The N-server problem

Cross-Origin Request Sharing

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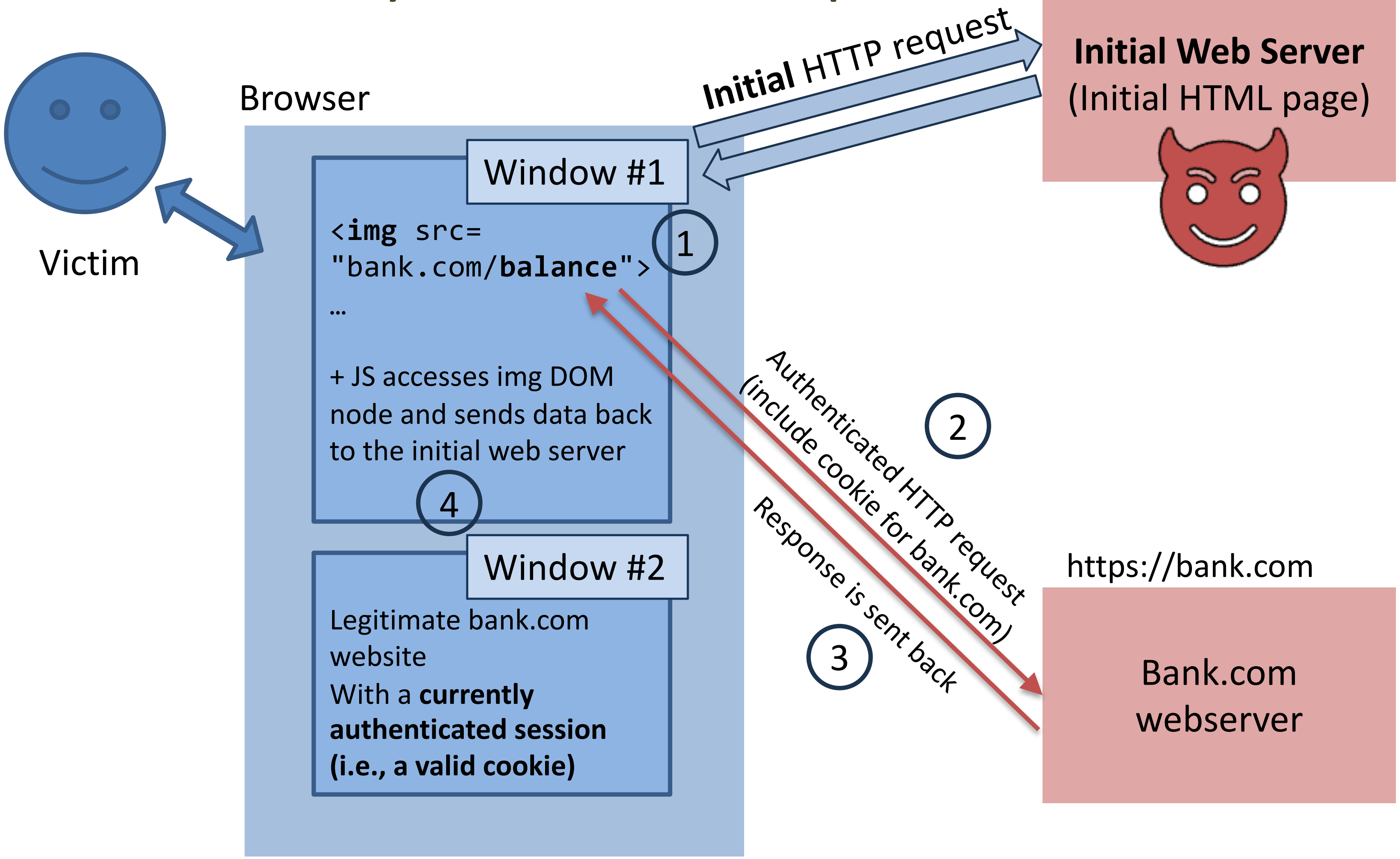
Loading Web Pages

- Loading a web page requires to load external resources (images, CSS, Javascript, …), potentially from different web servers
- Loading resources from different web servers without limitations was a "normal" behavior in the really old days of the Internet
- Now Internet has evolved into a platform able to run applications that can access/manipulate data, even personal/private data
- Browsers can also keep more than one web page open at the same time
- **How to ensure that private data is not shared across web pages coming from different servers?**
    - Especially when browsers have authenticated sessions active for websites

Security Risk Example



Victim
Browser
Window #1
<img src=
"bank.com/balance">
…
+ JS accesses img DOM node and sends data back to the initial web server
1
4
Window #2
Legitimate bank.com website
With a currently authenticated session (i.e., a valid cookie)
Initial HTTP request
https://tricky.com
Initial Web Server
(Initial HTML page)
Authenticated HTTP request
(include cookie for bank.com)
2
Response is sent back
3
https://bank.com
Bank.com webserver

1. The user visits a malicious website that creates a DOM <img> node that references https://bank.com and not https://tricky.com
2. The request is sent by the browser, **with cookies**, to https://bank.com
3. Private data is retrieved (the image is not shown since the data is not an image)

4. **Without additional restrictions, the private data could be accessed** via the <img> DOM object by the JS running in Window #1, which then can send such data to the initial malicious website

- **Note**: The browser must load the image src URL in any case for backward compatibility

Website separation

- To limit the previous security risks, now browsers **do not allow** DOM and JS access data and cookies coming from servers which are not the initial one
- However, to avoid “breaking the old web”, requests for `<img>`, `<link>`, `<script>` are still sent even if URLs point to different servers
  - And the received content is also rendered and incorporated in the page if it can be parsed correctly (images, CSS, Javascript)
- But <u>DOM and JS cannot access</u> such loaded content, to <u>avoid data stealing</u>
- This is because the response of such requests could include private data if sent to a server for which an authenticated session is already active (valid cookies)
  - In fact, browsers always send cookies <u>automatically</u> to the server that initially set them

Same Origin Policy (SOP)

- Website separation in practice: browsers implement the **Same Origin Policy (SOP)**, i.e., content and data coming from **origins** different from the initial server can be loaded but not freely accessed by the page

- What is an "origin"?
- An **origin** consists of a **URI scheme**, **domain** and **port number**:

```
http://example.com:3456/site/
```

Origin Comparison

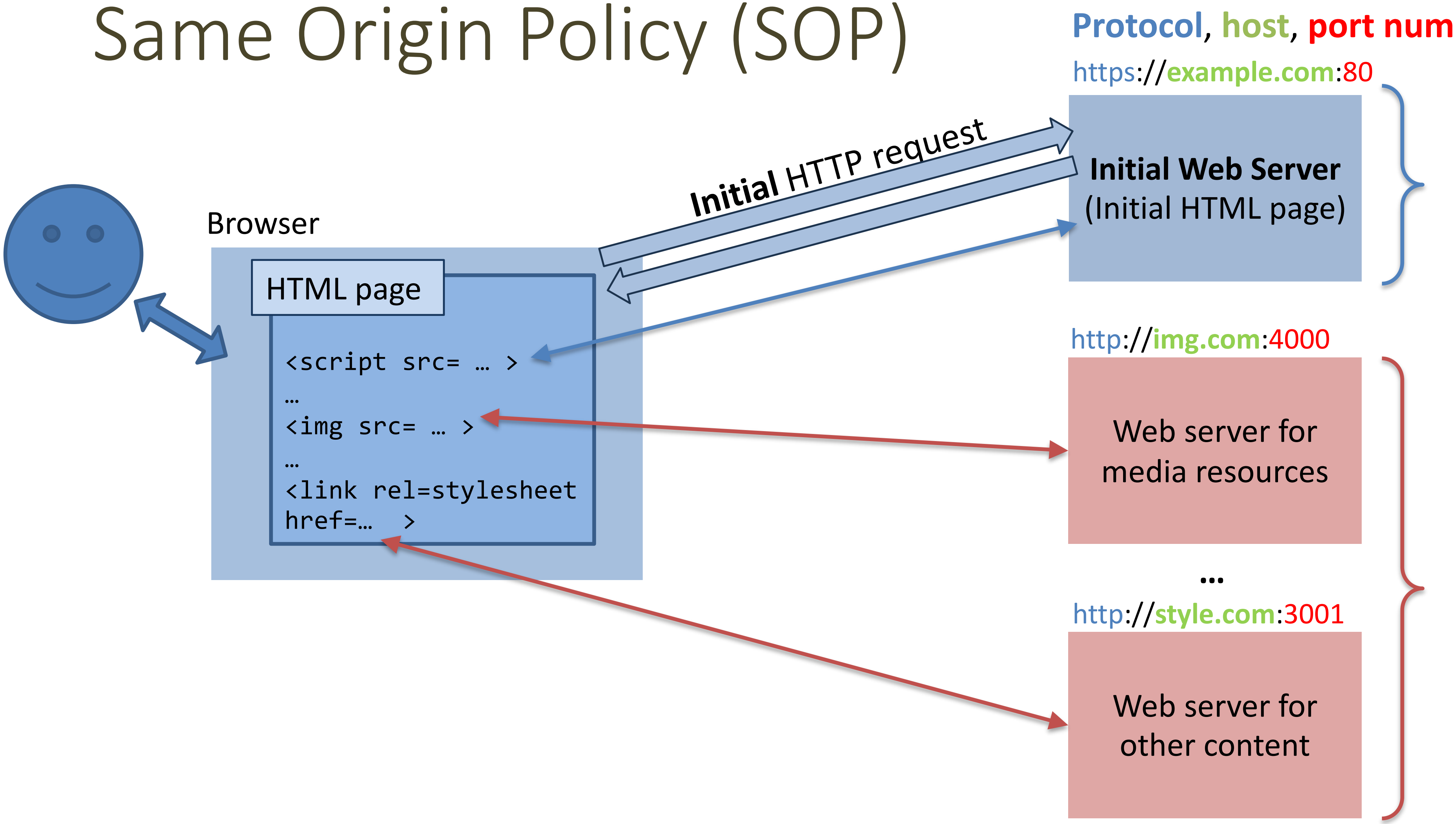
- An origin is the same only if presents the **same URI scheme**, **domain** and **port** number
- Consider this starting URL: `http://website.com/site/page.html`

New URL	Same Origin?
`http://website.com/example`	Yes: same scheme, domain, port
`http://website.com/site-two`	Yes: same scheme, domain, port
`**https**://website.com/example`	No: different scheme **and (implicit) port**
`http://**en**.website.com/example`	No: different domain
`http://**www**.website.com/example`	No: different domain
`http://website.com:**8080**/example`	No: different port

Note: implicit ports for http (80) and https (443)

https://portswigger.net/web-security/cors/same-origin-policy

Same Origin Policy (SOP)



```
<script src= … >
…
<img src= … >
…
<link rel=stylesheet
href=…  >
```

Everything is allowed: **Same Origin Policy (SOP)**

Resources are rendered and incorporated in the page but cannot be accessed by DOM and JS

What if they also need to be accessed?

Handling the Cross-Origin situation

- Option #1: do NOT load data except from the initial server (which is trusted by definition)
  - This approach is **too limiting** for modern web application where data can reside on (several) different web servers
- Option #2: Find a mechanism to allow Cross-Origin data access in a controlled fashion
  - Allow to separate the load onto different servers
  - Allow to use any other server, in particular API servers (even 3rd party ones, even more than one)

Mozilla Developer Network:
Web technology for developers —
HTTP — Cross-Origin Resource Sharing (CORS)
https://developer.mozilla.org/en-US/docs/Web/HTTP/CORS

Accessing multiple websites

CROSS-ORIGIN REQUEST SHARING (CORS)

Solving the Cross-Origin Issue: CORS

- Cross-Origin Resource Sharing (**CORS**): a **standard** mechanism to **handle cross-domain requests**
- CORS defines a **set of HTTP headers** that allow the browser and server to communicate about which requests are safe to be accessed by DOM and JS
- The **server** defines which origins are accepted for any request

https://developer.mozilla.org/en-US/docs/Web/HTTP/CORS

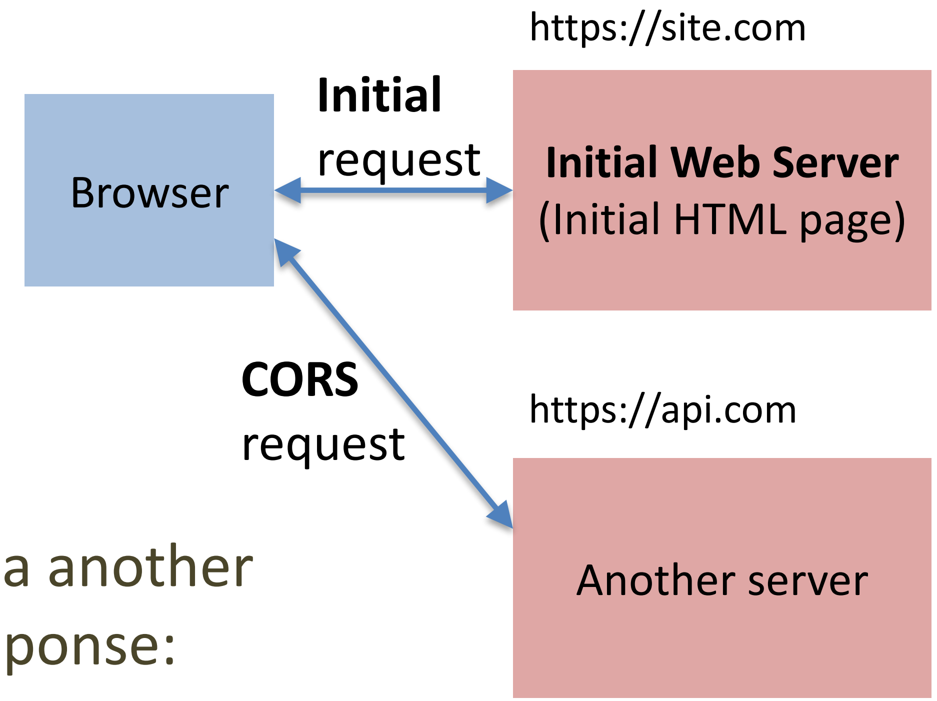
https://fetch.spec.whatwg.org/#http-cors-protocol

CORS in Practice

- The browser knows that the request is addressed to a different origin, i.e., it is a CORS request
- The browser sends the request including the origin by means of a specific HTTP header:

  `Origin:` `https://site.com`
- The *Response* from the receiving server includes, via another header, which origins can access the data in the response:

  `Access-Control-Allow-Origin:` `https://site.com`
- If the two match, the **browser** allows the DOM and JS to access the response
  – Otherwise, the content cannot be accessed, it will appear as "failed to load"



No CORS outside browsers

- CORS DOES NOT APPLY when making requests outside browsers
  - curl, wget, REST Client, etc., do not care about the extra headers
  - origin = null for the server receiving the request if the `Origin:` header is missing
- The `Origin:` header can be set to any value by external programs
  - It CANNOT be used as a security mechanism
  - The web server must rely on proper security mechanisms to authorize data access (cookies etc.)

CORS Preflight Requests

- The `Access-Control-Allow-Origin` value is not known before the browser sends an actual request
- What if a browser sends private information to servers that do not allow its `Origin`?
- Before sending requests with *private/sensitive information*, the browser always checks if such a request is safe to send by means of the HTTP “OPTION” method
  - Example: when doing POST, PUT, requests with special (e.g. cookie) headers, …
- Such cross-site requests are said "*preflighted*"
- This is **performed automatically** by the browser for every request
  - Need to know because it might impact application performance (2 HTTP exchanges vs 1)

https://developer.mozilla.org/en-US/docs/Web/HTTP/CORS

CORS Preflight example

```
// fetch https://api.com/the/resource/you/request with method POST

OPTIONS /the/resource/you/request
Access-Control-Request-Method: POST
Access-Control-Request-Headers: origin, x-requested-with, accept
Origin: https://an-origin.com
```

```
// Response from https://api.com/the/resource/you/request

HTTP/1.1 200 OK
Access-Control-Allow-Origin: https://an-origin.com
Access-Control-Allow-Methods: POST, GET, OPTIONS, DELETE
```

https://flaviocopes.com/express-cors/

CORS with Authentication

- By default, fetch requests do not send credentials (e.g., cookies)
- If needed, `fetch` has an option in the `init` object to include them
- Values: `'omit'` (default), `'same origin'` (send only in requests to the same origin), `'include'`

```
fetch('https://example.com', {
  …
  credentials: 'include'
  …
});
```

CORS with <script> tags

- Scripts loaded via `<script>` tag from <u>other origins</u> run with the same privileges of the other scripts in the web application
- Only load scripts you trust, and always include the integrity attribute to prevent malicious code injection
  - Note: to make the browser check the integrity attribute, the `crossorigin` attribute MUST be set (to “anonymous”), otherwise the integrity will not be checked
  - Note that in this case the server must send

```
HTTP/1.1 200 OK
Access-Control-Allow-Origin: *
```

```
<script
src="https://cdn.jsdelivr.net/npm/bootstrap@5.3.3/dist/js/bootstrap.bundle.min.js"
integrity="sha384-YvpcrYf0tY3lHB60NNkmXc5s9fDVZLESaAA55NDzOxhy9GkcIdslK1eN7N6jIeHz"
crossorigin="anonymous"></script>
```

https://developer.mozilla.org/en-US/docs/Web/Security/Subresource_Integrity

Loading modules via script tag

- Modules loaded via `<script>` are subject to CORS rules
- Unfortunately, modules loaded from the file system have **origin `null`** so browsers prevent module loading **even from local file system** (file:// URI)
- Solution: serve content from a (local) web server as static files

```
<body>
 ...
 <script type="module" src="main.js"></script>
 <script type="module" src="index.js"></script>
</body>
```

```
// In index.js:
import * as jsdom from 'main.js';  // import requires the .js be loaded as a module
```

https://github.com/expressjs/cors

https://flaviocopes.com/express-cors/

Controlling Allowed Origins in your Server

CORS ON THE SERVER SIDE

Enabling CORS in Express application

- Use the middleware `cors`
  - http://expressjs.com/en/resources/middleware/cors.html
  - `npm install cors`

```
const express = require('express');
const cors = require('cors');
const app = express();

app.use(cors());  // Careful: enables all origins
```

Simple Usage

- Enable **CORS for all** requests (for the app server)

  ```
  app.use(cors())
  ```

  By default, **all origins** will be enabled for all HTTP methods

  Also, enabling it as application-level middleware (i.e., `app.use(…)`) automatically handles preflight requests for all routes

- Enable CORS for a **Single Route**

  ```
  app.get('/products/:id', cors(), function (req, res, next) {
    …
    res.json({msg: 'This is CORS-enabled for a Single Route'})
  })
  ```

http://expressjs.com/en/resources/middleware/cors.html#enabling-cors-pre-flight

Configuration options

- The `cors(options)` call accepts a JS configuration object
- Always specify the allowed origins (as a string, function, regexp, array)
  - E.g., `"origin": "https://appwebsite.com"`
- May specify the allowed methods
- May fine-tune allowed headers and credentials *(more on this later)*

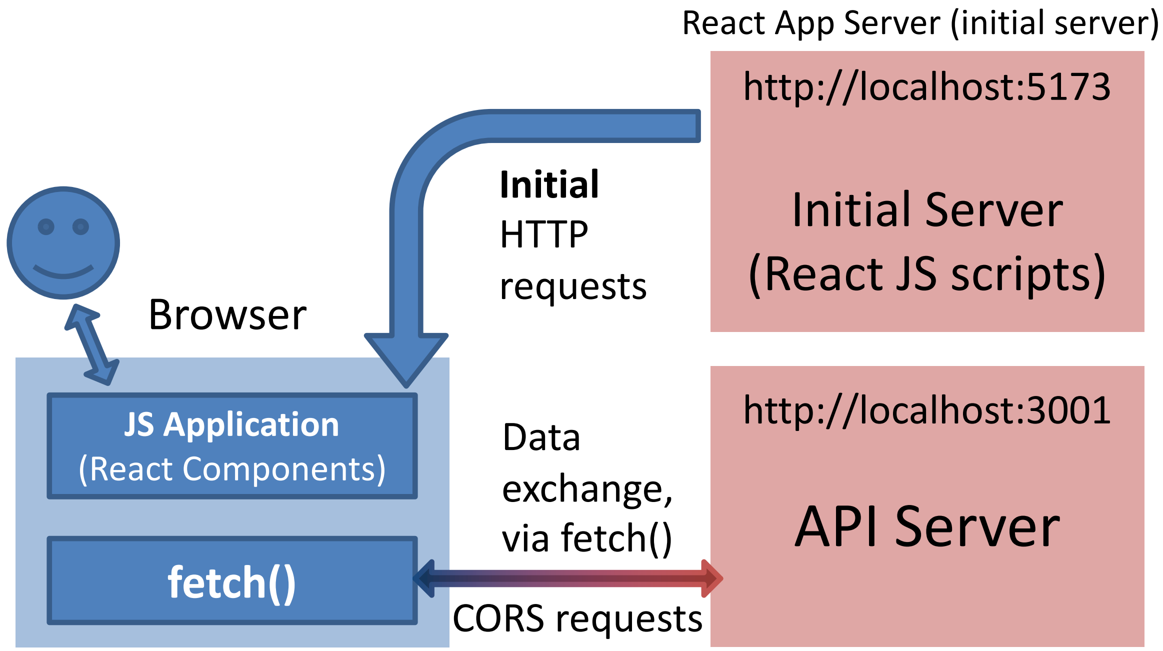
Default configuration options

```
{
  "origin": "*",
  "methods": "GET,HEAD,PUT,PATCH,POST,DELETE",
  "preflightContinue": false,
  "optionsSuccessStatus": 204
}
```

https://expressjs.com/en/resources/middleware/cors.html

CORS with React App

- There is a CORS issue: 2 servers (React dev server and API server)
- Remember that:
  - The server must be configured to accept CORS requests
  - The client will also need to use “credentials: include” if fetching from authenticated endpoints *(reminded later in the course)*



React App Server (initial server)
http://localhost:5173
Initial Server (React JS scripts)
Initial HTTP requests
Browser
JS Application (React Components)
fetch()
Data exchange, via fetch()
CORS requests
http://localhost:3001
API Server

```
const express = require('express');
const cors = require('cors');
const app = express();
const corsOptions = {
  origin: 'http://localhost:5173',
  credentials: true,
};
app.use(cors(corsOptions));
```

https://expressjs.com/en/resources/middleware/cors.html

References

- A tutorial on CORS
  - https://auth0.com/blog/cors-tutorial-a-guide-to-cross-origin-resource-sharing/
- https://portswigger.net/web-security/cors
- https://github.com/expressjs/cors
- https://flaviocopes.com/express-cors/
- https://owasp.org/www-community/attacks/CORS_OriginHeaderScrutiny
- https://owasp.org/www-project-web-security-testing-guide/latest/4-Web_Application_Security_Testing/11-Client-side_Testing/07-Testing_Cross_Origin_Resource_Sharing
- https://en.wikipedia.org/wiki/Cross-origin_resource_sharing

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