chromium-based Microsoft Edge**:
    - *Browse InPrivate in Microsoft Edge* https://support.microsoft.com/hu-hu/microsoft-edge/inprivate-b%C3%B6ng%C3%A9sz%C3%A9s-a-microsoft-edge-ben-cd2c9a48-0bc4-b98e-5e46-ac40c84e27e2

Protection Against Tracking (6)

- Built-in tracking protection:
  - **Firefox**:
    - *Enhanced Tracking Protection in Firefox for desktop* https://support.mozilla.org/en-US/kb/enhanced-tracking-protection-firefox-desktop
      - See: `about:protections`
  - **Chromium-based Microsoft Edge**:
    - *Tracking Prevention in Microsoft Edge* https://learn.microsoft.com/en-us/microsoft-edge/web-platform/tracking-prevention
      - See: `edge://settings/privacy`
  - **Safari**:
    - *Tracking Prevention in WebKit* https://webkit.org/tracking-prevention/

Protection Against Tracking (7)

- Complex solutions:
  - Adblock Plus (license: GPLv3) https://adblockplus.org/ https://gitlab.com/eyeo/extensions/extensions
    - Supported web browsers: Chrome, Firefox, Microsoft Edge, Opera, Safari
    - See the EasyPrivacy filter https://easylist.to/
  - Ghostery Browser Extension (license: non-free/Mozilla Public License 2.0) https://www.ghostery.com/ghostery-ad-blocker https://github.com/ghostery/ghostery-extension
    - Supported web browsers: Chrome, Firefox, Microsoft Edge, Opera, Safari
  - Privacy Badger (license: GPLv3) https://privacybadger.org/ https://github.com/EFForg/privacybadger
    - Supported web browsers: Chrome, Firefox, Microsoft Edge, Opera
  - uBlock Origin (license: GPLv3) https://github.com/gorhill/uBlock
    - Supported web browsers: Chromium, Firefox

Protection Against Tracking (8)

- Privacy-focused web browsers:
  - Brave: a free and open source web browser based on Chromium that focuses on privacy.
    - Developer: Brave Software, Inc.
    - Website: https://brave.com/
    - Repository: https://github.com/brave/brave-browser
    - Written in: C++, Swift, TypeScript
    - License: Mozilla Public License 2.0
    - Platform: Android, iOS, Linux, macOS, Windows

Protection Against Tracking (9)

- Google Chrome:
  - Google planned to restrict the use of third-party cookies by default for 1% of Chrome users to facilitate testing, and then ramping up to 100% of users from Q3 2024.
    - See:
      - Chris Mills. *Saying goodbye to third-party cookies in 2024*. December 8, 2023. https://developer.mozilla.org/en-US/blog/goodbye-third-party-cookies/
      - *Third-party cookies restricted by default for 1% of Chrome users*. January 4, 2024. https://developers.google.com/privacy-sandbox/blog/cookie-countdown-2024jan
  - Later Google decided not to do so, instead, to follow a different approach.
    - See: Anthony Chavez. *A new path for Privacy Sandbox on the web*. July 22, 2024. https://privacysandbox.com/news/privacy-sandbox-update/

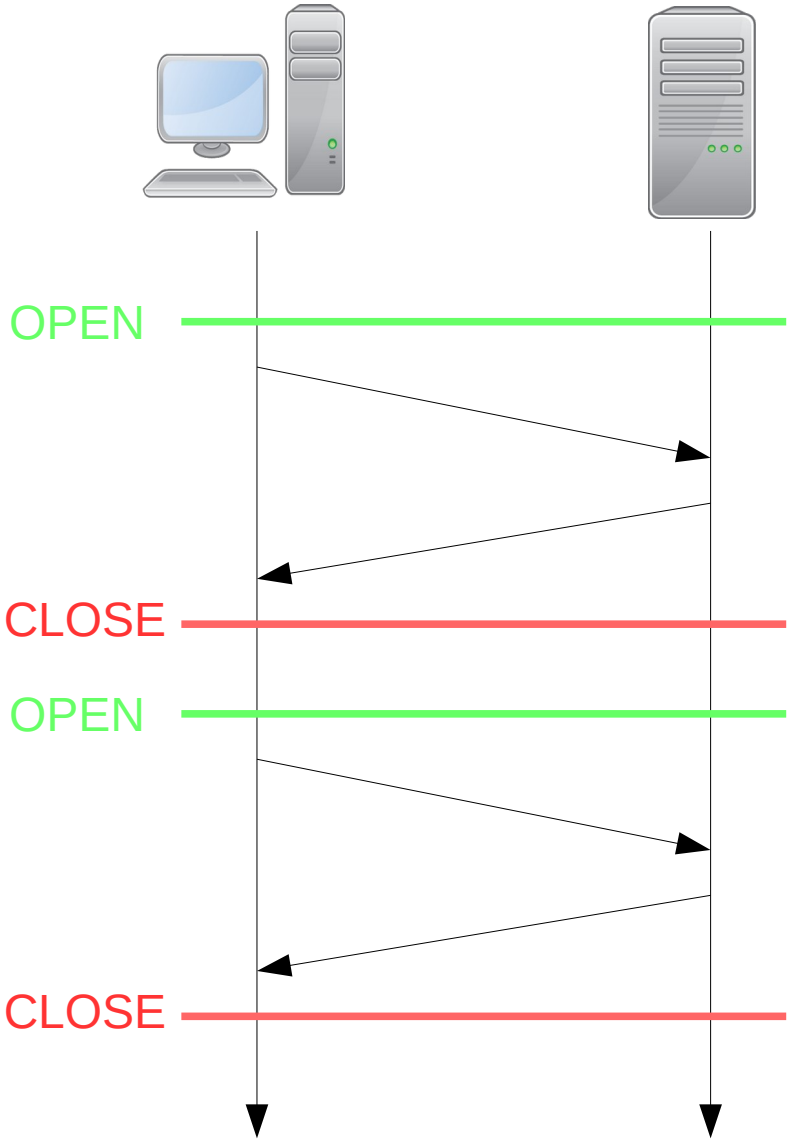
Protection Against Tracking (10)

- Further information:
  - *PrivacyTools* https://www.privacytools.io/

Comparison of Web Browsers

- *Can I use… – Browser comparison*
  https://caniuse.com/ciu/comparison
  https://github.com/Fyrd/caniuse
- *Comparison of Web Browsers*
  https://eylenburg.github.io/browser_comparison.htm
- *PrivacyTests.org* https://privacytests.org/

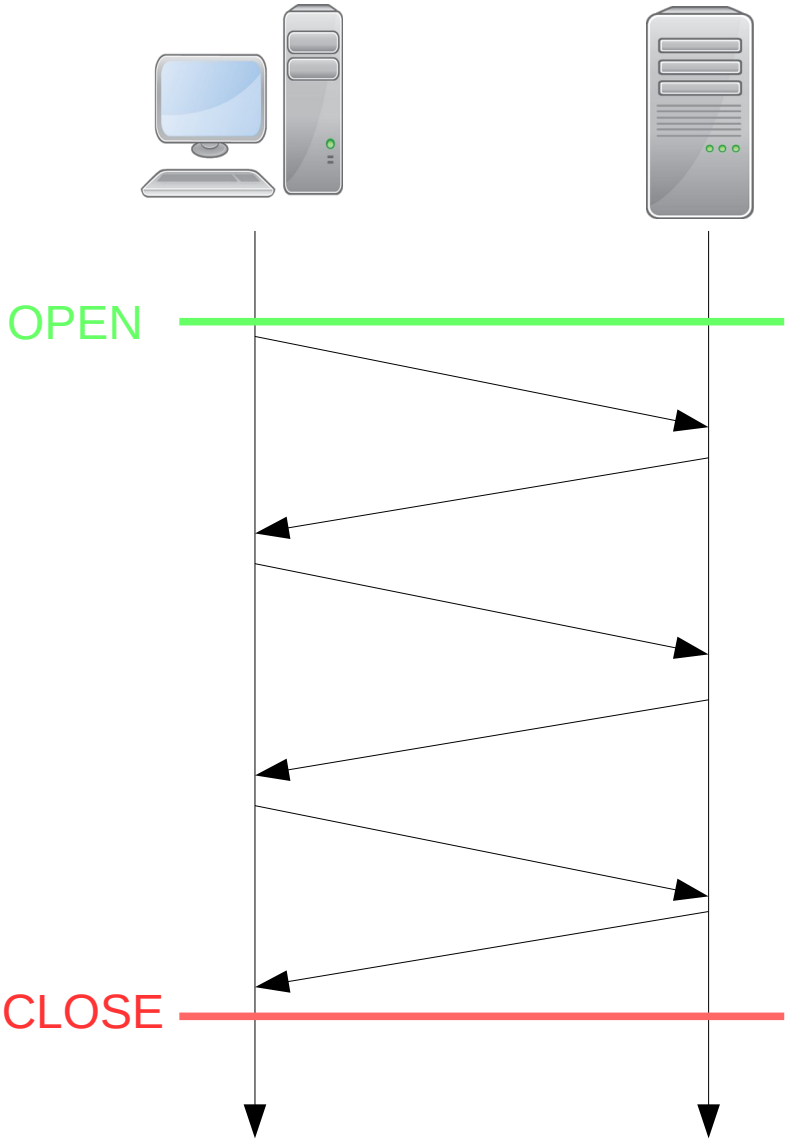
Connection Management in HTTP/1.0



Persistent Connections (1)

- Were introduced in HTTP/1.1.
- Allow multiple requests and responses to be transmitted over a single TCP connection.
- HTTP/1.1 defaults to the use of persistent connections.

Persistent Connections (2)



Connection Management (1)

- The `Connection` header field allows the sender to indicate desired control options for the current connection.
  - The field value is a list of case-insensitive options.

Connection Management (2)

- Explicit connection closing:
  - The `Connection` header field provides a `close` connection option for a sender to signal that the connection will be closed after the current request/response is complete.
    - Can be used in both requests and responses.
  - Example:
    - `Connection: close`
- Connection timeout:
  - Servers usually have some timeout value beyond which they will no longer maintain an inactive connection.

Connection Management (3)

- Concurrent connections:
  - Most servers are designed to be able to maintain thousands of concurrent connections.
  - Most clients maintain multiple connections in parallel, including more than one connection per server.
    - Multiple connections are typically used to avoid the **head-of-line blocking** problem.

Connection Management (4)

- Concurrent connections:
  - Previous revisions of HTTP specified a limit for the number of simultaneous open connections that a client can maintain to a given server.
    - RFC 2616: the maximum number of connections is 2.
  - This was found to be impractical for many applications, thus, HTTP/1.1 does not mandate a particular limit, but instead, encourages clients to be conservative when opening multiple connections.
    - Each connection consumes server resources, and a server might deny requests when a client opens an excessive number of connections.

Connection Management (5)

- Concurrent connections:
  - Limits for the number of connections in browsers:
    - **Firefox**: see the following options (`about:config`):
      - `network.http.max-connections` (default value: 900)
      - `network.http.max-persistent-connections-per-proxy` (default value: 32)
      - `network.http.max-persistent-connections-per-server` (default value: 6)
    - **Chromium**, **Google Chrome**: uses the default values of the above Firefox options as hard-coded settings.
      - See: https://www.chromium.org/developers/design-documents/network-stack/#connection-management
    - **Chromium-based Microsoft Edge**: https://docs.microsoft.com/en-us/microsoft-edge/devtools-guide-chromium/network/issues#queued-or-stalled-requests

Further Recommended Reading

- *MDN Web Docs – HTTP* https://developer.mozilla.org/docs/Web/HTTP
- Ilya Grigorik. *High Performance Browser Networking*. O'Reilly, 2013. https://hpbn.co/