IN4MATX 133: User Interface Software

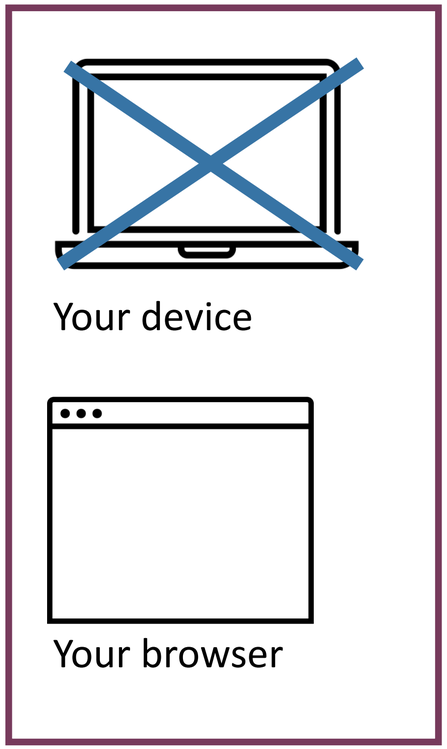
Lecture:
Server-Side Development

Goals for this Lecture

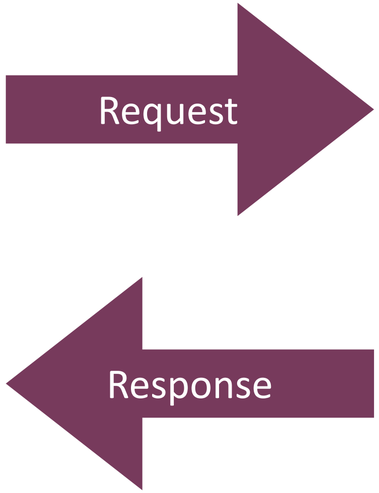
By the end of this lecture, you should be able to…

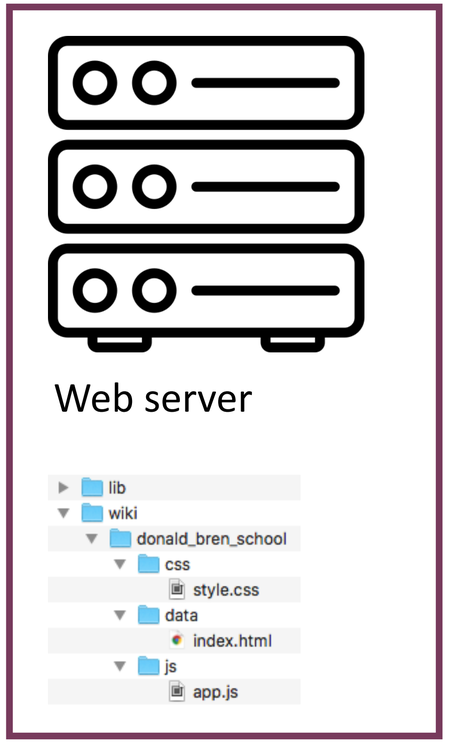
- Explain the advantages and disadvantages of different tools for server-side development
- Differentiate authentication from authorization
- Describe the utility of supporting authentication and authorization in interfaces
- Explain and implement the different stages to authenticating via OAuth
- Describe the advantages and disadvantages of OpenId

Client-side and server-side JavaScript



Edit what's being rendered
Trigger or react to events





Navigate file system programmatically
Dynamically generate pages or views
Transport, store, or interact with data

Client-side

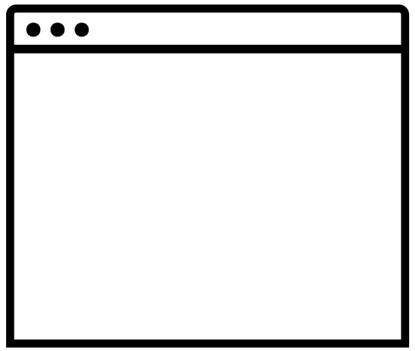
- Runs in the browser
- Changes happen in real-time in the browser
- Cannot make HTTP requests to many APIs
- Examples: AJAX, Angular, React, Vue.js

Server-side

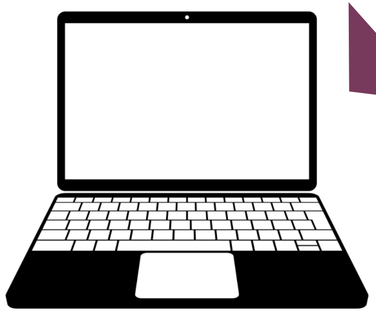
- Runs in the command line, etc. (but maybe can still be accessed from the browser)
- Changes happen in response to HTTP requests
- Can make HTTP requests to most APIs
- Examples: Node, ASP.NET

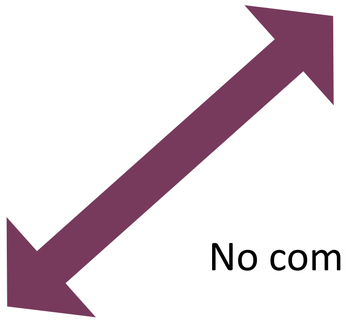
Servers on localhost

- Localhost: “this computer”

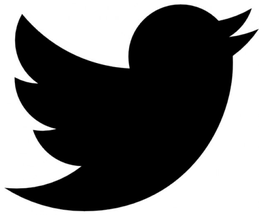


Same domain (localhost), so they can communicate





No communication restrictions



Live server: localhost:8080

Twitter proxy: localhost:7890

Browser implements same-origin policy to protect the other data you have open in the browser

No same-origin policy restrictions, can communicate with Twitter

Server-side development: Node.js

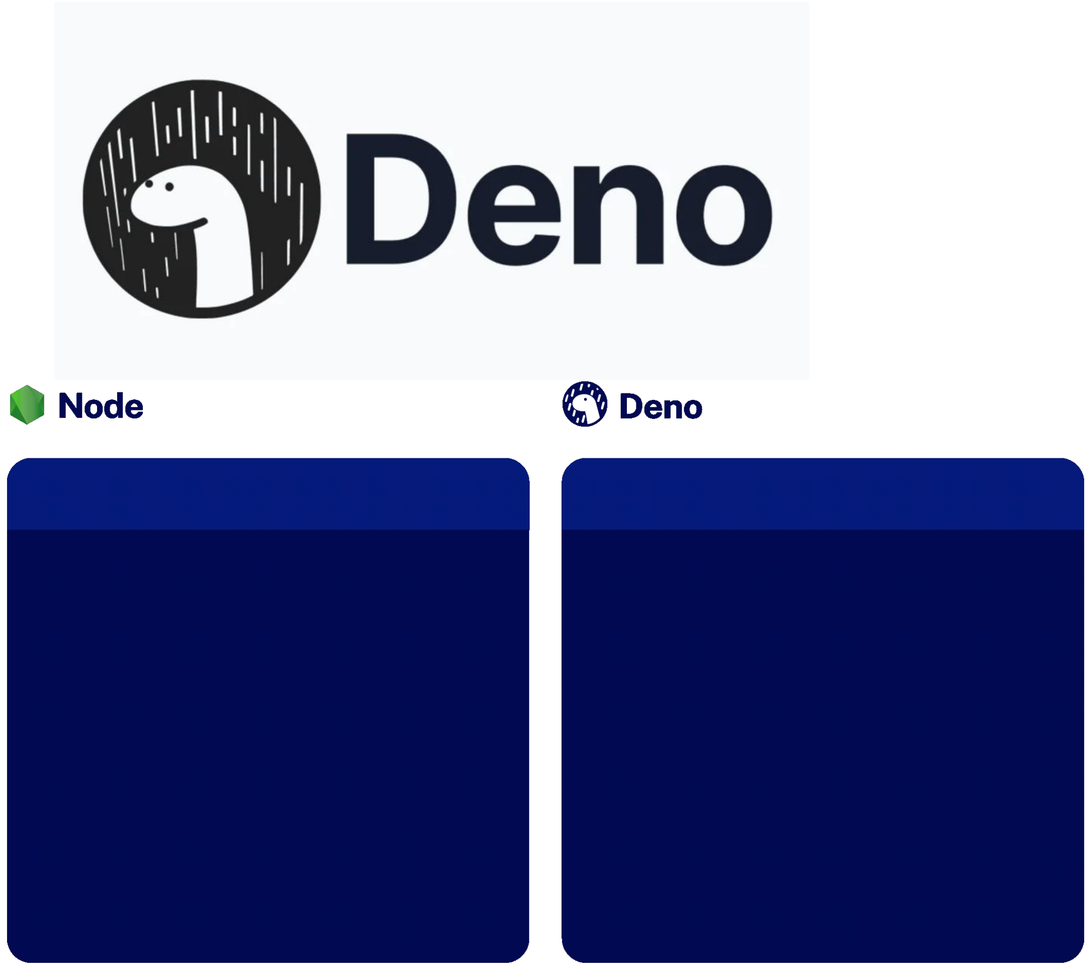
- Event-driven, non-blocking
  I/O model makes it efficient
- Best for highly-interactive pages
  - When a lot of computation is required,
    other frameworks are better
  - Event-driven loops are inefficient
- Lower threshold for us:
  we're already learning JavaScript!

Other server-side environments

- Ruby, via Ruby on Rails
- Python, via Django or Flask
- PHP, Laravel (and others)
- These days, you can create a dynamic website in almost any language
- https://developer.mozilla.org/en-US/docs/Learn/Server-side/First_steps/Web_frameworks

Other server-side environments

- A note on Deno
  - Evolution of Node (project lead by same person, Ryan Dahl)
  - A complete rewrite improving on mistakes made in Node.
  - JavaScript V8, TypeScript built-in
  - Young, but promising…



Node package manager (npm)

- Included in the download of Node
- Originally libraries
  specifically for Node
- Now includes
  many JavaScript packages

Node.js hello world

```
var http = require('http');
```

Require the http library

Node.js hello world

```
var http = require('http');
var server = http.createServer(function(req, res) {


});
```

Require the http library

Anonymous function with
request and response parameters

Node.js hello world

```
var http = require('http');
var server = http.createServer(function(req, res) {
  res.writeHead(200);
  res.end('Hello World');
});
```

Require the http library

Anonymous function with request and response parameters

"Ok" status in the header, write hello world text

Node.js hello world

```
var http = require('http');
var server = http.createServer(function(req, res) {
  res.writeHead(200);
  res.end('Hello World');
});
server.listen(8080);
```

Require the http library

Anonymous function with request and response parameters

"Ok" status in the header, write hello world text

Listen on port 8080

Remember, Node.js is server-side JavaScript

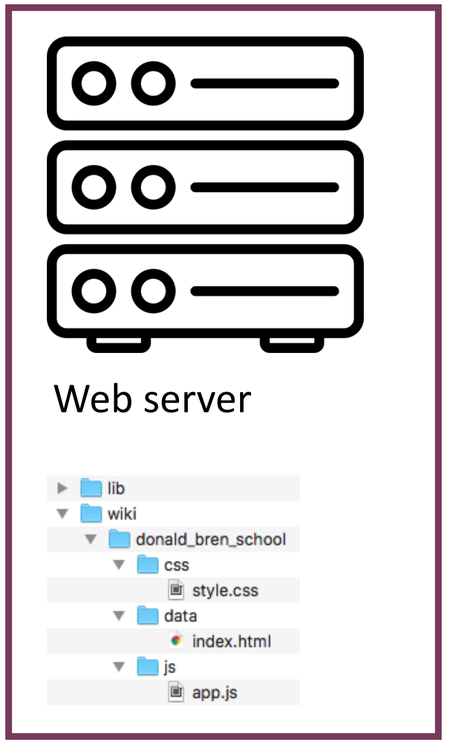
Where is the JavaScript running?

Server-side

```
node hello.js
```

hello.js:

```
var http = require('http');
var server = http.createServer(function(req, res) {
  res.writeHead(200);
  res.end('Hello World');
});
server.listen(8080);
console.log('Hello, console');
```



Node is listening on port 8080. But the JavaScript is **not** running in the browser.
It's running on the server.

Where is the JavaScript running?

Client-side

```
live-server
```

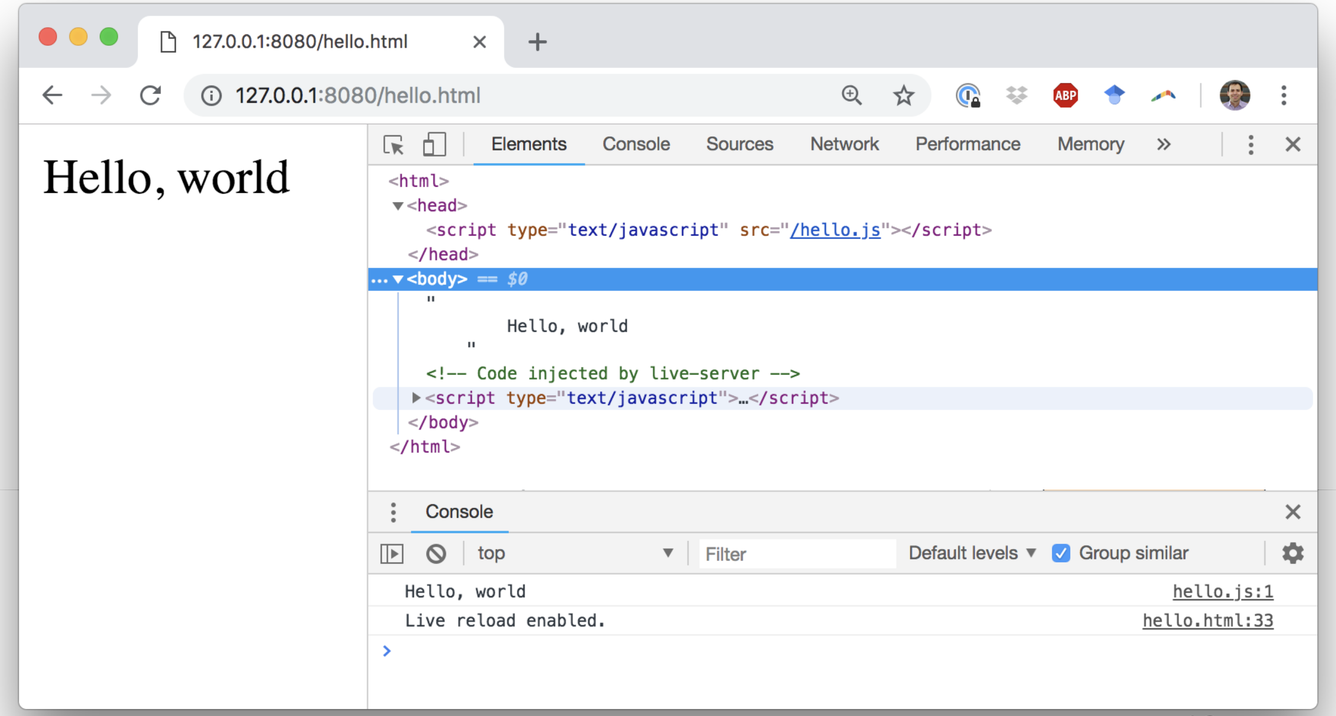
hello.html:

```
<html>
  <head>
    <script src="./hello.js"></script>
  </head>
  <body>
    Hello, world
  </body>
</html>
```

Live-server is listening on port 8080. The JavaScript is running in the browser.

hello.js:

```
console.log('Hello, world');
```



What does Node.js add?

- OS-level functionality like reading and writing files
- Tools for importing and managing packages
- The ability to listen on a port as a web server
- But it’s just JavaScript, and it’s pretty basic as a web framework

What does a “good” server-side web framework need?

- To speak in HTTP
  - Accept connections, handle requests, send replies
- Routing
  - Map URLs to the webserver function for that URL
- Middleware support
  - Add data processing layers
  - Make it easy to add support for user sessions, security, compression, etc.
- Node.js has these, but they’re somewhat difficult to use

We’ll dive into how Node plugins address this issue on Friday.

Switching topics: authentication & authorization

What is authentication?

- The process of establishing and verifying identity
- Identification: who are you? (username, account number, etc.)
- Authentication: prove it! (password, PIN, etc.)

What is authorization?

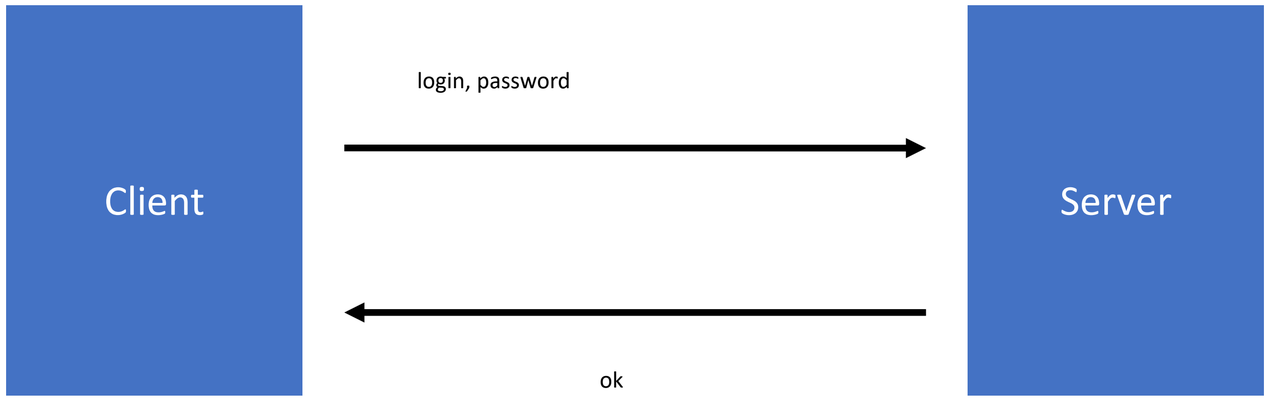
- Once we know a user's identify,
  we must decide what they are allowed to access or modify
- One way is the app defines permissions upfront based on a user's role
  - A student can access their own grades, but not modify them
  - A TA and a professor can access and modify everyone's grades
- Another way is for the app to request the user grant certain permissions
  - A Twitter app may ask, "can I Tweet on your behalf?"

Multi-factor authentication

- Should be a mix of things that you *have/possess* and things that you *know*
- ATM machine: 2-factor authentication
  - ATM card: something you *have*
  - PIN: something you *know*
- Password + code delivered via SMS: 2-factor authentication
  - Password: something you *know*
  - Code: validates that you *possess* your phone
- Two passwords != Two-factor authentication

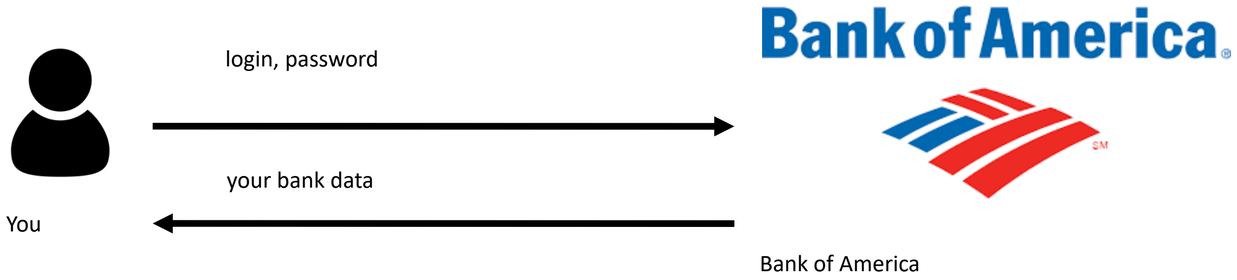
Password protocol

- Send a login and a password to a server
- Server checks your credentials and okays you
- Need to trust that the server is storing your password securely



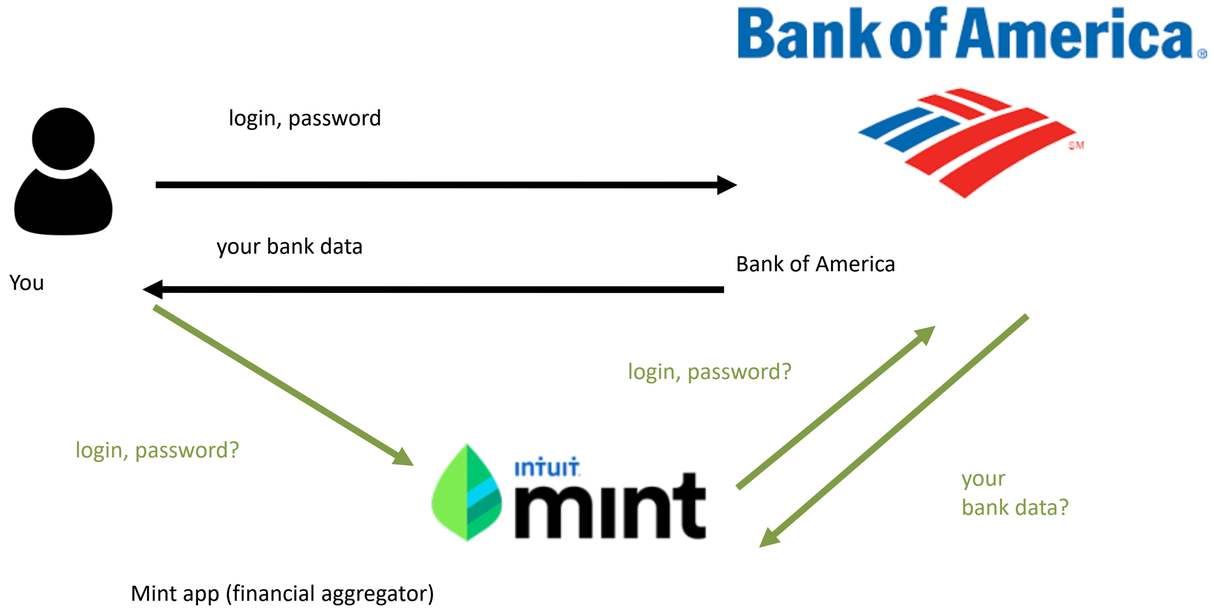
Password protocol: sending data

- Once you've logged in,
  the server can send you whatever data you're allowed to see



Sending data to a third party

- You want to send data that a server has to a third party
  - You could give them your username and password…
  - **Why is this a bad idea?**



Sending data to a third party

- Now you have to trust *another* service to manage your password
- What if you don’t want them to have full access?
  - e.g., you want Mint to load your savings account but not your checking account
- What if you want to revoke access later?
  - Can change your password, but that’s not a good solution

Oauth 2.0

- Open authentication
- Goal: support users in granting access to third-party applications
  - Do not require users to share their passwords with the third-party applications
  - Allow users to revoke access from the third parties at any time

Oauth 2.0 history

- There was a 1.0
  - It was complex (worse than 2.0)
  - It had security vulnerabilities
  - It shouldn’t be used anymore
- Google, Twitter, & Yahoo! teamed up to propose 2.0
- 2.0 is not compatible with 1.0

https://en.wikipedia.org/wiki/OAuth#OAuth_2.0

Oauth 2.0 terminology

- Client
  - Third-party app who wants to access resources owned by the *resource owner* (e.g., app you develop)
- Resource owner (user)
  - Person whose data is being accessed, which is stored on the *resource server*
- Resource server
  - App that stores the resources (e.g., Spotify, Google, Facebook)
- Authorization and Token endpoints
  - URIs from where a resource owner authorizes requests

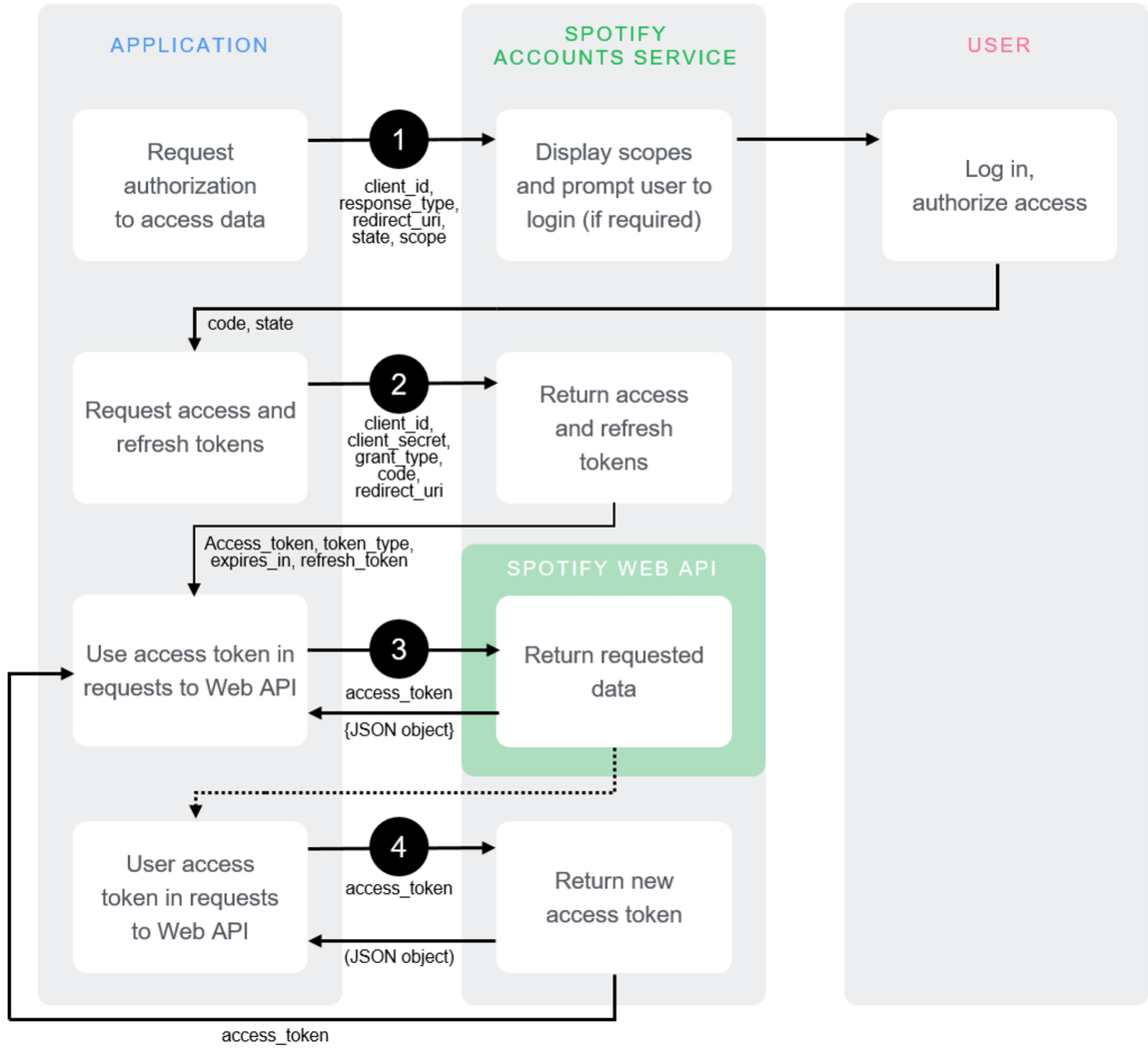
Oauth 2.0 terminology

- Authorization code
  - A string the client uses to request access tokens
- Access token
  - A string the client uses to access resources (e.g., songs on Spotify, Tweets, etc.)
  - Expires after some amount of time
- Refresh token
  - Once the access token expires, can be exchanged for a new access token

Oauth 2.0 steps

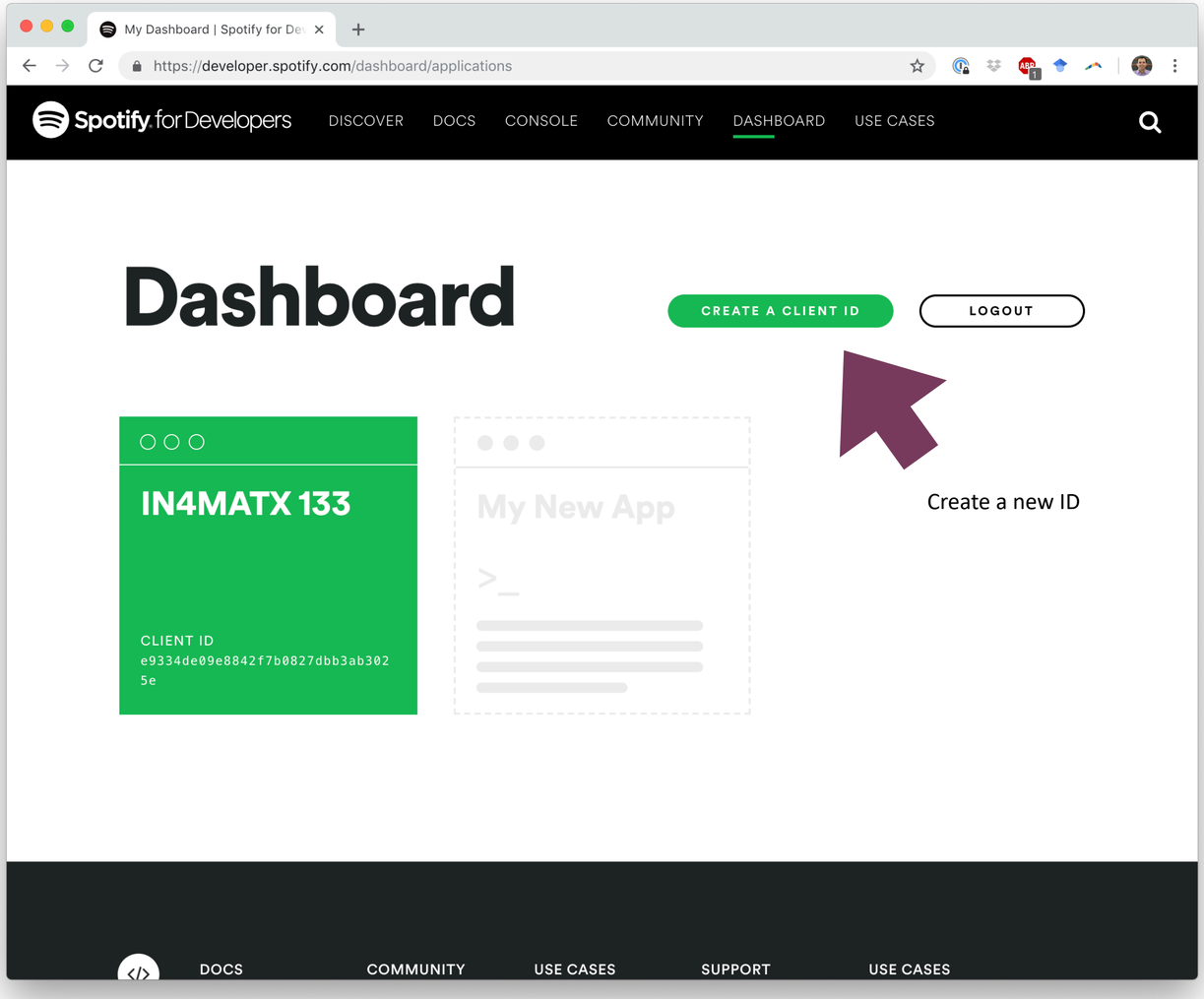
1. Request authorization
2. Get access token
3. Make API calls
4. Refresh access token

Oauth 2.0 steps



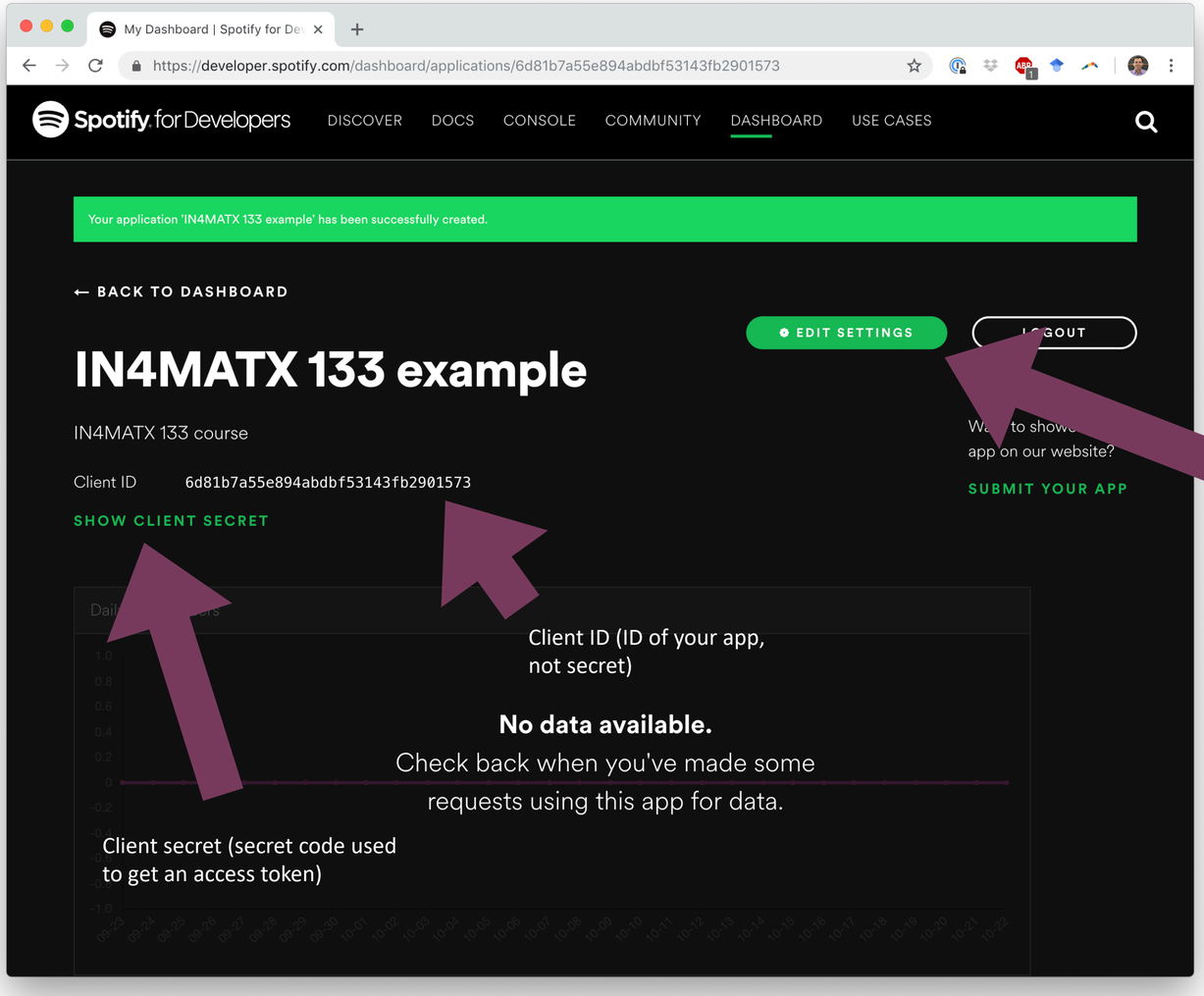
https://developer.spotify.com/documentation/general/guides/authorization-guide/

Oauth 2.0 and Spotify



https://developer.spotify.com/dashboard/

Oauth 2.0 and Spotify



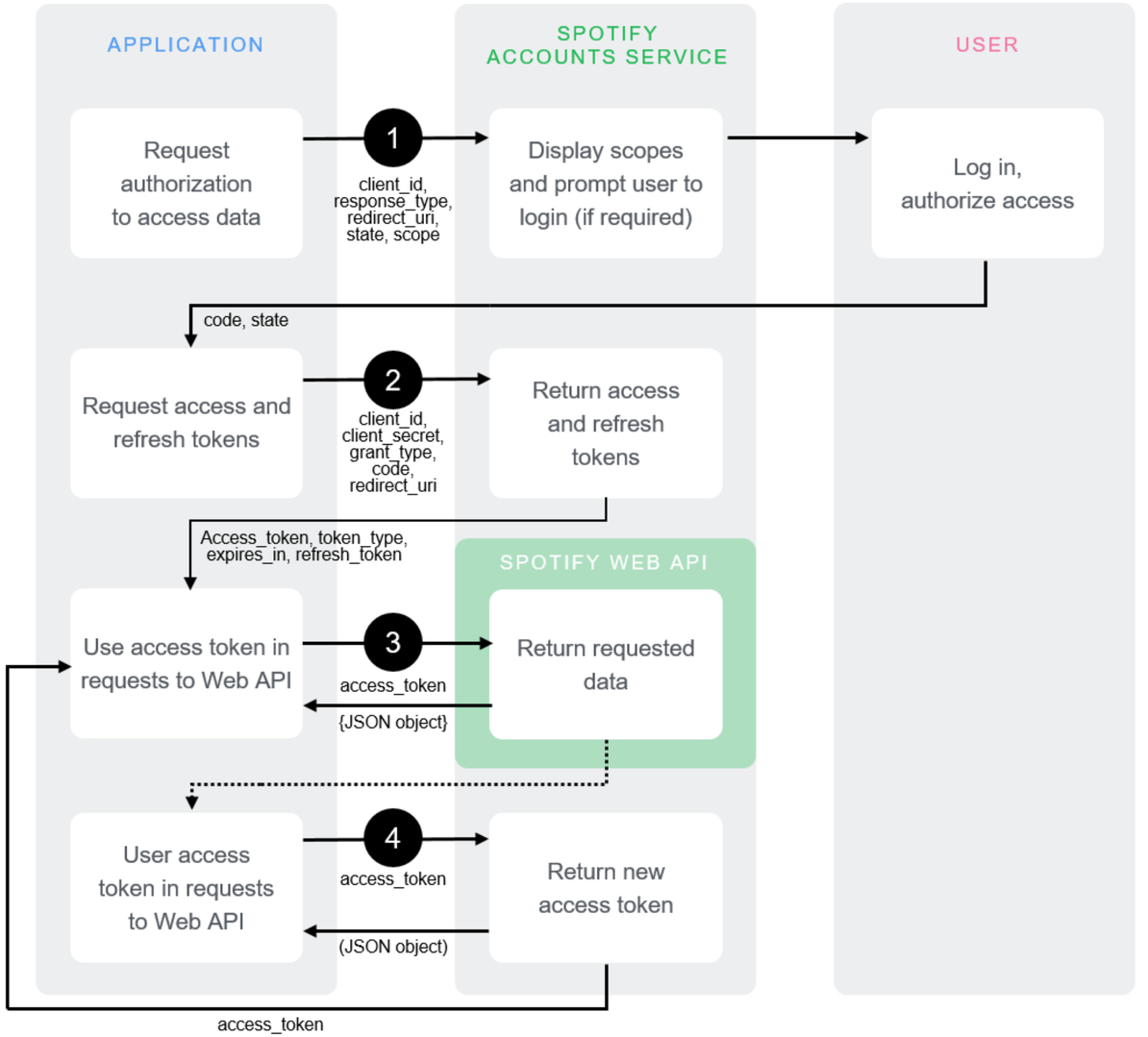
Need to specify what URI to return to (redirect URI)

https://developer.spotify.com/dashboard/

Oauth 2.0 on server-side JavaScript

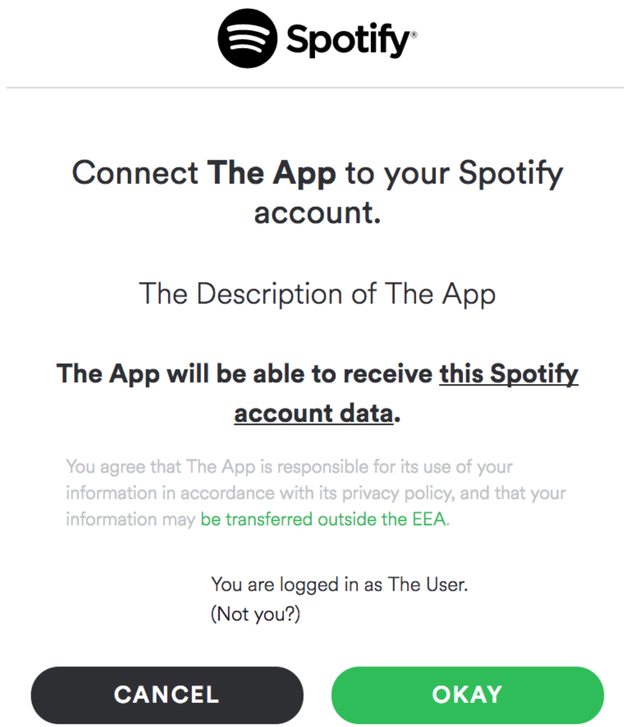
- This example will walk through the Oauth flow for server-side JavaScript (like Node.js/Express)
- There are browser-side ways of doing (some parts of) Oauth
- For A3, you'll send all browser-side requests to a Node.js/Express server

Step 1: request authorization to access data



Requesting authorization

- Make a page with links to Spotify's authorization endpoint (https://accounts.spotify.com/authorize/)
- Pass arguments in the query string
  - Client ID (public ID of your app)
  - Response type (string "code")
  - Redirect URI (where to return to)
  - Scope (what permissions to ask for)



https://developer.spotify.com/documentation/general/guides/authorization-guide/

Requesting authorization

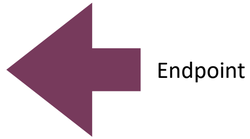
- `https://accounts.spotify.com/authorize?response_type=co`

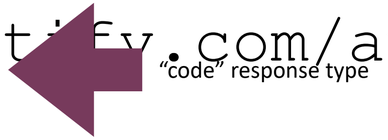
  `de&`

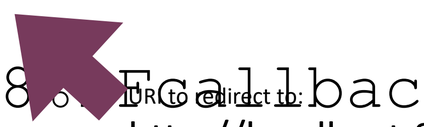
  `client_id=6d81b7a55e894abdbf53143fb2901573&`

  `scope=user-read-private%20user-read-email&`

  `redirect_uri=http%3A%2F%2Flocalhost%3A8888%2Fcallback`







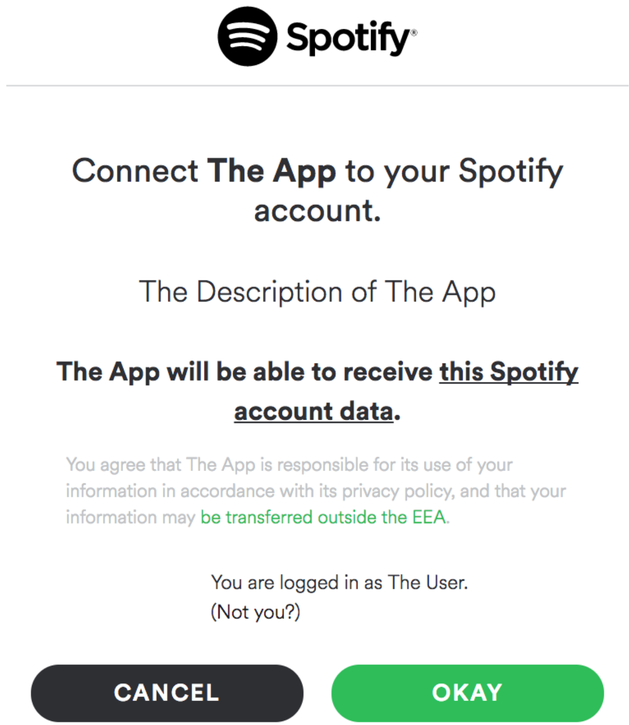
- Escaping characters: `encodeURIComponent()`

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/encodeURIComponent

https://developer.spotify.com/documentation/general/guides/authorization-guide/

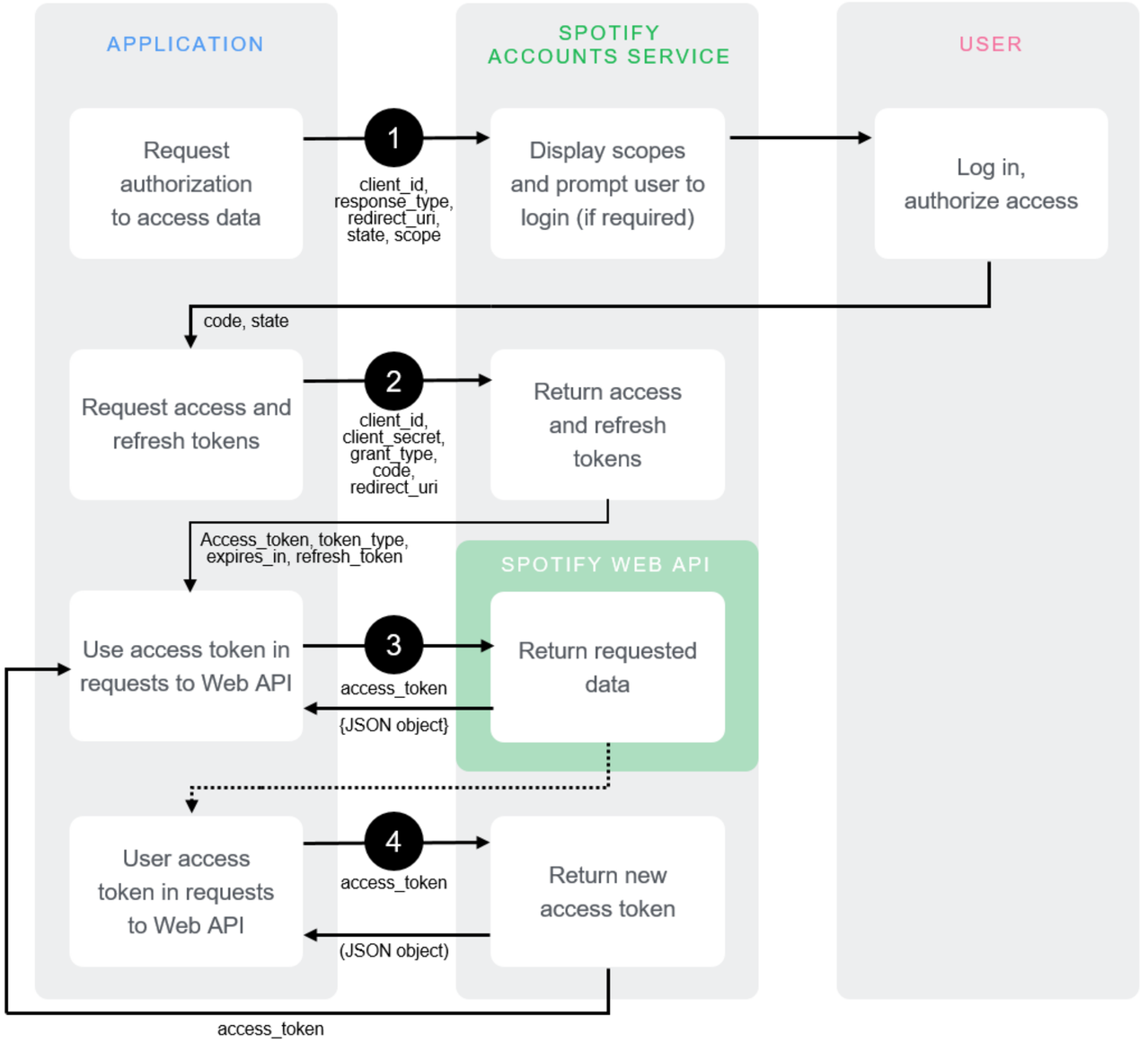
Handling response

- User clicks “okay”, browser then redirects back to your server
- The response contains additional parameters in the URL
- `http://localhost:8888/callback?code=...`
- In Express, `code` can be accessed through `req.query`



https://developer.spotify.com/documentation/general/guides/authorization-guide/

Step 2: request access and refresh tokens

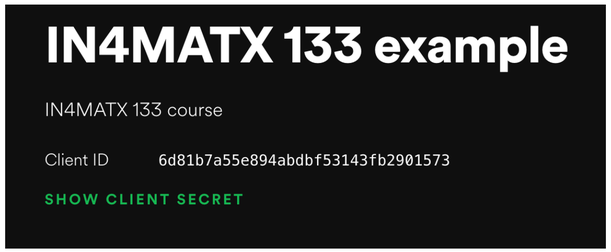


Requesting an access token

- Our goal: trade `code` for an access token
  - An access token needs to be included in API requests
- Why do we need to do this?
  - The user has granted permission for the ID we created on Spotify to access resources
  - But any website could send a user to that URL: client IDs, etc. is all public information
  - How can we verify our app uses the client ID we created on Spotify?

https://developer.spotify.com/documentation/general/guides/authorization-guide/

Requesting an access token



- We make a `POST` request with our client's secret code and ask for an access token
  - Endpoint: https://accounts.spotify.com/api/token
- Why a `POST` request rather than a `GET`?
  - `POST` sends content in the body of an HTTP request (cannot be read by someone watching your web traffic)
  - `GET` sends content in the URI
    - `https://accounts.spotify.com/authorize?response_type=code&client_id=6d81b7a55e894abdbf53143fb2901573`

https://security.stackexchange.com/questions/33837/get-vs-post-which-is-more-secure

https://developer.spotify.com/documentation/general/guides/authorization-guide/

Requesting an access token

- Body of `POST` request requires 3 parameters
  - Grant type (string “authorization_code”)
  - Code (returned as a parameter in the response from the authorization request)
  - Redirect URI (must be the same as before)
- Header of `POST` request requires 2 parameters
  - Authorization (concatenation of client ID and client secret, as a Buffer)
  - Encoding (via Content-Type, as “*application/x-www-form-urlencoded*”)

https://developer.spotify.com/documentation/general/guides/authorization-guide/

Requesting an access token

- Making the body: URLSearchParams
  - `params = new URLSearchParams();`
  - `params.append('grant_type', 'authorization_code');` etc.
- Header: a dictionary
  - `'Content-Type':'application/x-www-form-urlencoded'`
  - `'Authorization': 'Basic ' + Buffer.from(my_client_id + ':' + my_client_secret).toString('base64')`

https://www.w3schools.com/nodejs/met_buffer_from.asp

https://developer.mozilla.org/en-US/docs/Web/API/URLSearchParams

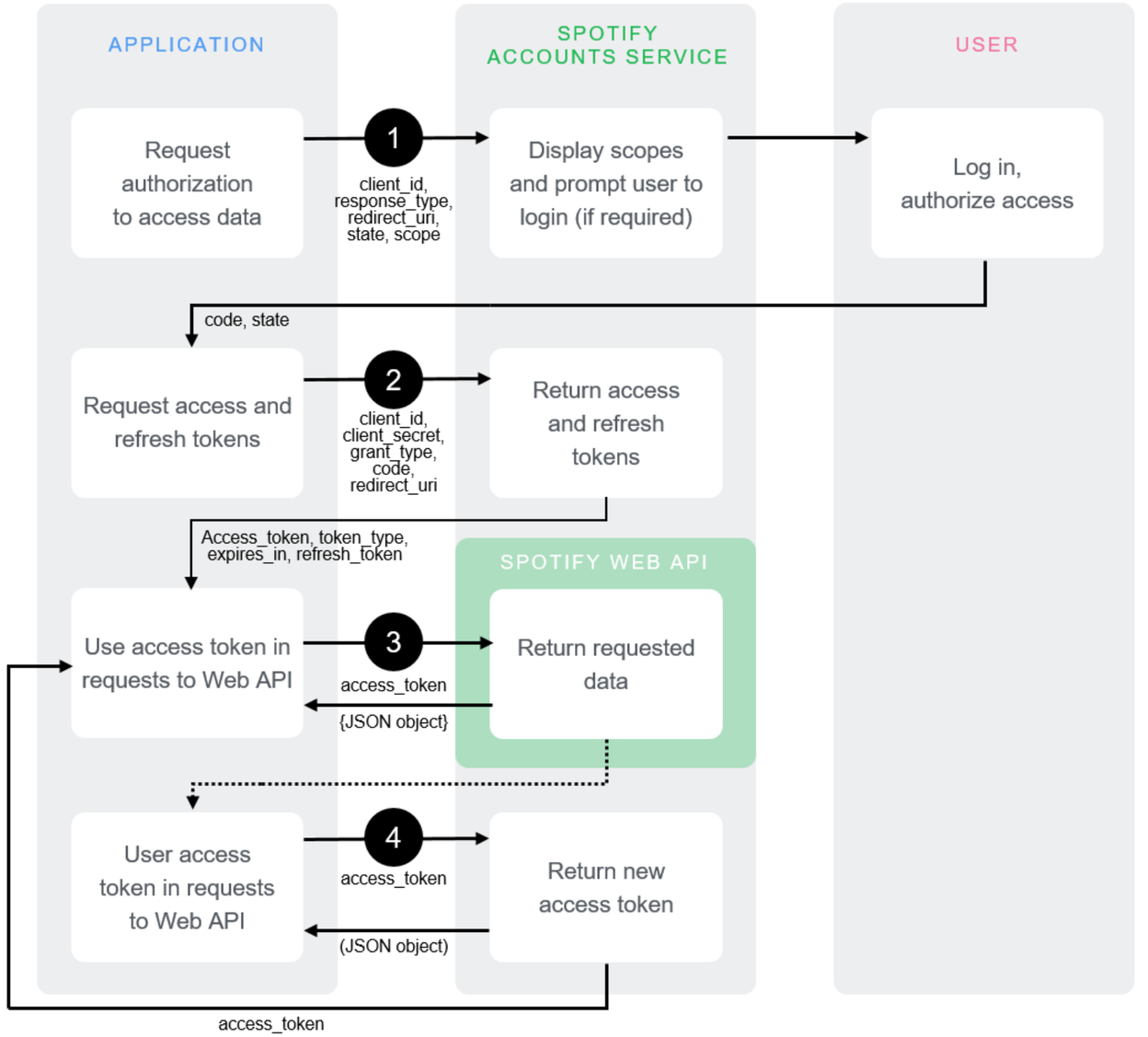
https://developer.spotify.com/documentation/general/guides/authorization-guide/

Handling response

- In the response body, Spotify sends back:
  - Access Token (needed to make API calls)
  - Expires in (how long the access token is good for)
  - Refresh Token (once the Access Token expires, this can be used to get a new one)
- What would you do with these tokens?
  - Store them in a database for later access
  - In A3, we'll store them in a text file (bad form, but easier)

https://developer.spotify.com/documentation/general/guides/authorization-guide/

Step 3: use access token in requests to web API



Making an API request

- Pass the access token in the header
  - Much like the client id and secret, but no need to convert it
  - `'Authorization': 'Bearer ` + access_token`
- Make a `GET` request to one of the API endpoints
  - e.g., https://api.spotify.com/v1/me
  - Will return a JSON object with the requested resource
    - e.g., birthdate, email, a profile image

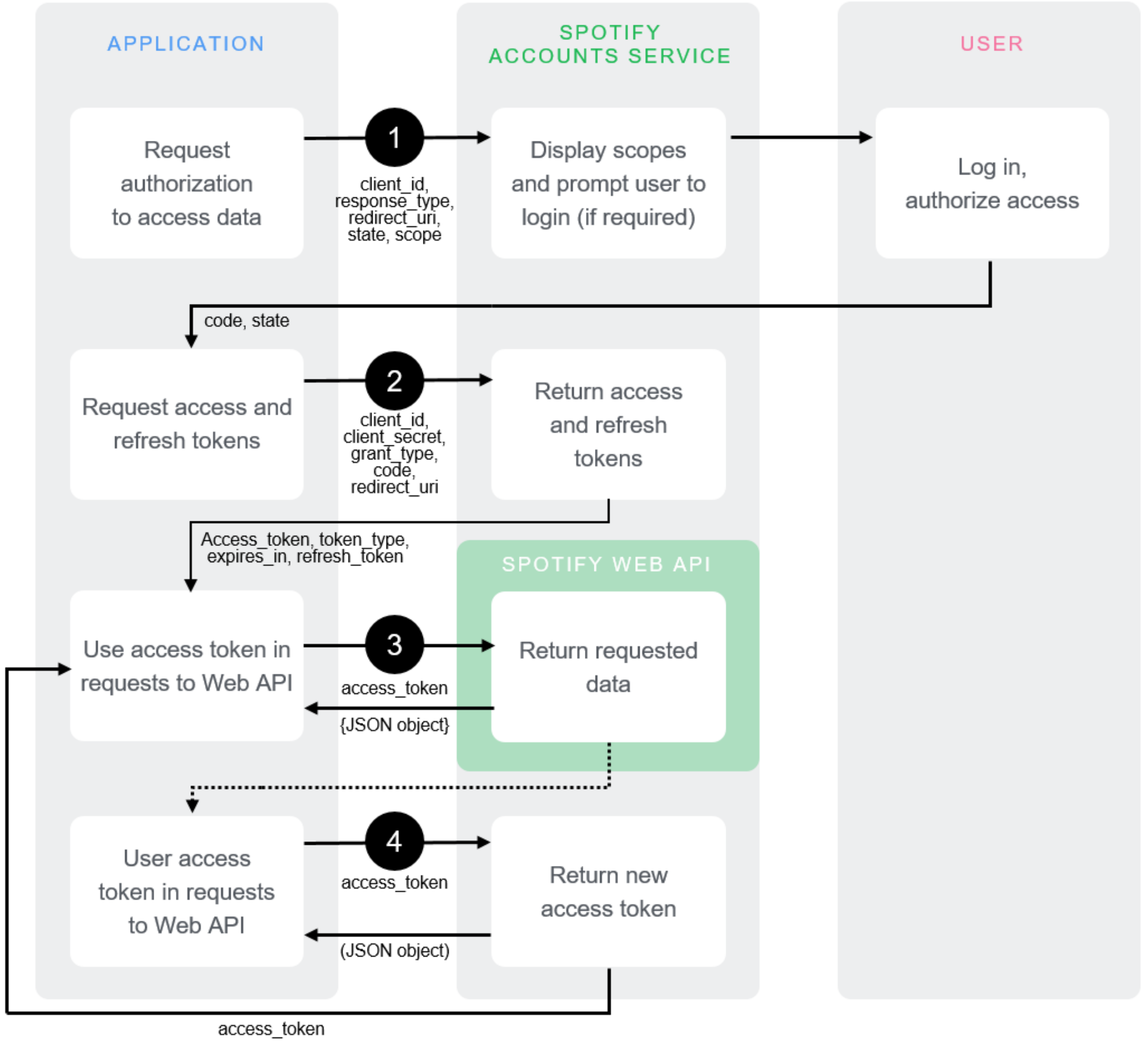
https://developer.spotify.com/documentation/web-api/reference/users-profile/get-current-users-profile/
https://developer.spotify.com/documentation/general/guides/authorization-guide/

Making an API request

- Spotify has endpoints for artists, albums, tracks, and more
- Often specify a subresource in the URI
    - e.g., https://api.spotify.com/v1/albums/{id} for a specific album

https://developer.spotify.com/documentation/web-api/reference/

Step 4: refresh access token



Refresh token

- Tokens typically expire after a fixed amount of time
  - One hour for Spotify tokens
  - After that time, all API requests will return with code `401` (Unauthorized)
- A user can use the refresh token to get a new token
- Why do tokens expire?
  - To allow a user to revoke their privileges

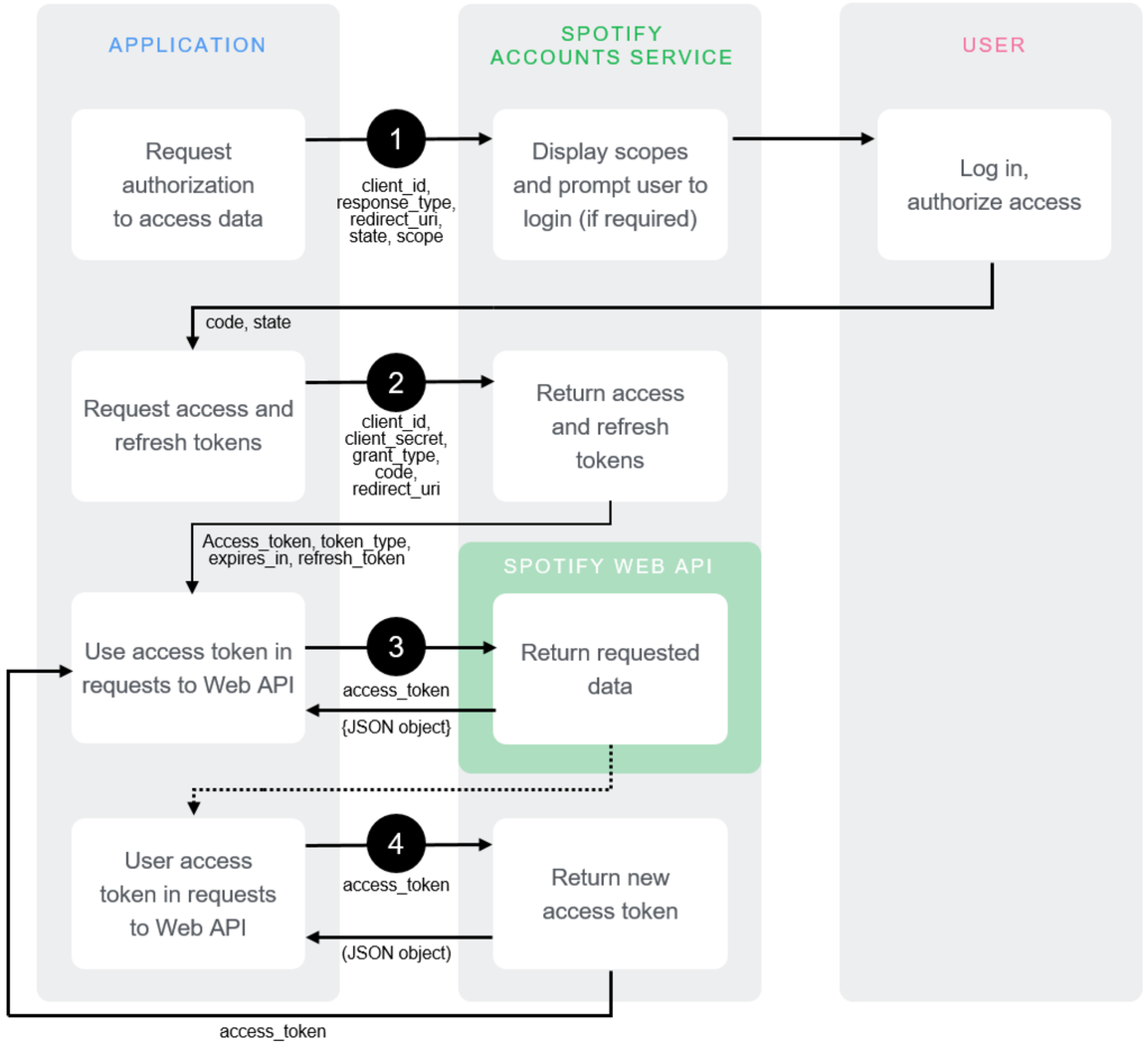
https://developer.spotify.com/documentation/web-api/
https://developer.spotify.com/documentation/general/guides/authorization-guide/

Refresh token

- Same endpoint as requesting an access token
  - Endpoint: https://accounts.spotify.com/api/token
- Similar parameters; header with encoding and authorization
  - `'Content-Type':'application/x-www-form-urlencoded'`
  - `'Authorization': 'Basic ' + Buffer.from(my_client_id + ':' + my_client_secret).toString('base64')`
- Different body parameters
  - “refresh_token” as “grant_type”, the token itself as “refresh_token”

https://developer.spotify.com/documentation/general/guides/authorization-guide/

Oauth 2.0 steps

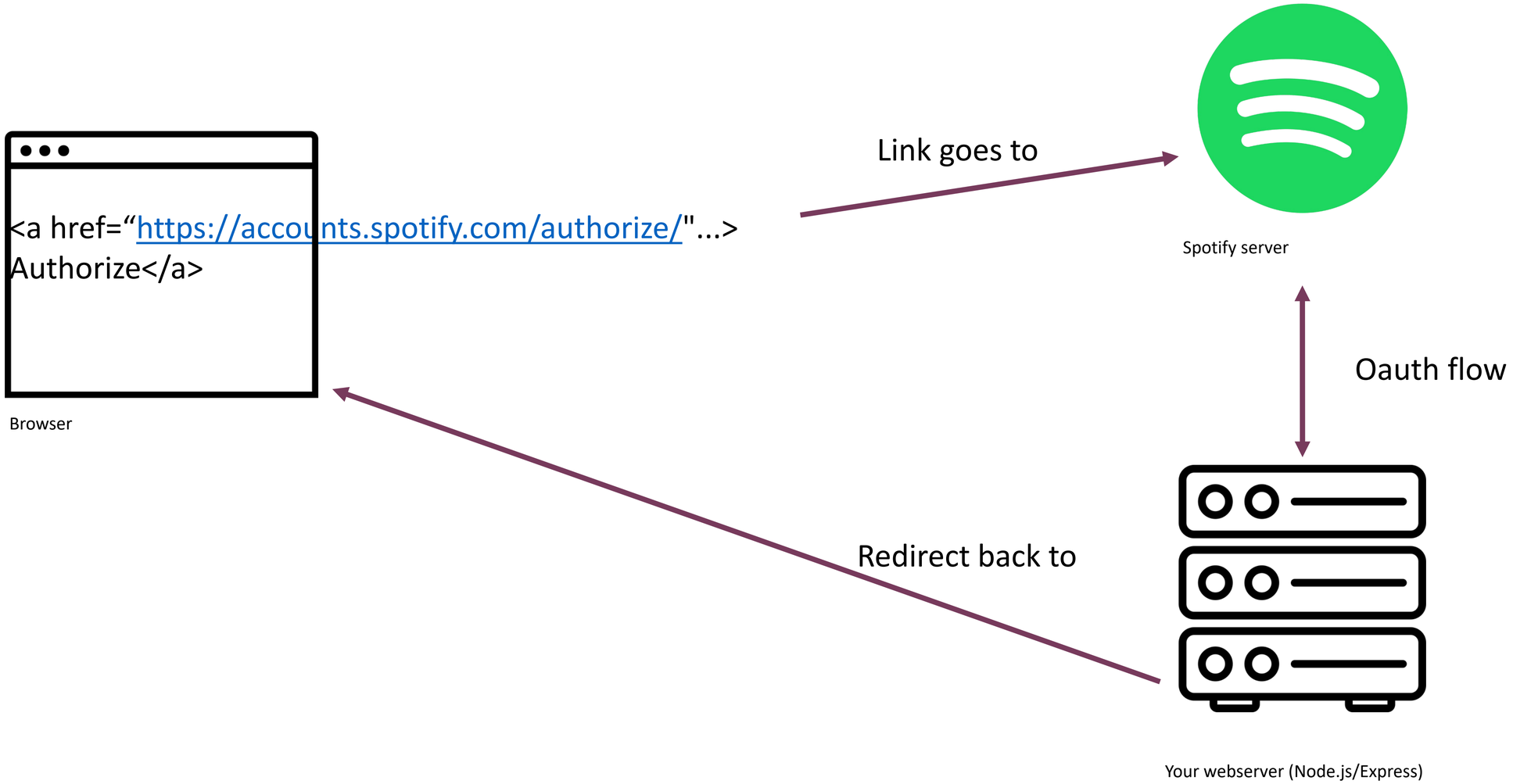


https://developer.spotify.com/documentation/general/guides/authorization-guide/

Authorizing from the browser

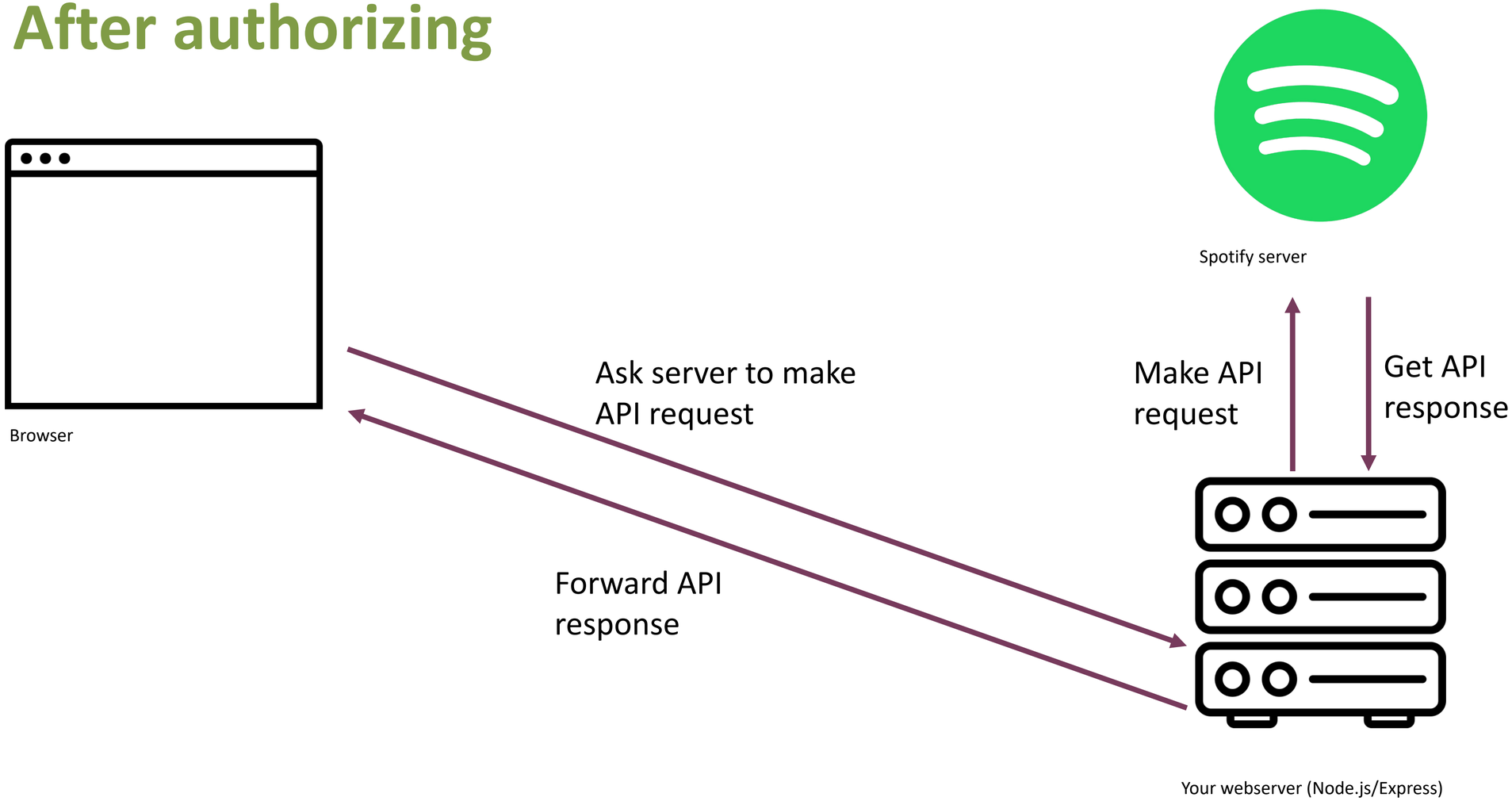
- Create a link to the authorization endpoint (https://accounts.spotify.com/authorize/)
  - Which will redirect to your server-side JavaScript
- Once tokens have been received, redirect back to client-side JavaScript

Authorizing from the browser



Making an API request from the browser

After authorizing



Making an API request from the browser

- How does the browser indicate that it wants the server to make an API request?
  - All web servers communicate in HTTP
  - Make an HTTP request to the server, asking it to make the API request
  - It returns the response

Goals for this Lecture

By the end of this lecture, you should be able to…

- Explain the advantages and disadvantages of different tools for server-side development
- Differentiate authentication from authorization
- Describe the utility of supporting authentication and authorization in interfaces
- Explain and implement the different stages to authenticating via OAuth
- Describe the advantages and disadvantages of OpenId

More on Node and Express

Node file system

```
var fs = require('fs');

fs.readFile("/path/to/file", function(err, data) {
  console.log(data);
});
```

Require the file system library

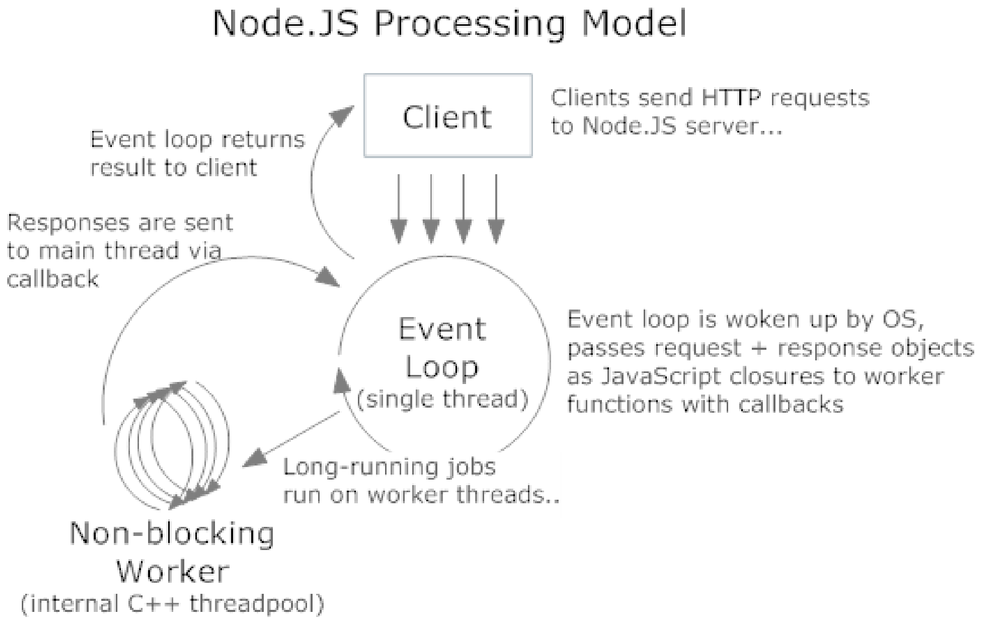
Read file, wait for asynchronous response

Node file system

```
var http = require('http');
var fs = require('fs');
var server = http.createServer(function(req, res) {
fs.readFile(__dirname + req.url, function (err,data) {
    if (err) {
      res.writeHead(404);
      res.end(JSON.stringify(err));
      return;
    }
    res.writeHead(200);
    res.end(data);
  });
});
server.listen(8080);
```

Node processing model

- Requests are handled in a single-threaded event loop
  - Every time someone loads a page node manages, it’s added to this loop
- Requests are then processed asynchronously
  - When the work a request asks for is done, responses are returned to the client



Express.js

- A fairly minimal web framework that improves Node.js functionality
    - Can route HTTP requests, render HTML, and configure middleware

```
var expressApp = express();

expressApp.get('/', function (httpRequest, httpResponse)
{
 httpResponse.send('hello world');
});
expressApp.listen(3000);
```

Express installation

- `npm install express`
  - Will save it to your node_modules folder

Express routing

- By HTTP method

```
expressApp.get(urlPath, requestProcessFunction);
expressApp.post(urlPath, requestProcessFunction);
expressApp.put(urlPath, requestProcessFunction);
expressApp.delete(urlPath, requestProcessFunction);
expressApp.all(urlPath, requestProcessFunction);
```

- urlPath may contain parameters (e.g., `'/user/:user_id'`)

httpRequest object

```
expressApp.get('/user/:user_id', function (httpRequest, httpResponse) …
```

- Has a lot of properties
  - Middleware can add properties
  - `request.params`: object containing url route params (e.g., user_id)
  - `request.query`: object containing query params (e.g., &foo=9 => {foo: ‘9’})
  - `request.body`: object containing the parsed body (e.g., if a JSON object was sent)

httpResponse object

```
expressApp.get('/user/:user_id', function (httpRequest, httpResponse) …
```

- Has a lot of methods for setting HTTP response fields
  - `response.write(content)`: build up the response body with content
  - `response.status(code)`: set the HTTP status code for the reply
  - `response.end()`: end the request by responding to it (the only actual response!)
  - `response.send(content)`: write content and then end
- Methods should be chained

```
response.status(code).write(content1).write(content2).end();
```

Middleware

- Give other software the ability to manipulate requests

```
expressApp.all(urlPath, function (request, response,
next) {
 // Do whatever processing on request (or setting
response)
 next(); // pass control to the next handler
 });
```

Middleware

- Middleware examples:
  - Check to see if a user is logged in, otherwise send error response and don't call `next()`
  - Parse the request body as JSON and attach the object to request.body and call `next()`
  - Session and cookie management, compression, encryption, etc.

Example Express server

```
var express = require('express');
var app = express(); // Creating an Express "App"
app.use(express.static(__dirname)); // Adding middleware
app.get('/', function (request, response) { // A simple request
handler
 response.send('Simple web server of files from ' + __dirname);
});
app.listen(3000, function () { // Start Express on the requests
 console.log('Listening at http://localhost:3000 exporting the
directory ' +
 __dirname);
});
```

Example Express user list

```
app.get('/students/list', function (request, response) {
 response.status(200).send(in4matx133.enrolledStudents());
 return;
});
app.get('/students/:id', function (request, response) {
 var id = request.params.id;
 var user = in4matx133.isEnrolled(id);
 if (user === null) {
 console.log('Student with _id:' + id + ' not found.');
 response.status(400).send('Not found');
 return;
 }
response.status(200).send(user);
 return;
});
```

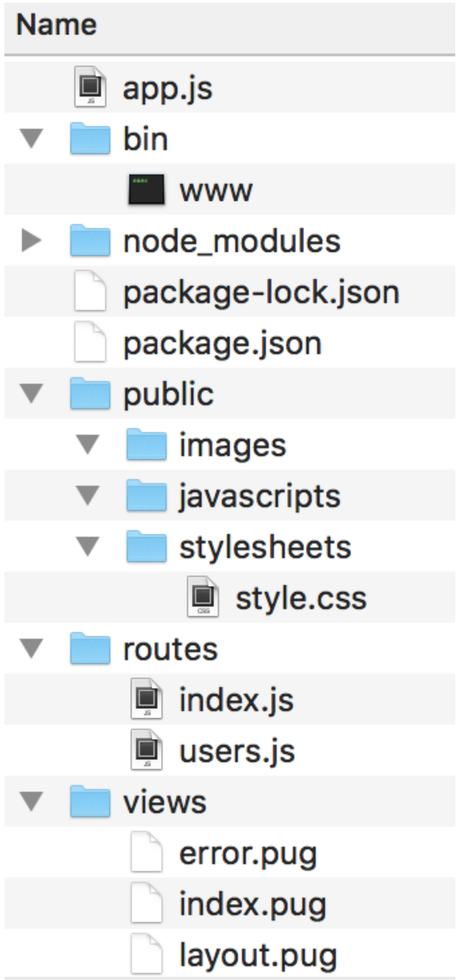
Express generator

- Express provides a tool that can create and initialize an application skeleton
  - Sets up a directory structure for isolating different components
  - Your app doesn’t have to be built this way, but it’s a useful starting point

https://expressjs.com/en/starter/generator.html

Express generator

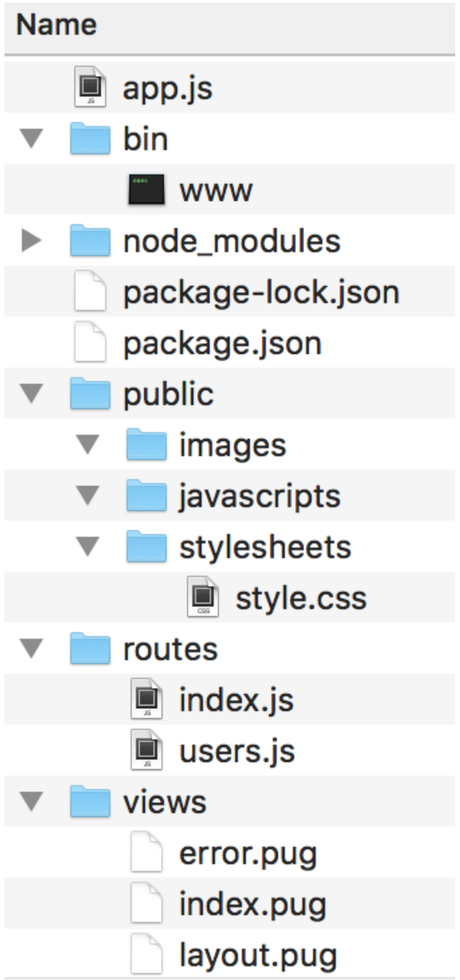
- `npm install express-generator -g`
- Can be invoked on command line with `express`
- Adds some boilerplate code
  and commonly used dependencies
- Install dependencies with `npm install`
  - `cd` into project directory first
- Run with `npm start`



https://expressjs.com/en/starter/generator.html

Express generator

- `package.json`, `package-lock.json`, and `node_modules` folder: library management and installed libraries
- `public` folder: all public-facing images, stylesheets, and JavaScript files



Express generator

- Routes folder: files which handle your URL mappings

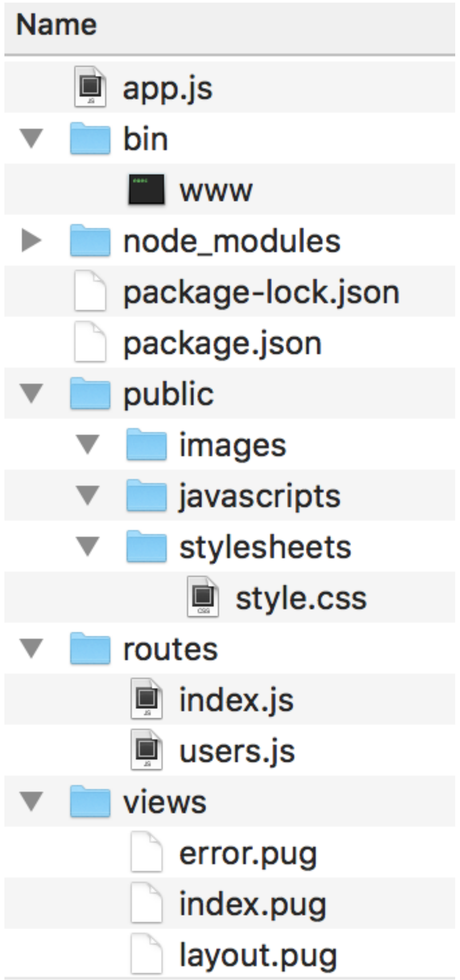
```
var express = require('express');
var router = express.Router();

/* GET home page. */
router.get('/', function(req, res, next) {
  res.render('index', { title: 'Express' });
});

module.exports = router;
```

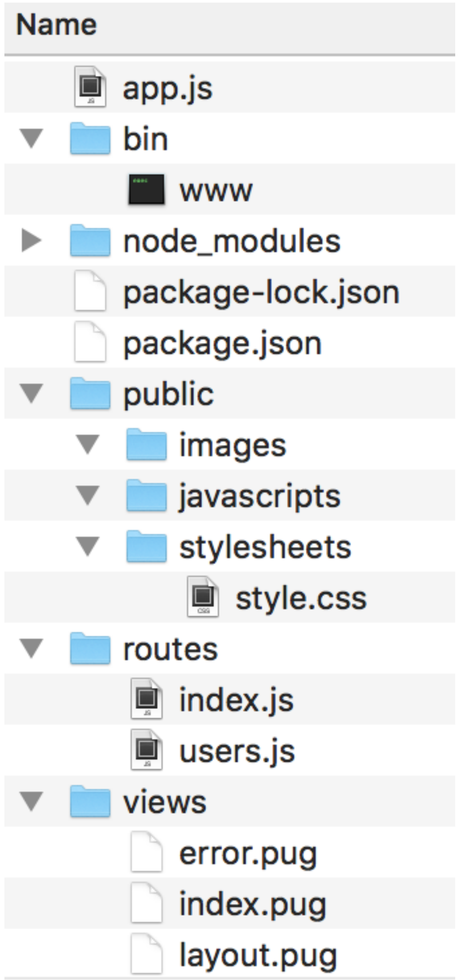
Variable passed to renderer

So another page can import your router



Express generator

- Views folder: any webpages which need to be rendered
- Uses a *view engine*, Pug, which generates HTML



Pug view engine

```
<!DOCTYPE html>
<html>
	<head>
		<title>Express</title>
		<link rel="stylesheet" href="/stylesheets/style.css">
	</head>
	<body>
		<h1>Express</h1>
		<p>Welcome to Express</p>
	</body>
</html>
```

- layout.pug

```
doctype html
html
  head
    title= title
    link(rel='stylesheet', href='/stylesheets/style.css')
  body
    block content
```

- index.pug

```
extends layout
```

Imports other file

```
block content
  h1= title
  p Welcome to #{title}
```

Parses variable passed

https://pugjs.org/api/getting-started.html

Express generator

- app.js: sets up middleware, routers, etc.

```
var indexRouter = require('./routes/index');
var usersRouter = require('./routes/users');

var app = express();

app.use(express.json());
app.use(express.urlencoded({ extended: false }));
app.use(cookieParser());
app.use(express.static(path.join(__dirname, 'public')));

app.use('/', indexRouter);
app.use('/users', usersRouter);
```

Import route files

To parse content as json

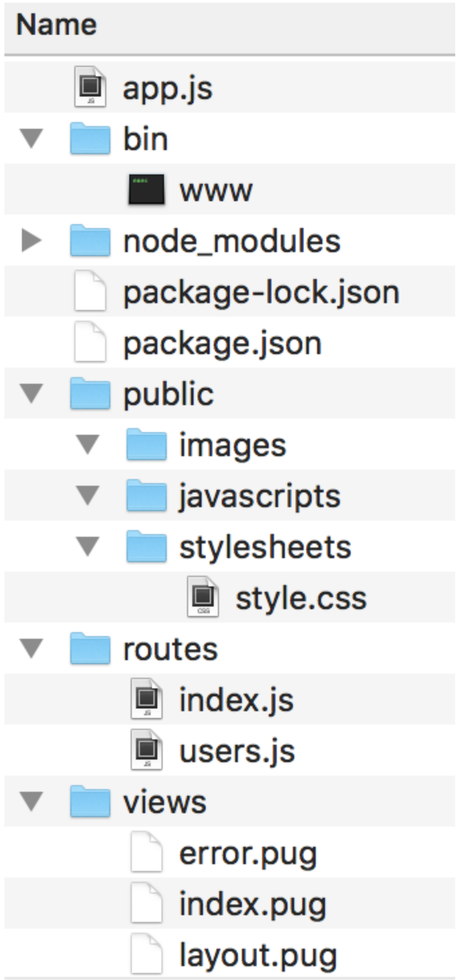
To encode URLs

To handle cookies (user state)

To treat the public folder as static content

Use route files

Middle



Express generator

- bin/www: set up what port to listen on
- File that is run with `npm start`

```
var app = require('../app');
var http = require('http');

var port = normalizePort(process.env.PORT || '3000');
app.set('port', port);
var server = http.createServer(app);

server.listen(port);
server.on('error', onError);
server.on('listening', onListening);
```