CS193X: Web Programming Fundamentals

Spring 2017

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CS193X schedule

Today
- Web application architecture
  - Server-side rendering with Handlebars
- Modules, Middleware, Routes
- Web application architecture
  - Single-page web app
- Victoria has office hours after class

Friday
- Authentication
- Accessibility
- Testing
Homework 5

HW5 due **Tue 5/30 Wed 5/31**
- Late cutoff is still **Thur 6/1**

**HW5 FYI:** Must support any column name!
- See [Piazza post](#) for announcement
- See [HW5](#) for more detail
Final project

**Final Project Proposal** due **this Friday 6/2**
- No late cutoff! Must turn in on time.

Final Project is due Mon, June 12
- No late cutoff! Must turn in on time.
- Turn in details to come.
NodeJS and MongoDB
Let's go back to our dictionary example that let us look up the definition of words ([GitHub](https://github.com)): 

<table>
<thead>
<tr>
<th>English dictionary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Look up a word: <strong>dog</strong></td>
</tr>
<tr>
<td>The definition of <strong>dog</strong> is:</td>
</tr>
</tbody>
</table>

A quadruped of the genus Canis, esp. the domestic dog (C.familiaris).
Current code: Static routes

We've defined our server to:
1. Statically serve index.html / style.css / fetch.js

```javascript
app.use(express.static('public'));
```

- public
  - fetch.js
  - index.html
  - style.css
Current code: Static routes

We've defined our server to:
1. Statically serve index.html / style.css / fetch.js

So when there's a request to localhost:3000/ ...
Current code: Static routes

We've defined our server to:
1. Statically serve index.html / style.css / fetch.js

```javascript
app.use(express.static('public'));
```

- "Does the 'public' folder have an 'index.html' file?

- Our NodeJS server.js program checks the public directory to see if "index.html" exists, which is does, so it replies with that file.
- It similarly provides fetch.js and style.css, embedded in index.html.
Current code: Static routes

We've defined our server to:
1. Statically serve index.html / style.css / fetch.js
Current code: JSON route

We've also defined our server to:
2. Return JSON in response to request to lookup/<word>
Current code: JSON route

We've also defined our server to:
2. Return JSON in response to request to lookup/<word>

```javascript
async function onLookupWord(req, res) {
  const routeParams = req.params;
  const word = routeParams.word;

  const query = { word: word.toLowerCase() };
  const result = await collection.findOne(query);

  const response = {
    word: word,
    definition: result ? result.definition : ''
  };
  res.json(response);
}
app.get('/lookup/:word', onLookupWord);
```
Current code: JSON route

We've also defined our server to:

2. Return JSON in response to request to lookup/<word>

If we navigate to http://localhost:3000/lookup/dog, we see the raw JSON response:

```
{"word":"dog","definition":"A quadruped of the genus Canis, esp. the domestic dog (C.familiaris)."}
```
Current code: JSON route

We've also defined our server to:
2. Return JSON in response to request to lookup/<word>

async function onSearch(event) {
  event.preventDefault();
  const input = document.querySelector('#word-input');
  const word = input.value.trim();

  const result = await fetch('/lookup/' + word);
  const json = await result.json();

  const wordDisplay = results.querySelector('#word');
  const defDisplay = results.querySelector('#definition');
  wordDisplay.textContent = json.word;
  defDisplay.textContent = json.definition;
}
Dynamically generated web pages
Dictionary example

What if we wanted each definition to also have its own page: [http://localhost:3000/dog](http://localhost:3000/dog) should show a web page with the definition of "dog:

```
dog

The definition of dog is:

A quadruped of the genus Canis, esp. the domestic dog (C.familiaris).
```
Naive solution: static files

One solution would be to create 1000s of very similar web pages:

cat/index.html

```html
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8">
  <title>Define: cat</title>
  <link rel="stylesheet" href="/css/style.css">
</head>
<body>
  <h1>cat</h1>
  <div id="results" class="hidden">
    The definition of <strong id="word">cat</strong> is:
    <blockquote id="definition">
      An animal of various species of the genera Felis and Lynx. The domestic cat is Felis domestica. The European wild cat (Felis catus) is much larger than the domestic cat. In the United States the name wild cat is commonly applied to the bay lynx (Lynx rufus) See Wildcat, and Tiger cat.
    </blockquote>
  </div>
</body>
</html>
```
Naive solution: static files

One solution would be to create 1000s of very similar web pages:

category/index.html

```html
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8">
  <title>Define: category</title>
  <link rel="stylesheet" href="/css/style.css">
</head>
<body>
  <h1>category</h1>
  <div id="results" class="hidden">
    The definition of <strong id="word">category</strong> is:
    <blockquote id="definition">One of the highest classes to which the objects of knowledge or thought can be reduced, and by which they can be arranged in a system; an ultimate or indecomposable conception; a predicament. The categories of predicaments -- the former a Greek word, the latter its literal translation in the Latin language -- were intended by Aristotle and his followers as an enumeration of all things capable of being named; an enumeration by the summa genera i.e., the most extensive classes into which things could be distributed. J. S. Mill.</blockquote>
  </div>
</body>
</html>
```
One solution would be to create 1000s of very similar web pages:

catastrophe/index.html

```html
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8">
  <title>Define: catastrophe</title>
  <link rel="stylesheet" href="/css/style.css">
</head>
<body>
  <h1>catastrophe</h1>
  <div id="results" class="hidden">
    The definition of <strong id="word">catastrophe</strong> is:
    <blockquote id="definition">A violent and widely extended change in the surface of the earth, as, an elevation or subsidence of some part of it, effected by internal causes. Whewell.</blockquote>
  </div>
</body>
</html>
```
Naive solution: static files

We could put each of these files under public/ and have a unique HTML file for each word of the dictionary.
Naive solution: static files

However, that would be a pain:

- Very time-consuming to hand-code
- Even if we wrote a script to generate the 1000s of HTML files, it'd be annoying to have to rerun the script every time there's a new word, new definition, if there's a change in the HTML format, etc.
Dynamically generated pages

Instead, we'll make our server dynamically generate a web page for the word as soon as it is requested:

GET localhost:3000/dog
Dynamically generated pages

Instead, we'll make our server dynamically generate a web page for the word as soon as it is requested:

```
GET localhost:3000/dog
```

Server.js will create an HTML page for the word on the spot...
Dynamically generated pages

Instead, we'll make our server dynamically generate a web page for the word as soon as it is requested:

```
GET localhost:3000/dog
```

And we see the HTML displayed.

**dog**

The definition of *dog* is:

>A quadruped of the genus Canis, esp. the domestic dog (C.familiaris).
Dynamically generated pages

Instead, we'll make our server dynamically generate a web page for the word as soon as it is requested:

GET localhost:3000/dog

Server.js will create an HTML page for the word on the spot...

How does this step work?
Recall: Web app architectures
There are roughly 4 strategies for architecting a web application:

1. **Server-side rendering:**
   Server sends a new HTML page for each unique path

2. **Single-page application:**
   Server sends the exact same web page for every unique path (and the page runs JS to change what it look like)

3. Combination of 1 and 2 ("Isomorphic" / "Universal")

4. **Progressive Loading**
Structuring a web app

There are roughly 4 strategies for architecting a web application:

1. **Server-side rendering:**
   Server sends a new HTML page for each unique path
   
   → Let's start with this one.
We'll make our server dynamically generate a web page for the word as soon as it is requested:

```
GET localhost:3000/dog
```

Server.js will create an HTML page for the word on the spot...
We start with defining a dummy route:

```javascript
async function onViewWord(req, res) {
    const routeParams = req.params;
    const word = routeParams.word;

    const result = `<h1>${word}</h1>`;
    res.text(result);
}

app.get('/:word', onViewWord);
```
HTML Strings

We start with defining a dummy route:

```javascript
async function onViewWord(req, res) {
    const routeParams = req.params;
    const word = routeParams.word;

    const result = `<h1>${word}</h1>`;
    res.text(result);
}
app.get('/:word', onViewWord);
```

This just echoes what we passed in as a query parameter.
Now we look up and show the definition too:

```javascript
async function onViewWord(req, res) {
  const routeParams = req.params;
  const word = routeParams.word;

  const query = { word: word.toLowerCase() };
  const result = await collection.findOne(query);
  const definition = result ? result.definition : '';

  let response = `<h1>${word}</h1>`;
  response += `<p>${definition}</p>`;
  res.end(response);
}
app.get('/:word', onViewWord);
```
async function onViewWord(req, res) {
    const routeParams = req.params;
    const word = routeParams.word;

    const query = { word: word.toLowerCase() };
    const result = await collection.findOne(query);
    const definition = result ? result.definition : '';

    let response = '<h1>${word}</h1>;
    response += '<p>${definition}</p>;
    res.end(response);
}

app.get('/:word', onViewWord);

dog
A quadruped of the genus Canis, esp. the domestic dog (C.familiaris).
We can make our HTML response a little fancier:

```javascript
const response =
`
<!DOCTYPE html>
<html>
<head>
    <meta charset='utf-8'>
    <title>Define: ${word}</title>
    <link rel='stylesheet' href='/css/style.css'>
</head>
<body>
    <h1>${word}</h1>
    <div id='results' class='hidden'>
        The definition of <strong id='word'>${word}</strong> is:
        <blockquote id='definition'>${definition}</blockquote>
    </div>
</body>
</html>```

res.end(response);
```
We can make our HTML response a little fancier:

The definition of **dog** is:

A quadruped of the genus Canis, esp. the domestic dog (C.familiaris).
HTML Strings

```javascript
async function onViewWord(req, res) {
  const routeParams = req.params;
  const word = routeParams.word;

  const query = { word: word.toLowerCase() };
  const result = await collection.findOne(query);
  const definition = result ? result.definition : '';

  const response = `<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>Define: ${word}</title>
    <link rel="stylesheet" href="/css/style.css">
  </head>
  <body>
    <h1>${word}</h1>
    <div id="results" class="hidden">
      The definition of <strong id="word">${word}</strong> is: 
      <blockquote id="definition">${definition}</blockquote>
    </div>
  </body>
</html>
`;
  res.end(response);
}

app.get('/:word', onViewWord);
```
Template Engines
Goal: HTML Template

We want our NodeJS code to be able to take an HTML template, fill in its placeholder values, and return the completed page:

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>Define: {{ word }}</title>
    <link rel="stylesheet" href="/css/style.css">
  </head>
  <body>
    <h1>{{ word }}</h1>
    <div id="results" class="hidden">
      The definition of <strong id="word">{{ word }}</strong> is:
      <blockquote id="definition">{{ definition }}</blockquote>
    </div>
  </body>
</html>
```

GET localhost:3000/dog

word: "dog",
definition: "A quadruped of the genus Canis, ..."
Goal: HTML Template

We want our NodeJS code to be able to take an HTML template, fill in its placeholder values, and return the completed page:

```html
<!DOCTYPE html>
<html>
    <head>
        <meta charset="utf-8">
        <title>Define: dog</title>
        <link rel="stylesheet" href="/css/style.css">
    </head>
    <body>
        <h1>dog</h1>
        <div id="results" class="hidden">
            The definition of <strong id="word">dog</strong> is:
            <blockquote id="definition">A quadruped of the genus Canis, esp. the</blockquote>
        </div>
    </body>
</html>
```
Template Engine

**Template Engine**: Allows you to define templates in a text file, then fill out the contents of the template in JavaScript.

- Node will replace the variables in a template file with actual values, then it will send the result to the client as an HTML file.

Some popular template engines:

- **Handlebars**: We'll be using this one
- **Pug**
- **EJS**
- Handlebars lets you write templates in HTML
- You can embed `{{ placeholders }}` within the HTML that can get filled in via JavaScript.
- Your templates are saved in `.handlebars` files

```html
<div class="entry">
  <h1>{{title}}</h1>
  <div class="body">
    {{body}}
  </div>
</div>
```
You can setup Handlebars and NodeJS using the `express-handlebars` NodeJS library:

```javascript
const exphbs = require('express-handlebars');
...

const app = express();
const hbs = exphbs.create();
app.engine('handlebars', hbs.engine);
app.set('view engine', 'handlebars');
```
Dictionary example

```javascript
async function onViewWord(req, res) {
  const routeParams = req.params;
  const word = routeParams.word;

  const query = { word: word.toLowerCase() };
  const result = await collection.findOne(query);
  const definition = result ? result.definition : '';

  const response = `<!DOCTYPE html>
  <html>
    <head>
      <meta charset="utf-8">
      <title>Define: ${word}</title>
      <link rel="stylesheet" href="/css/style.css">
    </head>
    <body>
      <h1>${word}</h1>
      <div id="results" class="hidden">
        The definition of <strong id="word">${word}</strong> is:
        <blockquote id="definition">${definition}</blockquote>
      </div>
    </body>
  </html>`;
  res.end(response);
}

app.get('/:word', onViewWord);
```
Handlebars template

We can create a template in a file `words.handlebars`:

```html
<!DOCTYPE html>
<html>
<head>
    <meta charset="utf-8">
    <title>Define: {{ word }}</title>
    <link rel="stylesheet" href="/css/style.css">
</head>
<body>
    <h1>{{ word }}</h1>
    <div id="results" class="hidden">
        The definition of <strong id="word">{{ word }}</strong> is:
        <blockquote id="definition">{{ definition }}</blockquote>
    </div>
</body>
</html>
```

`handlebars` is the file extension for Handlebar templates.
Handlebars template

We save this in a directory called "views":

views/ is the default directory in which Handlebars will look for templates.
Dictionary example

```javascript
async function onViewWord(req, res) {
    const routeParams = req.params;
    const word = routeParams.word;

    const query = { word: word.toLowerCase() };
    const result = await collection.findOne(query);
    const definition = result ? result.definition : '';

    const response = `<!DOCTYPE html>
    <html>
        <head>
            <meta charset="utf-8">
            <title>Define: ${word}</title>
            <link rel="stylesheet" href="/css/style.css">
        </head>
        <body>
            <h1>${word}</h1>
            <div id="results" class="hidden">
                The definition of <strong id="word">${word}</strong> is:
                <blockquote id="definition">${definition}</blockquote>
            </div>
        </body>
    </html>`;
    res.end(response);
}

app.get('/:word', onViewWord);
```
Set template engine

We configure our server to use Handlebars as the template engine:

```javascript
const exphbs = require('express-handlebars');

const app = express();
const hbs = exphbs.create();
app.engine('handlebars', hbs.engine);
app.set('view engine', 'handlebars');
```
Call `res.render`

We call `res.render` to fill in the "word" Handlebars template.

```javascript
async function onViewWord(req, res) {
    const routeParams = req.params;
    const word = routeParams.word;

    const query = { word: word.toLowerCase() };
    const result = await collection.findOne(query);
    const definition = result ? result.definition : '';

    const placeholders = {
        word: word,
        definition: definition
    };

    res.render('word', placeholders);
}

app.get(':word', onViewWord);
```
Call `res.render`

```javascript
const placeholders = {
    word: word,
    definition: definition
};
res.render('word', placeholders);
```

The first parameter is the string name of the template to render, without the ".handlebars" extension.
Call `res.render`

The second parameter contains the definitions of the variables to be filled out in the template.

```javascript
const placeholders = {
  word: word,
  definition: definition
};
res.render('word', placeholders);
```

```html
<title>Define: {{ word }}</title>
<link rel="stylesheet" href="/css/style.css">
</head>
<body>
  <h1>{{ word }}</h1>
  <div id="results" class="hidden">
    The definition of <strong id="word">{{ word }}</strong> is:
    <blockquote id="definition">{{ definition }}</blockquote>
  </div>
</body>
```
The Handlebars templating engine will return to the client the filled in template as HTML:

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>Define: dog</title>
    <link rel="stylesheet" href="/css/style.css">
  </head>
  <body>
    <h1>dog</h1>
    <div id="results" class="hidden">
      The definition of <strong id="word">dog</strong> is:
      <blockquote id="definition">A quadruped of the genus Canis, esp. the
    </blockquote>
  </body>
</html>
```
The Handlebars templating engine will return to the client the filled in template as HTML:

```
dog

The definition of dog is:

   A quadruped of the genus Canis, esp. the domestic dog (C.familiaris).
```
Note on templates

- The server is dynamically generating HTML files to return back to the client, but these HTML files *aren't* saved on the server; they are just passed directly to the client from memory.
Note on style

Right now, we are splitting our view code in two places:

- **index.html**: The file that gets loaded when you go to localhost:3000
- **word.handlebars**: The HTML template for word pages

**Style-wise**, if you use a template engine, you usually serve *all* your view files via the template engine.
Note on style

We can make index.html into a Handlebars "template" that does not have any parameters:

```html
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>Dictionary lookup</title>
    <link rel="stylesheet" href="style.css">
    <script src="fetch.js" defer></script>
  </head>
  <body>
    <h1>English dictionary</h1>
    <form id="search">
      Look up a word:  
      <input type="text" id="word-input"/>
      <input type="submit" value="Search!">
    </form>
    <hr />
    <div id="results" class="hidden">
      The definition of <a href="" id="word"></a> is:
      <blockquote id="definition"></blockquote>
    </div>
  </body>
</html>
```
Note on style

Then in server.js, we will render the "index" template when there is a GET request to localhost:3000:

```javascript
function onViewIndex(req, res) {
    res.render('index');
}
app.get('/', onViewIndex);
```
Completed example

Completed example code:

- [dictionary-server-side](#)
- See [run instructions](#)
Modules and Routes
Routes

So far, our server routes have all been defined in one file.

Right now, server.js:
- Starts the server
- Sets the template engine
- Serves the public/ directory
- Defines the JSON-returning routes
- Defines the HTML-returning routes

As our server grows, it'd be nice to split up server.js into separate files.
NodeJS modules

NodeJS allows you to load external files, or "modules", via `require()`. We've already loaded three types of modules:

- Core NodeJS modules, e.g. `require('http')`
- External NodeJS modules downloaded via npm, e.g. `require('express')`
- A JSON file, e.g. `require('./dictionary.json')`

We will now see how to define our own NodeJS modules and include them in other JavaScript files via the `require()` statement.
A NodeJS module is just a JavaScript file.
- One module = One file
- There can only be one module per file

Let's say that you define the following JavaScript file:

```javascript
// This is a *poor* style and a bad example of a module;
// you should NOT write modules like this.

// This runs immediately, as soon as it is included.
console.log('hello');
```
NodeJS modules

You can include it in another JavaScript file by using the require statement:

```
scripts.js
1   require('./silly-module.js');
2
```

- Note that you **MUST** specify "./", "../", "/", etc.
- Otherwise NodeJS will look for it in the node_modules/ directory. See require() resolution rules
NodeJS modules

```javascript
silly-module.js

// This is a *poor* style and a bad example of a module;
// you should NOT write modules like this.

// This runs immediately, as soon as it is included.
console.log('hello');
```

```javascript
scripts.js

require('./silly-module.js');
```

$ node scripts.js
hello

The NodeJS file executes immediately when require()d.
Private variables

Everything declared in a module is **private to that module** by default.

Let's say that you define the following JavaScript file:

```javascript
// This is a private variable that is not shared.
let helloCounter = 0;

// This is a private function that is not shared.
function printHello() {
    helloCounter++;
    console.log('hello');
}
```
Private variables

If we include it and try to run printHello or access helloCounter, it will not work:

```javascript
scripts.js
1  require('./broken-module.js');
2  printHello();
```

$ node scripts.js
/.../scripts.js:2
printHello();
^

ReferenceError: printHello is not defined
at Object.<anonymous>
Private variables

If we include it and try to run `printHello` or access `helloCounter`, it will not work:

```
1   require('./broken-module.js');
2   console.log(helloCounter);
```

```
$ node scripts.js
scripts.js:2
  console.log(helloCounter);  ^
ReferenceError: helloCounter is not defined
  at Object.<anonymous>
```
module.exports

- **module** is a special object automatically defined in each NodeJS file, representing the current module.

- When you call `require('./fileName.js')`, the `require()` function will return the value of `module.exports` as defined in `fileName.js`.
  - `module.exports` is initialized to an empty object.
$ node scripts.js
{}

Prints an empty object because we didn't modify module.exports in broken-module.js.
$ node scripts.js
hello there

- Prints "hello there", because we set `module.exports` to "hello there" in `string-module.js`.
- The value of "result" is the value of "module.exports" in `string-module.js`.
function-module.js

1 function printHello() {
2   console.log('hello');
3 }
4 module.exports = printHello;
5

scripts.js

1 const result = require('./function-module.js');
2 console.log(result);
3 result();

$ node scripts.js
[Function: printHello]
hello

- We can export a function by setting it to module.exports
We can export multiple functions by setting fields of the `module.exports` object.

```javascript
print-util.js
1 function printHello() {
2   console.log('hello');
3 }
4
5 function greet(name) {
6   console.log('hello, ${name}');
7 }
8
9 module.exports.printHello = printHello;
10 module.exports.greet = greet;

scripts.js
1 const printUtil = require('./print-util.js');
2 printUtil.printHello();
3 printUtil.greet('world');
4 printUtil.greet("it's me");

$ node scripts.js
hello
hello, world
hello, it's me
```
We can export multiple functions by setting fields of the `module.exports` object.

```
function printHello() {
    console.log('hello');
}

function greet(name) {
    console.log(`hello, ${name}`);
}

module.exports.printHello = printHello;
module.exports.greet = greet;
```

```
const printUtil = require('./print-util.js');
printUtil.printHello();
pprintUtil.greet('world');
pprintUtil.greet('it\'s me');
```

```
$ node scripts.js
hello
hello, world
hello, it's me
```

- We can export multiple functions by setting fields of the `module.exports` object.
You can create private variables and fields by not exporting them.
Simple module examples

Module example code is here:
- simple-modules
- Run instructions

NodeJS Module documentation:
- https://nodejs.org/api/modules.html
Back to Routes
So far, our server routes have all been defined in one file.

Right now, server.js:
- Starts the server
- Sets the template engine
- Serves the public/ directory
- Defines the JSON-returning routes
- Defines the HTML-returning routes

As our server grows, it'd be nice to split up server.js into separate files.
Goal: HTML vs JSON routes

Let's try to split server.js into 3 files.

Right now, server.js does the following:

- **Starts the server**
- **Sets the template engine**
- **Serves the public/ directory**
- **Defines the JSON-returning routes**
- **Defines the HTML-returning routes**

→ We'll continue to use server.js for the logic in blue
→ We'll try to move JSON routes to api.js
→ We'll try to move the HTML routes to view.js
Goal: HTML vs JSON routes

→ We'll continue to use `server.js` for the logic in blue
→ We'll try to move JSON routes to `api.js`
→ We'll try to move the HTML routes to `view.js`

Desired directory structure:

- `dictionary-with-routes`
  - `node_modules`
  - `public`
  - `routes`
    - `api.js`
    - `views.js`
  - `views`
    - `package.json`
    - `server.js`
Desired: server.js

const express = require('express');
const MongoClient = require('mongodb').MongoClient;
const exphbs = require('express-handlebars');

const app = express();
const hbs = exphbs.create();
app.engine('handlebars', hbs.engine);
app.set('view engine', 'handlebars');
app.use(express.static('public'));

const DATABASE_NAME = 'eng-dict2';
const MONGO_URL = `mongodb://localhost:27017/${DATABASE_NAME}`;

let db = null;
let collection = null;

async function startServer() {
  // Set the db and collection variables before starting the server.
  db = await MongoClient.connect(MONGO_URL);
  collection = db.collection('words');
  // Now every route can safely use the db and collection objects.
  await app.listen(3000);
  console.log('Listening on port 3000');
}
startServer();
Desired api.js (DOESN'T WORK)

And we'd like to be able to define the /lookup/:word route in a different file, something like the following:

```javascript
async function onLookupWord(req, res) {
  const routeParams = req.params;
  const word = routeParams.word;

  const query = { word: word.toLowerCase() };
  const result = await collection.findOne(query);

  const response = {
    word: word,
    definition: result ? result.definition : ''
  };
  res.json(response);
}
app.get('/lookup/:word', onLookupWord);
```

Q: How do we define routes in a different file?
Express lets you create `Router` objects, on which you can define modular routes:

```javascript
const express = require('express');
const router = express.Router();

async function onLookupWord(req, res) {
    ...
}
router.get('/lookup/:word', onLookupWord);
module.exports = router;
```
Router

1. const express = require('express');
2. const router = express.Router();
3. 
4. async function onLookupWord(req, res) {
   ... 
5. }
6. router.get('/lookup/:word', onLookupWord);
7. 
8. module.exports = router;
9. 
10. - Create a new Router by calling express.Router()
- Set routes the same way you'd set them on App
- Export the router via module.exports
Using the Router

Now we include the router by:

- Importing our router module via `require()`
- Calling `app.use(router)` on the imported router

```javascript
const api = require('./routes/api.js');
const app = express();
app.use(api);
```

Now the app will also use the routes defined in `routes/api.js`!

However, we have a bug in our code...
We need to access the MongoDB collection in our route...

```javascript
const express = require('express');
const router = express.Router();

async function onLookupWord(req, res) {
    const routeParams = req.params;
    const word = routeParams.word;

    const query = { word: word.toLowerCase() };
    const result = await collection.findOne(query);

    const response = {
        word: word,
        definition: result ? result.definition : ''
    };
    res.json(response);
}

router.get('/lookup/:word', onLookupWord);

module.exports = router;
```
Middleware: app.use()

Now if we load this middleware on each request:

```javascript
async function startServer() {
    const db = await MongoClient.connect(MONGO_URL);
    const collection = db.collection('words');

    // Adds the "words" collection to every MongoDB request.
    function setCollection(req, res, next) {
        req.collection = collection;
        next();
    }
    app.use(setCollection);
    app.use(api);

    await app.listen(3000);
    console.log('Listening on port 3000');
}
```

Note that we need to use the api router **AFTER** the middleware.
MongoDB variables

Which used to be defined as a global variable in server.js.

Q: What's the right way to access the database data?

```javascript
let db = null;
let collection = null;

async function startServer() {
  // Set the db and collection variables before
  db = await MongoClient.connect(MONGO_URL);
  collection = db.collection('words');
  // Now every route can safely use the db and
  await app.listen(3000);
  console.log('Listening on port 3000');
}

startServer();
```
Middleware

In Express, you define **middleware functions** that get called certain requests, depending on how they are defined.

The app.METHOD routes we have been writing are actually middleware functions:

```javascript
function onViewIndex(req, res) {
    res.render('index');
}

app.get('/', onViewIndex);
```

onViewIndex is a middleware function that gets called every time there is a GET request for the "/" path.
Middleware: `app.use()`

We can also define middleware functions using `app.use()`:

```javascript
// Middleware function that prints a message for every request.
function printMessage(req, res, next) {
    console.log('request to server!');
    next();
}
app.use(printMessage);
```

Middleware functions receive 3 parameters:
- `req` and `res`, same as in other routes
- `next`: Function parameter. Calling this function invokes the next middleware function in the app.
  - If we resolve the request via `res.send`, `res.json`, etc, we don't have to call `next()`
Middleware: app.use()

We can write middleware that defines new fields on each request:

```javascript
const db = await MongoClient.connect(MONGO_URL);
const collection = db.collection('words');

// Adds the "words" collection to every MongoDB request.
function setCollection(req, res, next) {
  req.collection = collection;
  next();
}

app.use(setCollection);
```
Middleware: app.use()

Now if we load this middleware on each request:

```javascript
async function startServer() {
    const db = await MongoClient.connect(MONGO_URL);
    const collection = db.collection('words');

    // Adds the "words" collection to every MongoDB request.
    function setCollection(req, res, next) {
        req.collection = collection;
        next();
    }

    app.use(setCollection);
    app.use(api);

    await app.listen(3000);
    console.log('Listening on port 3000');
}
```
Middleware: app.use()

Then we can access the collection via req.collection:

```javascript
async function onLookupWord(req, res) {
    const routeParams = req.params;
    const word = routeParams.word;

    const query = { word: word.toLowerCase() };
    const result = await req.collection.findOne(query);

    const response = {
        word: word,
        definition: result ? result.definition : ''
    };
    res.json(response);
}
router.get('/lookup/:word', onLookupWord);
```
Middleware: app.use()

Then we can access the collection via req.collection:

```javascript
async function onLookupWord(req, res) {
    const routeParams = req.params;
    const word = routeParams.word;

    const query = { word: word.toLowerCase() };
    const result = await req.collection.findOne(query);

    const response = {
        word: word,
        definition: result ? result.definition : ''
    };
    res.json(response);
}
router.get('/lookup/:word', onLookupWord);
```
Views router

We can similarly move the HTML-serving logic to views.js and require() the module in server.js:

```javascript
const api = require('./routes/api.js');
const views = require('./routes/views.js');

app.use(setCollection);
app.use(api);
app.use(views);
```
Views router

```javascript
const express = require('express);
const router = express.Router();

async function onViewWord(req, res) {
    ...
    res.render('word', placeholders);
}
router.get('/:word', onViewWord);

function onViewIndex(req, res) {
    res.render('index');
}
router.get('/', onViewIndex);

module.exports = router;
```
Routes and middleware

Simple middleware example code is here:
- simple-middleware
- Run instructions

Dictionary with routes example code here:
- dictionary-with-routes
- Run instructions

Express documentation:
- Router
- Writing / Using Middleware
Recall: Web app architectures
Structuring a web app

There are roughly 4 strategies for architecting a web application:

1. **Server-side rendering:**
   Server sends a new HTML page for each unique path

2. **Single-page application:**
   Server sends the exact same web page for every unique path (and the page runs JS to change what it look like)

3. Combination of 1 and 2 ("Isomorphic" / "Universal")

4. **Progressive Loading**
Structuring a web app

There are roughly 4 strategies for architecting a web application:

1. **Server-side rendering:**
   Server sends a new HTML page for each unique path

2. **Single-page application:**
   Server sends the exact same web page for every unique path (and the page runs JS to change what it look like)

→ Let's talk about this one now
Single-page web app
Single page web app

- The server always sends the **same one HTML file** for all requests to the web server.
- The server is configured so that requests to `/<word>` would still return e.g. index.html.
- The client JavaScript parses the URL to get the route parameters and initialize the app.

```
GET localhost:3000/
```
Single page web app

- The server always sends the **same one HTML file** for all requests to the web server.
- The server is configured so that requests to `/<word>` would still return e.g. `index.html`.
- The client JavaScript parses the URL to get the route parameters and initialize the app.

```plaintext
GET localhost:3000/dog
```

```
index.html
```
Single page web app

Another way to think of it:

- You embed all your views into index.html
- You use JavaScript to switch between the views
- You configure JSON routes for your server to handle sending and retrieving data

```
GET localhost:3000/dog
```

index.html
Dictionary example

Let's write our dictionary example as a single-page web app.

**English dictionary**

Look up a word: 

The definition of **dog** is:

A quadruped of the genus Canis, esp. the domestic dog (C.familiaris).
Recall: Handlebars

For our multi-page dictionary app, we had two handlebars files: index.handlebars and word.handlebars

index.handlebars

```html
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8">
  <title>Dictionary lookup</title>
  <link rel="stylesheet" href="style.css">
  <script src="fetch.js" defer></script>
</head>
<body>
  <h1>English dictionary</h1>
  
  <form id="search">
    Look up a word: <input type="text" id="word-input"/>
    <input type="submit" value="Search!">
  </form>

  <hr />

  <div id="results" class="hidden">
    The definition of <a href="#" id="word"></a> is:
    <blockquote id="definition"></blockquote>
  </div>

</body>
</html>
```

word.handlebars

```html
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8">
  <title>Define: {{ word }}</title>
  <link rel="stylesheet" href="/css/style.css">
</head>
<body>
  <h1>{{ word }}</h1>
  
  <div id="results" class="hidden">
    The definition of <strong id="word">{{ word }}</strong> is:
    <blockquote id="definition">{{ definition }}</blockquote>
  </div>
</body>
</html>
```
SPA

In a single-page web app, the HTML for both the Search page and the Word page are in index.html:

```html
<!-- View for the search page -->
<section id="main-view" class="hidden">
  <h1>English dictionary</h1>

  <form id="search">
    Look up a word: <input type="text" id="word-input"/>
    <input type="submit" value="Search!"/>
  </form>

  <hr />

  <div id="results" class="hidden">
    The definition of <a href="" id="word"></a> is:
    <blockquote id="definition"></blockquote>
  </div>
</section>

<!-- View for a single word -->
<section id="word-view" class="hidden">
  <h1></h1>
  The definition of <strong id="wv-word"></strong> is:
  <blockquote id="wv-def"></blockquote>
</section>
```
Server-side routing

For all requests that are not JSON requests, we return "index.html"

```javascript
const path = require('path');

async function onAllOtherPaths(req, res) {
    res.sendFile(path.resolve(__dirname, 'public', 'index.html'));
}

app.get('/*', onAllOtherPaths);
```
Client-side parameters

All views are hidden at first by the client.

<!-- View for the search page -->
<section id="main-view" class="hidden">
  ...
</section>

<!-- View for a single word -->
<section id="word-view" class="hidden">
  ...
</section>
Client-side parameters

When the page loads, the client looks at the URL to decide what page it should display.

```javascript
const urlPathString = window.location.pathname;
const parts = urlPathString.split('/');
if (parts.length > 1 && parts[1].length > 0) {
  const word = parts[1];
  this._showWordView(word);
} else {
  this._showSearchView();
}
```
Client-side parameters

To display the word view, the client makes a `fetch()` requests for the definition.

```javascript
class WordView {
    constructor(containerElement, word) {
        this.containerElement = containerElement;
        this._onSearch(word);
    }

    async _onSearch(word) {
        const result = await fetch('/lookup/' + word);
        const json = await result.json();
    }
}```
Completed example code:

- dictionary-spa
- See run instructions
Overflow Slides
(not covered in lecture)
Another example: E-cards
Example: E-cards

We'll be creating an e-card app, whose data is saved in a MongoDB database:
Example: E-cards

When the user loads to an index page, we want to present them with an E-Card Maker UI.
Example: E-cards

When the user has created an e-card, we want it accessible via URL of this form:

/id/<ecard_id>
Step 1: Saving data

We'll need to save 3 pieces of data:
- Card style
- Card message
- A unique id for each card
Example: E-card saving data

```javascript
async function onSaveCard(req, res) {
  const style = req.body.style;
  const message = req.body.message;
  const doc = {
    style: style,
    message: message
  };

  const collection = db.collection('card');
  const response = await collection.insertOne(doc);

  res.json({ cardId: response.insertedId });
}
app.post('/save', jsonParser, onSave);
Step 2: Loading a card

When the user has created an e-card, we want it accessible via URL of this form:

/id/<ecard_id>
Web app architecture

How do we implement an app so that to show a different view depending on the URL path?

Create-a-card:
localhost:3000/

View card:
localhost:3000/id/<card_id>
Web app architectures
Structuring a web app

There are roughly 4 strategies for architecting a web application:

1. **Server-side rendering:**
   Server sends a new HTML page for each unique path

2. **Single-page application:**
   Server sends the exact same web page for every unique path (and the page runs JS to change what it look like)

3. Combination of 1 and 2 ("Isomorphic" / "Universal")

4. **Progressive Loading**
1. Server-side rendering:
   - **CS193X:** We will show you how to do this

2. Single-page application:
   - **CS193X:** We will show you how to do this

3. Combination of 1 and 2 ("Isomorphic" / "Universal")
   - This is probably the most common technique
   - **CS193X:** We will talk about this but won't show you how to code it

4. Progressive Loading
   - This is probably the future (but it's complex)
   - **CS193X:** We will talk about this but won't show you how to code it
Server-side rendering
Server-side rendering

Multi-page web app:

- The server generates a different web page
- Usually involves filling out and returning an HTML template in response to a request
  - This is done by a **templating engine**: Jade, Handlebars, etc
E-cards: Server-side rendering

We change our E-cards example to have 2 Handlebars templates:

- card.handlebars
- Index.handlebars

views/ is the default directory in which Handlebars will look for templates.

Note that there are no longer any HTML files in our public/ folder.
index.handlebars

This is the same contents of index.html with no placeholders, since there were no placeholders needed:

```html
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>CS193x e-cards</title>
    <link rel="stylesheet" href="/css/card-style.css">
    <link rel="stylesheet" href="/css/creator-style.css">
    <script src="/js/creator-view.js" defer></script>
    <script src="/js/main.js" defer></script>
  </head>
  <body>
    <section class="main" id="creator-view">
      <h1>CS193x e-cards</h1>
      <h2>Preview</h2>
      <section id="card-view">
        <div id="card-image"></div>
        <div id="card-message"></div>
      </section>
    </section>
  </body>
</html>
```
But for the card-view, we want a different card style and message depending on the card:

```html
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>CS193x e-cards</title>
    <link rel="stylesheet" href="/css/card-style.css">
  </head>
  <body>
    <section class="main">
      <h1>CS193x e-cards</h1>
      <section id="card-view">
        <div id="card-image" class="{{ style }}"></div>
        <div id="card-message">{{ message }}</div>
      </section>
    </section>
  </body>
</html>
```
But for the card-view, we want a different card style and message depending on the card:

```html
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>CS193x e-cards</title>
    <link rel="stylesheet" href="/css/card-style.css">
  </head>
  <body>
    <section class="main">
      <h1>CS193x e-cards</h1>
      <section id="card-view">
        <div id="card-image" class="{{ style }}"></div>
        <div id="card-message">{{ message }}</div>
      </section>
    </section>
  </body>
</html>
```
Setting up NodeJS to use Handlebars and adding templates does nothing on its own. To use the templates, we need to call `res.render`:

```javascript
function onGetMain(req, res) {
    res.render('index');
}
app.get('/', onGetMain);
```

`res.render(viewName, placeholderDefs)`
- Returns the HTML stored in "views/viewName.handlebars" after replacing the placeholders, if they exist
E-cards: Server-side rendering

For retrieving the card, we have placeholders we need to fill in, so we define the placeholder values in the second parameter:

```javascript
async function onGetCard(req, res) {
  const cardId = req.params.cardId;
  const collection = db.collection('card');
  const doc = await collection.findOne({ _id: ObjectId(cardId) });

  res.render('card', { message: doc.message, style: doc.style });
}

app.get('/id/:cardId', onGetCard);
```
Single-page web app
Single page web app

- The server always sends the **same one HTML file** for all requests to the web server.
- The server is configured so that requests to `/id/<card_id>` would still return e.g. `index.html`.
- The client JavaScript parses the URL to get the route parameters and initialize the app.

```
GET localhost:3000/
```

```
index.html
```
Single page web app

- The server always sends the **same one HTML file** for all requests to the web server.
- The server is configured so that requests to /id/<card_id> would still return e.g. index.html.
- The client JavaScript parses the URL to get the route parameters and initialize the app.

GET id/2338242394

index.html
Single page web app

Another way to think of it:

- You configure several JSON routes for your server
- You embed all your view into index.html
- You use JavaScript to switch between the views

GET id/2338242394
E-card example code

E-cards written with Handlebar templates
- `simple-middleware`

E-cards written in Single-Page-App style
- `dictionary-with-routes`