IN4MATX 133: User Interface Software

Lecture 9: Server-Side Development, Authentication, & Authorization

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Announcements

- A2 due Friday
- Lucas' Friday discussion will be office hours
- If you arrive at office hours and no one is there,
  we're probably in a breakout looking at someone's code
  - Just wait, we'll be back :-)

Today's goals

By the end of today, 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

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 web2py
- These days, you can create a dynamic website in almost any language

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

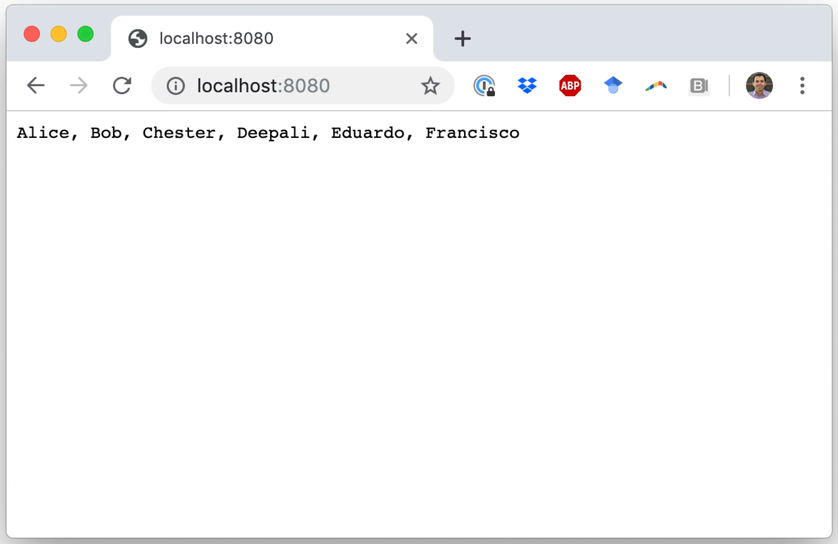
"Ok" status in the header, write hello world text

Listen on port 8080

Running Node.js

- `node file.js`

Node.js


localhost:8080
localhost:8080
Alice, Bob, Chester, Deepali, Eduardo, Francisco

Remember,
Node.js is server-side JavaScript

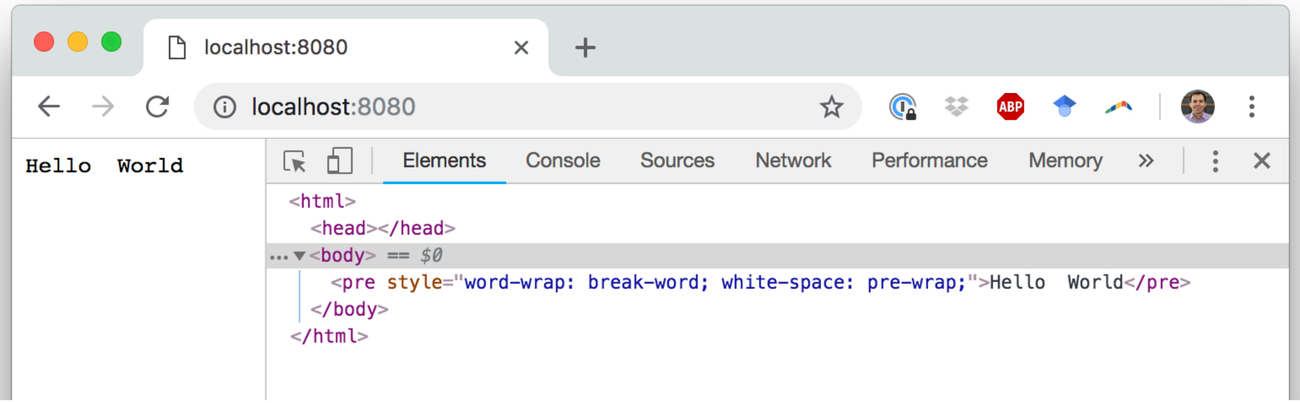
Where is the JavaScript running?

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 in the console.

Where is the JavaScript running?

Client-side

`live-server`

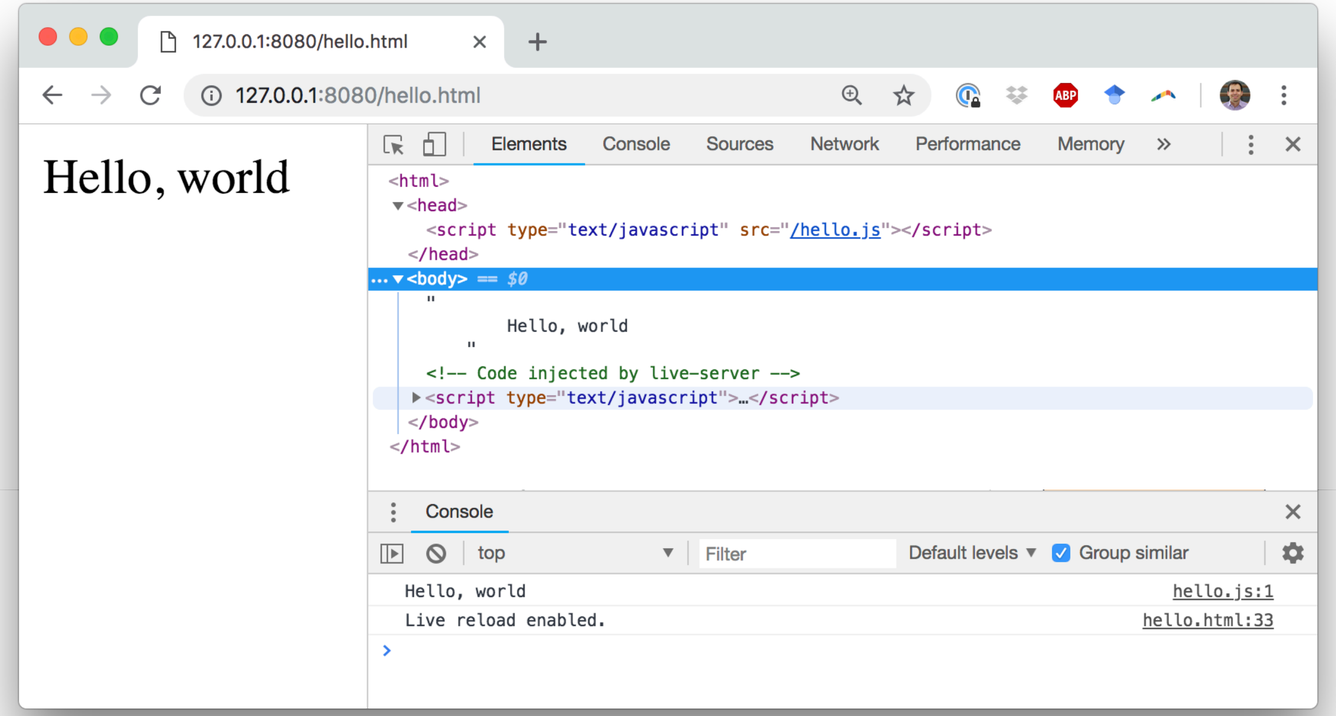
hello.html:

```
<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.

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

- Node.js has the capabilities of a “good” web framework
  - To speak in HTTP
  - Routing
  - Middleware support
- But they’re somewhat difficult to use.
- People have written extensions to Node (like Express) to make server-side development easier
  - This is why Node made a package manager (npm)!

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

Question

2factor

Which of these is an example of “good” two-factor authentication?

A. A government agency requiring a birth certificate and a passport

B. A store requiring a membership card and a PIN

C. A website requiring a password and a security question

D. Two of the above

E. All of the above

Question 

2factor

Which of these is an example of “good” two-factor authentication?

A. A government agency requiring a birth certificate and a passport

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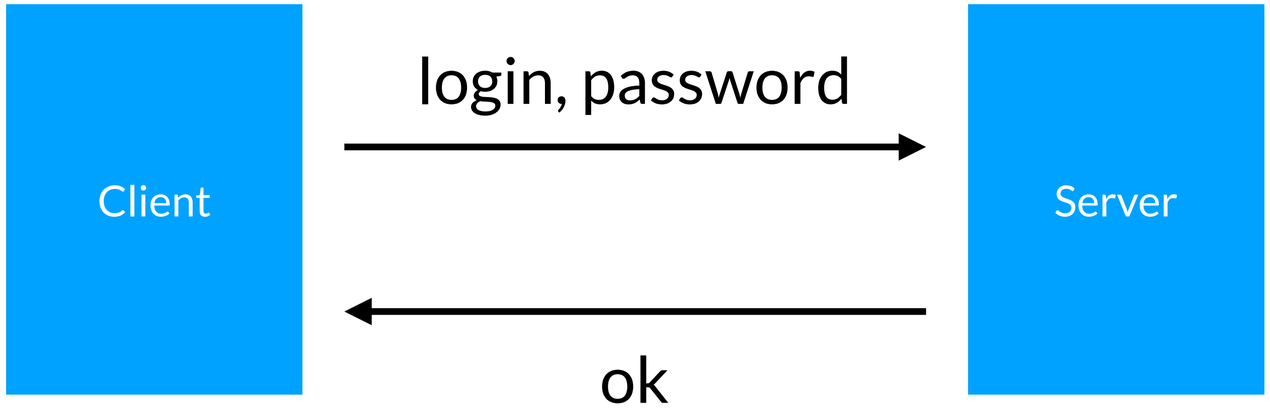
C. A website requiring a password and a security question

D. Two of the above

E. All of the above

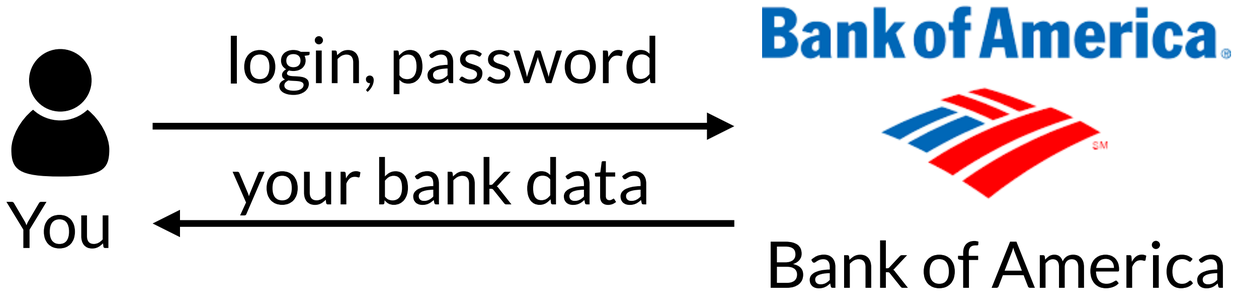
Password protocol

- 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



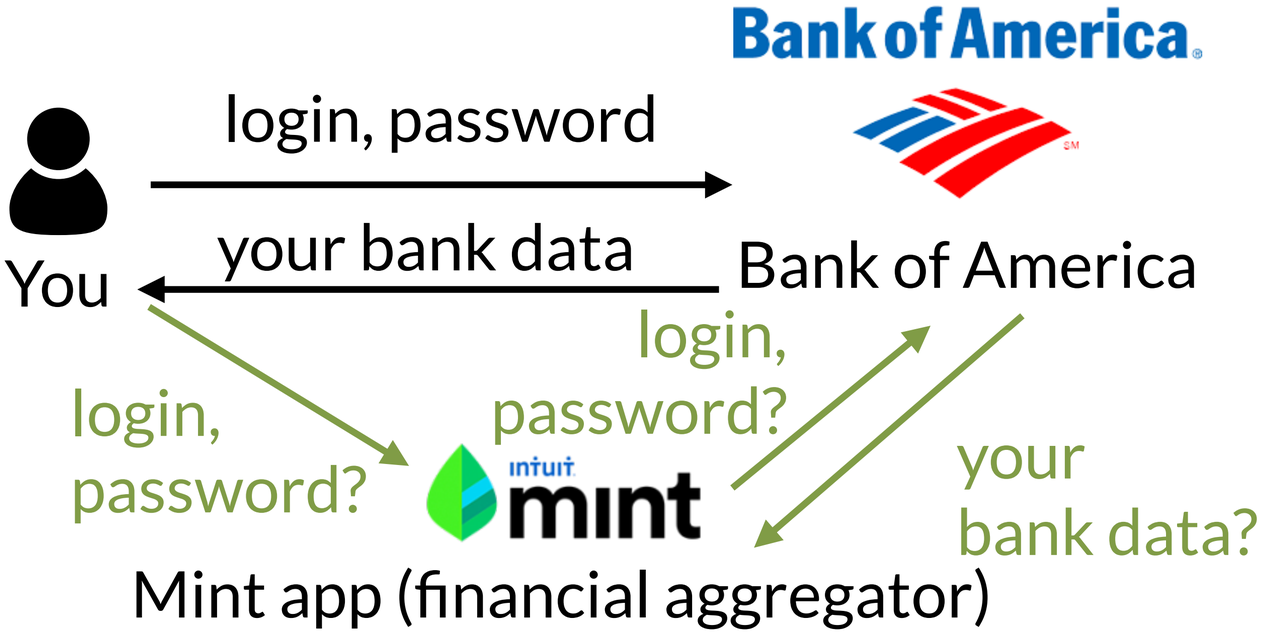
Password protocol: sending data

- 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

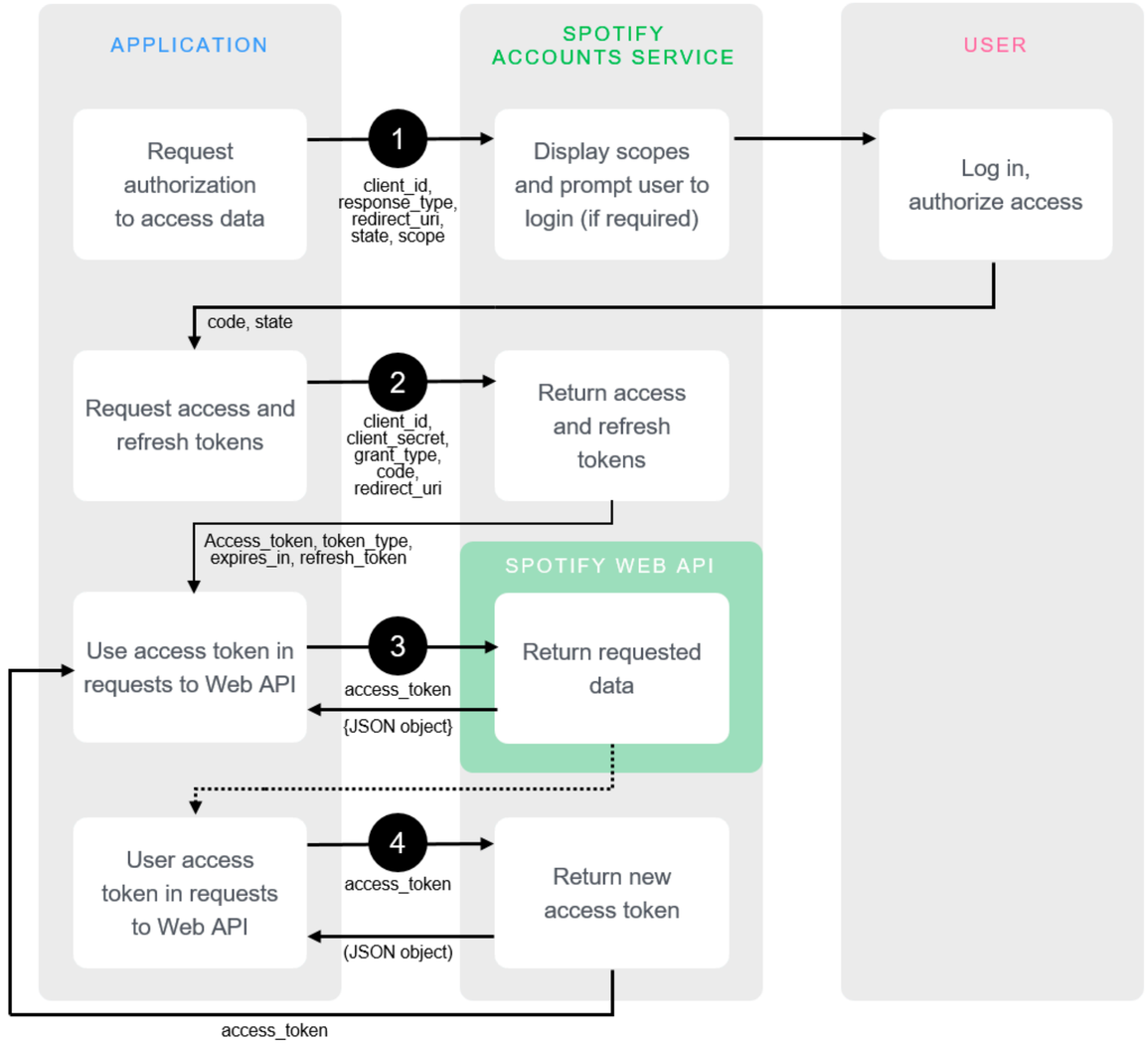
Oauth 2.0 terminology

- 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

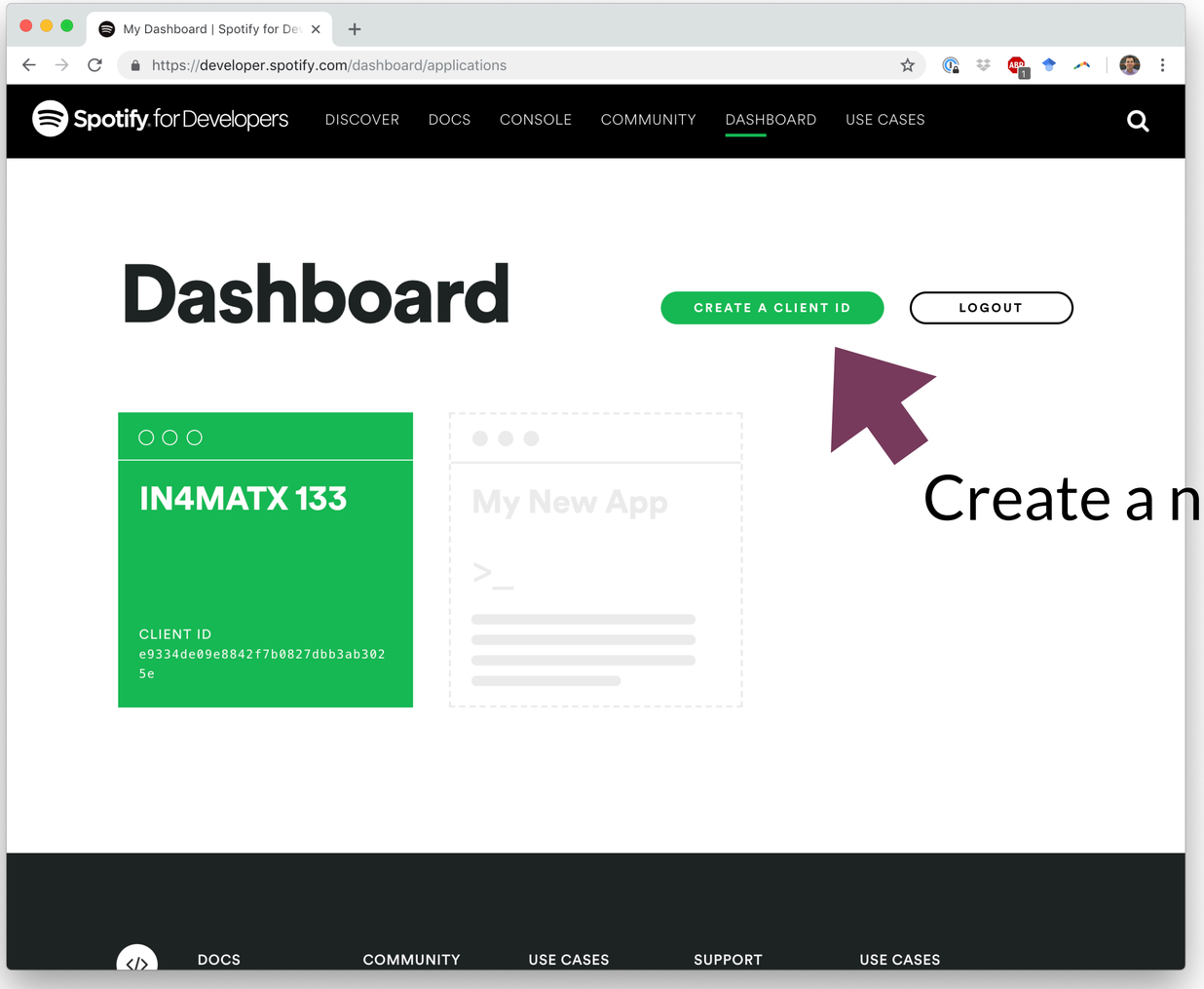
1. Request authorization
2. Get access token
3. Make API calls
4. Refresh access token

Oauth 2.0 steps



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

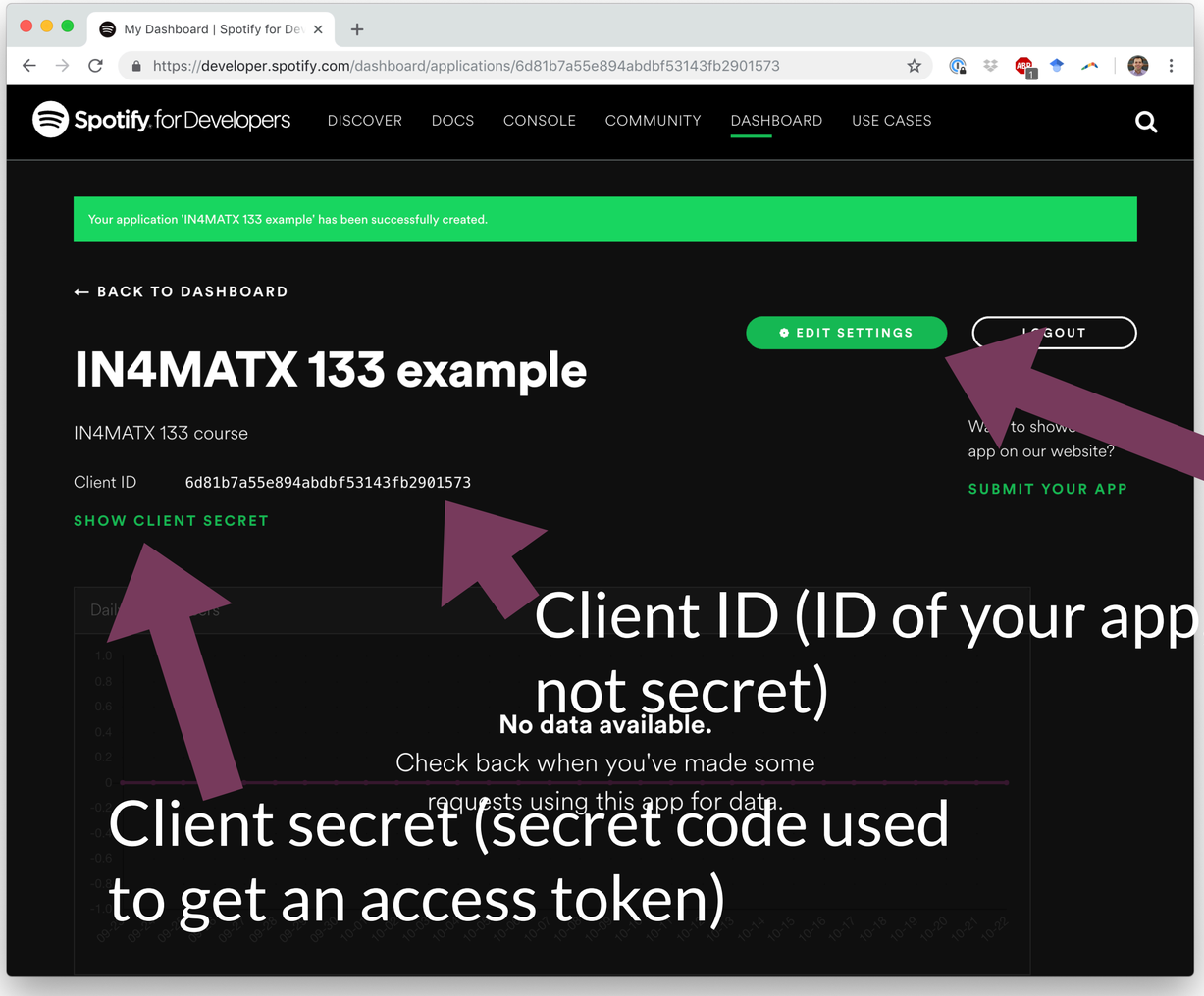
Oauth 2.0 and Spotify



Create a new ID

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

Oauth 2.0 and Spotify



Client ID (ID of your app, not secret)

Client secret (secret code used to get an access token)

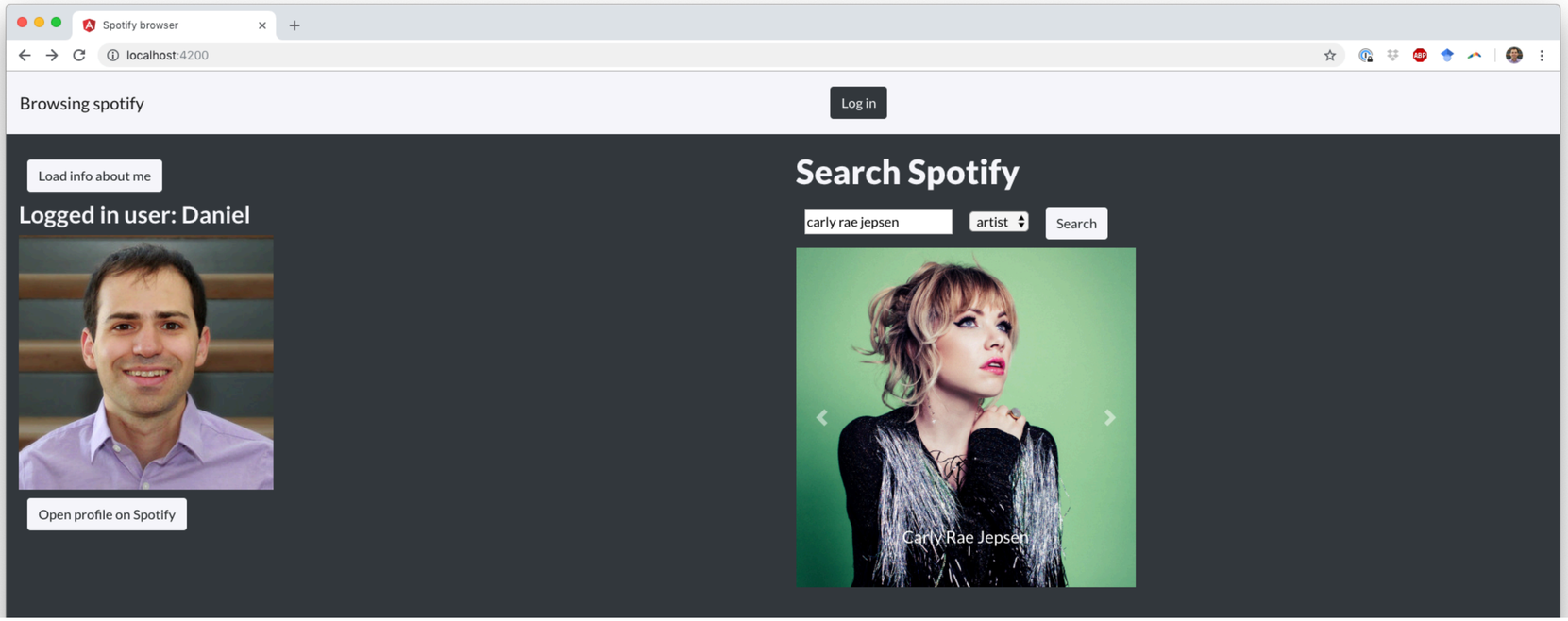
Need to specify what URI to return to (redirect URI)

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

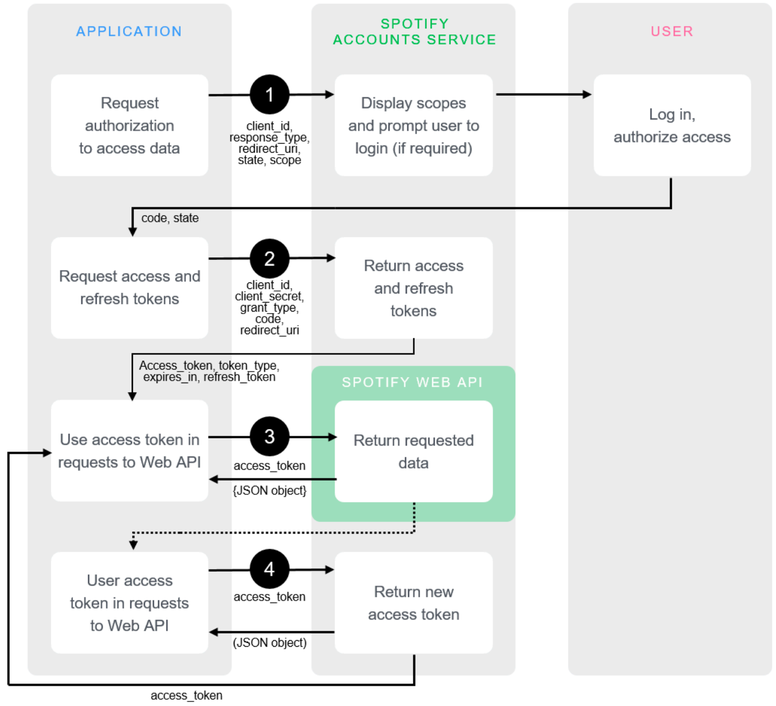
Assignment 3



Assignment 3

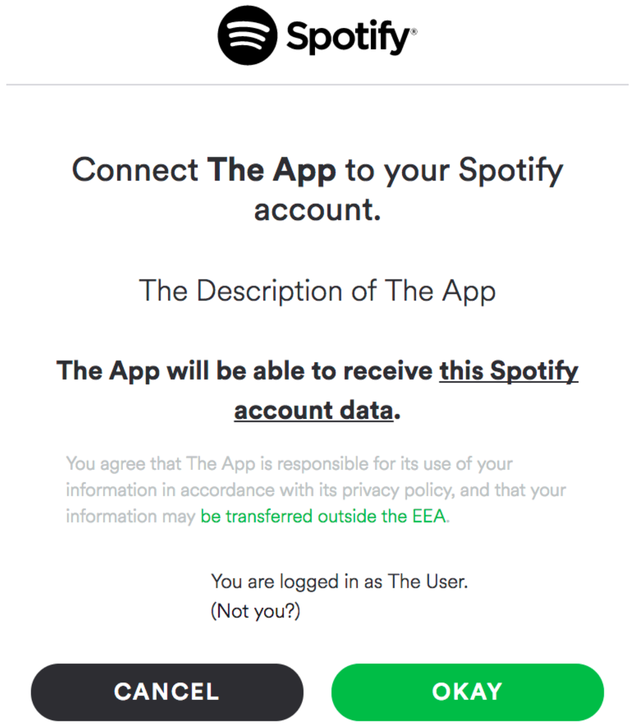
- There’s an #a3 channel on Slack
- There’s also an #assignment-partners channel

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?` ← Endpoint

  `response_type=code&` ← "code" response type

  `client_id=6d81b7a55e894abdbf53143fb2901573&` ← Client id for app

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

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

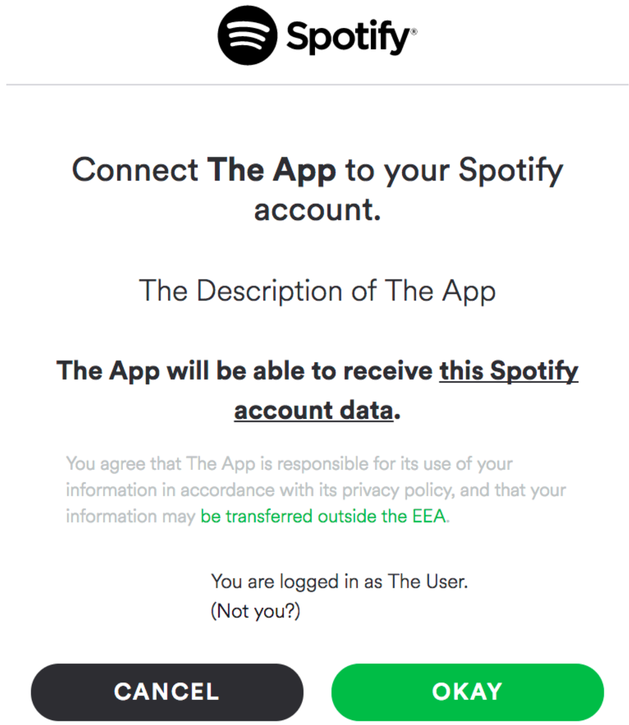
  ↖ URI to redirect to:
  http://localhost:8888/callback

- 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/

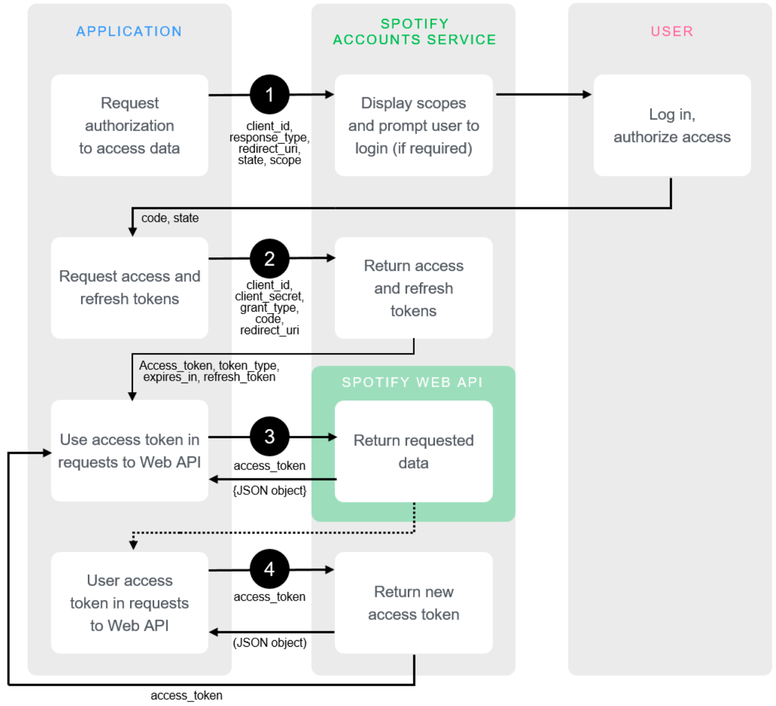
Handling response

- 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



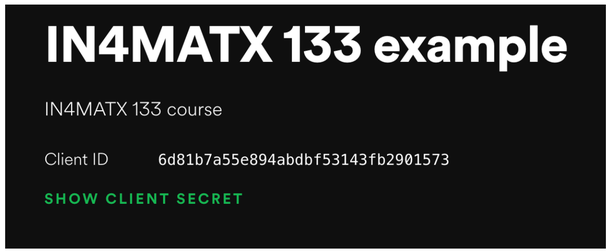
Requesting an access token

- 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')`

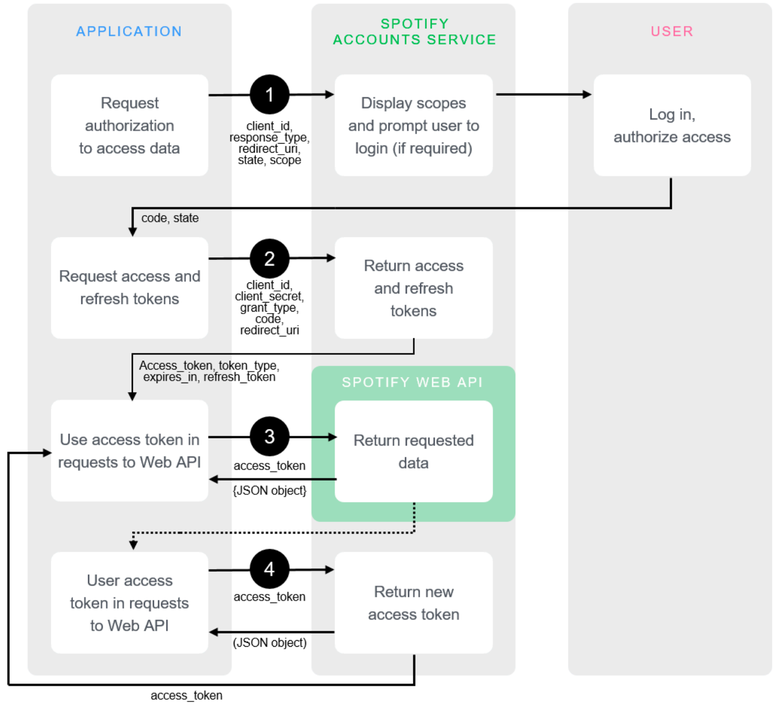
https://www.w3schools.com/nodejs/met_buffer_from.asp
https://developer.mozilla.org/en-US/docs/Web/API/URLSearchParams
https://developer.spotify.com/documentation/general/guides/authorization-guide/

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

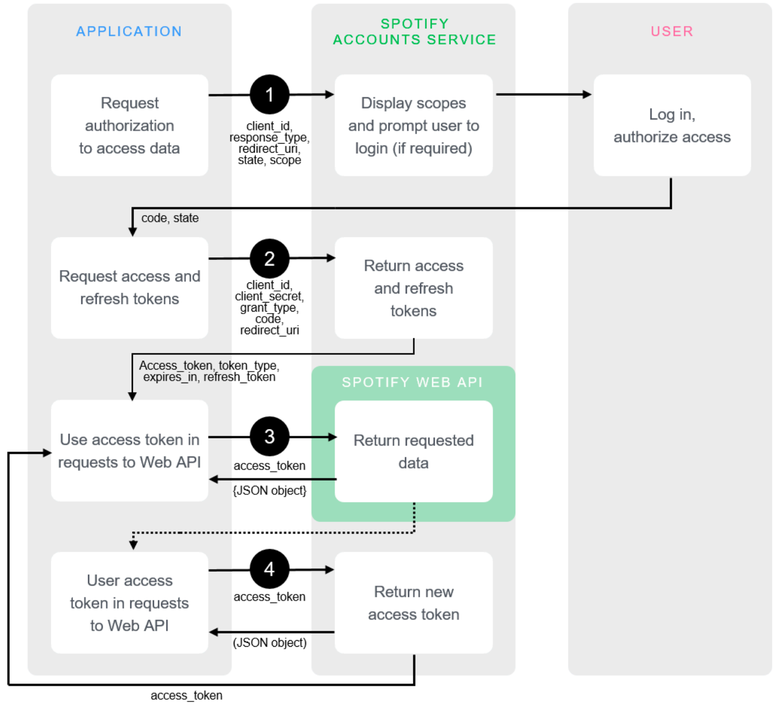
https://developer.spotify.com/documentation/web-api/reference/users-profile/get-current-users-profile/
https://developer.spotify.com/documentation/general/guides/authorization-guide/

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

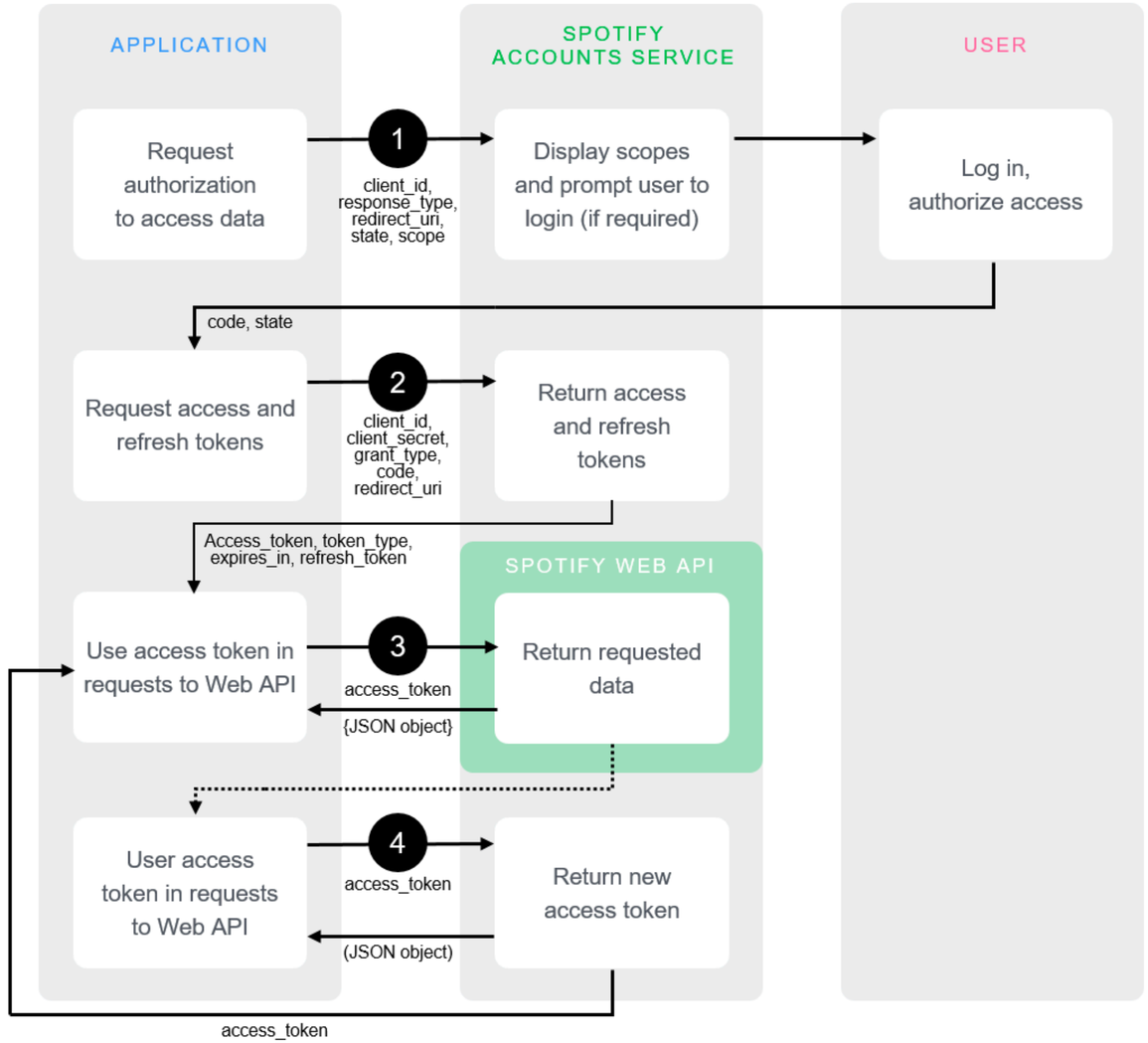
https://developer.spotify.com/documentation/web-api/
https://developer.spotify.com/documentation/general/guides/authorization-guide/

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

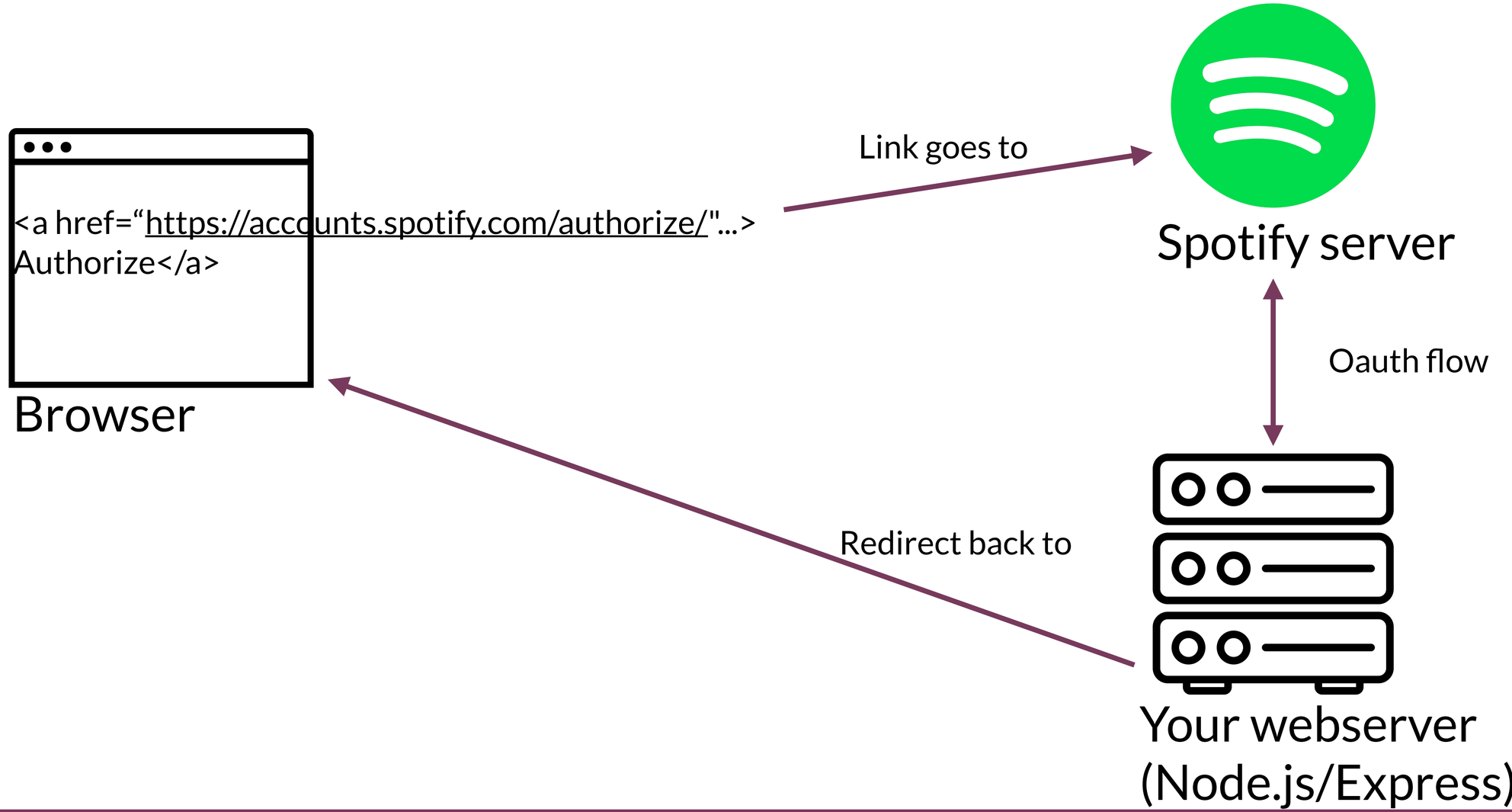


https://developer.spotify.com/documentation/general/guides/authorization-guide/

Authorizing from the browser

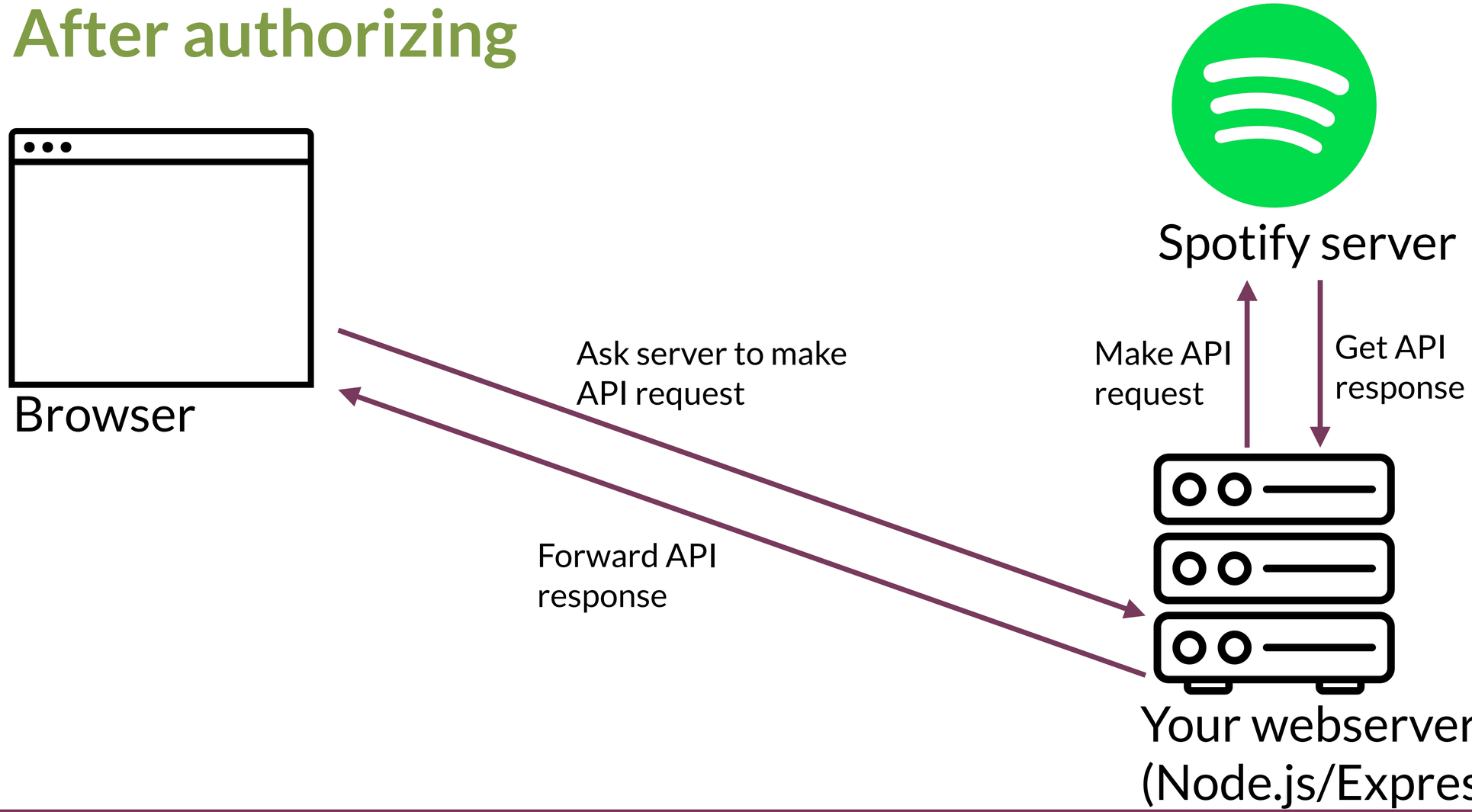
- Create a link to the authorization endpoint (https://accounts.spotify.com/authorize/)
  - Which will redirect to your server-side JavaScript
- Once tokens have been received, redirect back to client-side JavaScript

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

Question

spotify2

Which can make an HTTP request to the Spotify API?

(Assume the browser uses default settings)

A) 4

B) 1, 4

C) 1, 2, 4

D) 1, 3, 4

E) 1, 2, 3, 4

(1) A browser open to spotify.com

(2) A browser with client-side JavaScript at localhost:8888

(3) A browser with server-side JavaScript at localhost:8888

(4) A server running in the Spotify domain

Question

spotify2

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(Assume the browser uses default settings)

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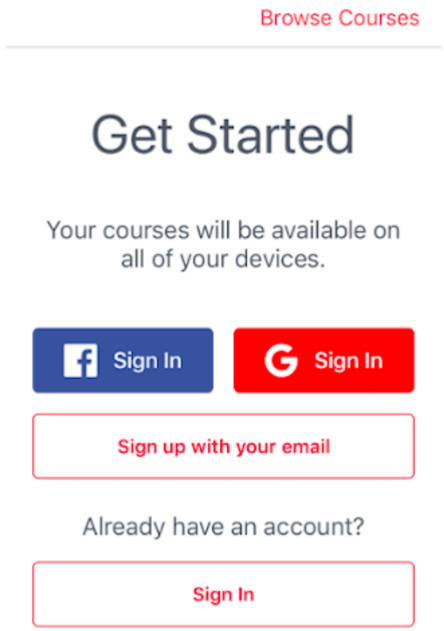
(4) A server running in the Spotify domain

OpenID Connect

- Ever seen a button with “sign in with Google”, etc.?
- Implemented with OpenID Connect
  - Added layer on top of Oauth

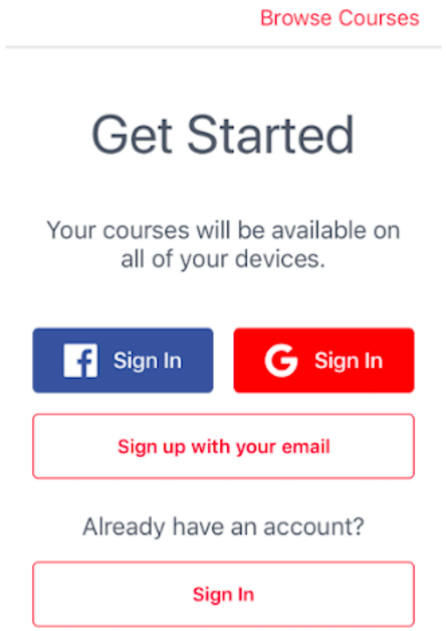


OpenID

https://openid.net/connect/

OpenID Connect

- Benefits:
  - No need to get an ID for every service
  - Only one password to remember/store
- Drawbacks
  - Facebook/Google/etc.
    gather (more) information about you
    and and the websites you go to



Today's goals

By the end of today, 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

IN4MATX 133: User Interface Software

Lecture 9: Server-Side Development, Authentication, & Authorization

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Same origin policy*

- Sites running in the same domain but with different ports are technically different origins

- So our live server would typically not be able to access data from another script running on a different port (like the Twitter proxy)

Compared URL	Outcome	Reason
http://www.example.com/dir/page2.html	Success	Same scheme, host and port
http://www.example.com/dir2/other.html	Success	Same scheme, host and port
http://username:password@**www.example.com**/dir2/other.html	Success	Same scheme, host and port
http://www.example.com:**81**/dir/other.html	Failure	Same scheme and host but different port
https://www.example.com/dir/other.html	Failure	Different scheme
http://**en.example.com**/dir/other.html	Failure	Different host
http://**example.com**/dir/other.html	Failure	Different host (exact match required)
http://**v2.www.example.com**/dir/other.html	Failure	Different host (exact match required)
http://www.example.com:**80**/dir/other.html	Depends	Port explicit. Depends on implementation in browser.

https://en.wikipedia.org/wiki/Same-origin_policy

Same origin policy*

- However, the Twitter Proxy (and the Spotify Server in A3) allow for connections from other ports
  - This can be configured in Express
- That means if these were publicly available on the web (versus running on your computer), anyone would be able to use your credentials to make Twitter/Spotify API requests

```
// CORS
app.use(function(req, res, next) {
  res.header("Access-Control-Allow-Origin", "*");
  res.header('Access-Control-Allow-Methods', 'GET,PUT,POST,DELETE');
  res.header("Access-Control-Allow-Headers", "X-Requested-With");
  if (req.method === 'OPTIONS') return res.send(200);
  next();
});
```

https://github.com/leftlogic/twitter-proxy

More on Node and Express

Node file system

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

Require the file system library

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

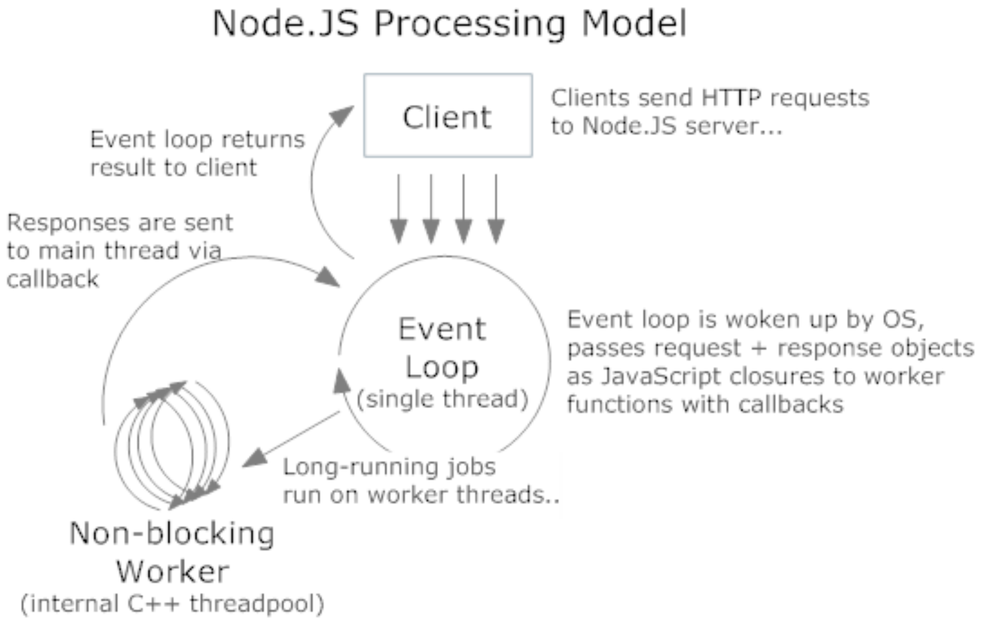
Read file, wait for asynchronous response

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;
});
```

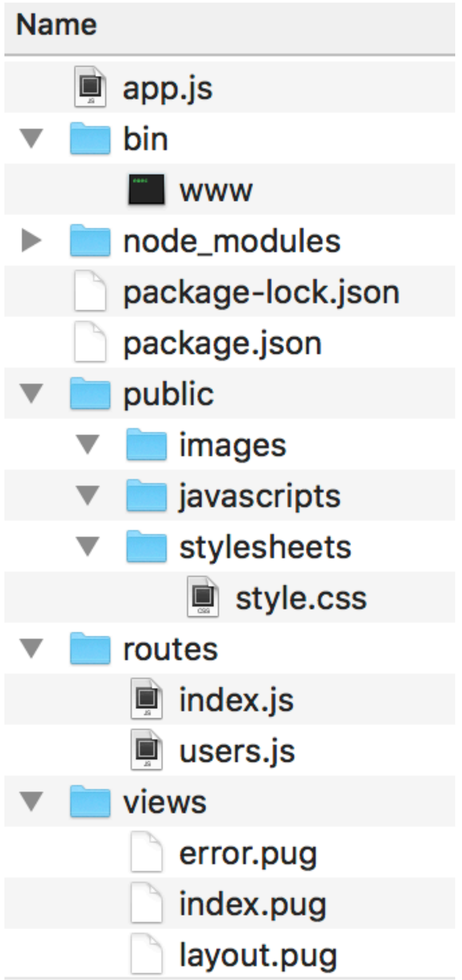
Express generator

- 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

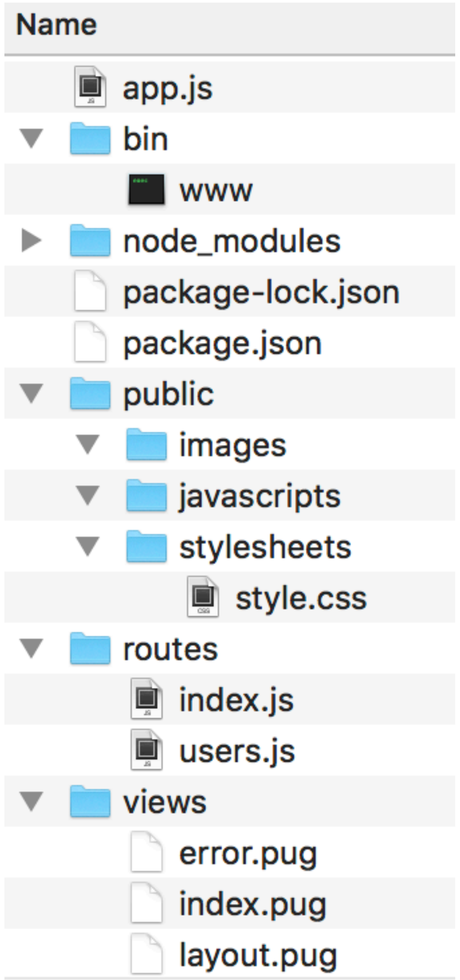
- `npm install express-generator -g`
- Can be invoked on command line with `express`
- Adds some boilerplate code
  and commonly used dependencies
- Install dependencies with `npm install`
  - `cd` into project directory first
- Run with `npm start`



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

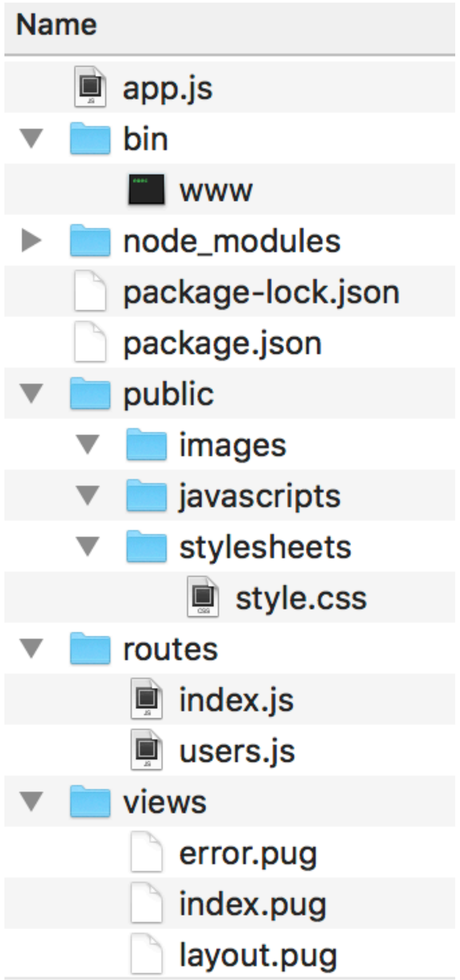
```
var express = require('express');
var router = express.Router();

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

module.exports = router;
```

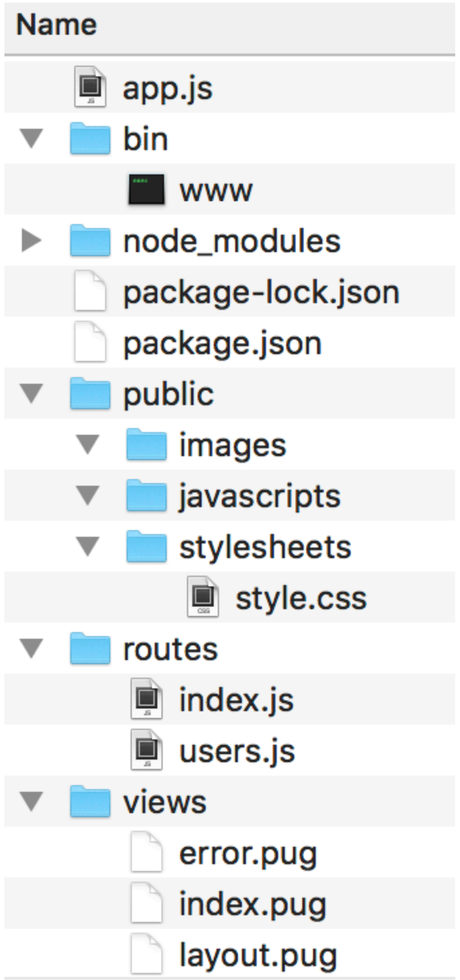
Variable passed to renderer

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

- 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

```
<!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>
```

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);
```

Middleware

Import route files

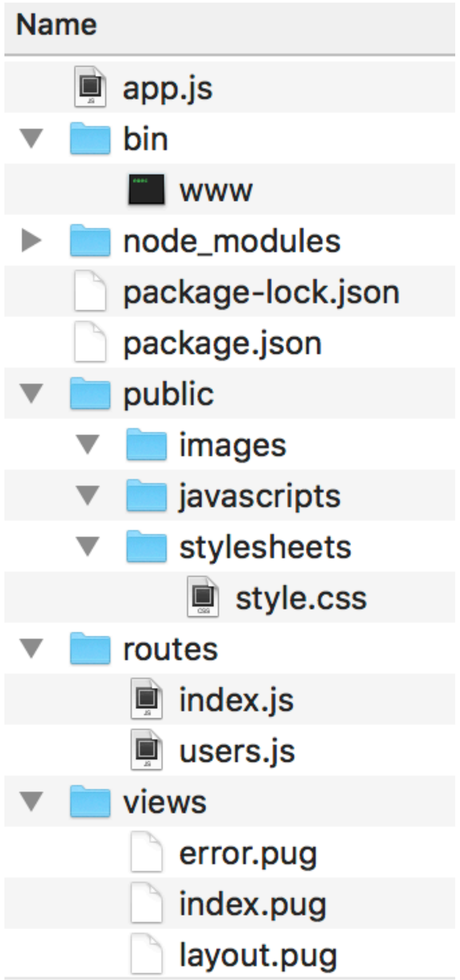
To parse content as json

To encode URLs

To handle cookies (user state)

To treat the public folder as static content

Use route files



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);
```