

# 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

# Dictionary example

Let's go back to our dictionary example that let us look up the definition of words ([GitHub](#)):

## English dictionary

Look up a word:

---

The definition of **dog** is:

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

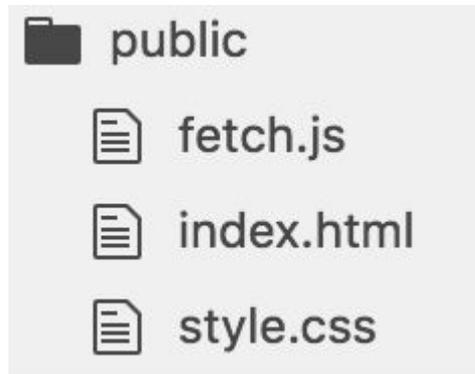
---

# Current code: Static routes

We've defined our server to:

1. Statically serve index.html / style.css / fetch.js

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



# Current code: Static routes

We've defined our server to:

1. Statically serve `index.html` / `style.css` / `fetch.js`

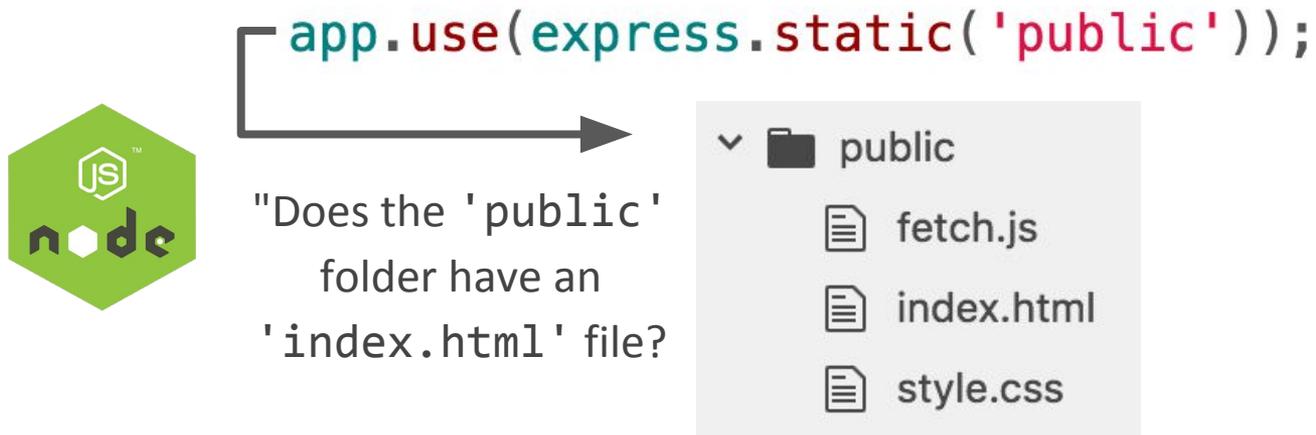


So when there's a request to `localhost:3000/` ...

# Current code: Static routes

We've defined our server to:

1. Statically serve index.html / style.css / fetch.js

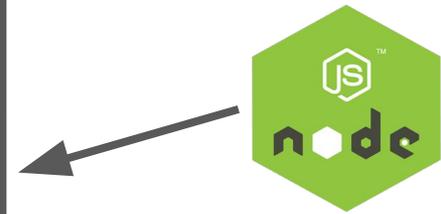
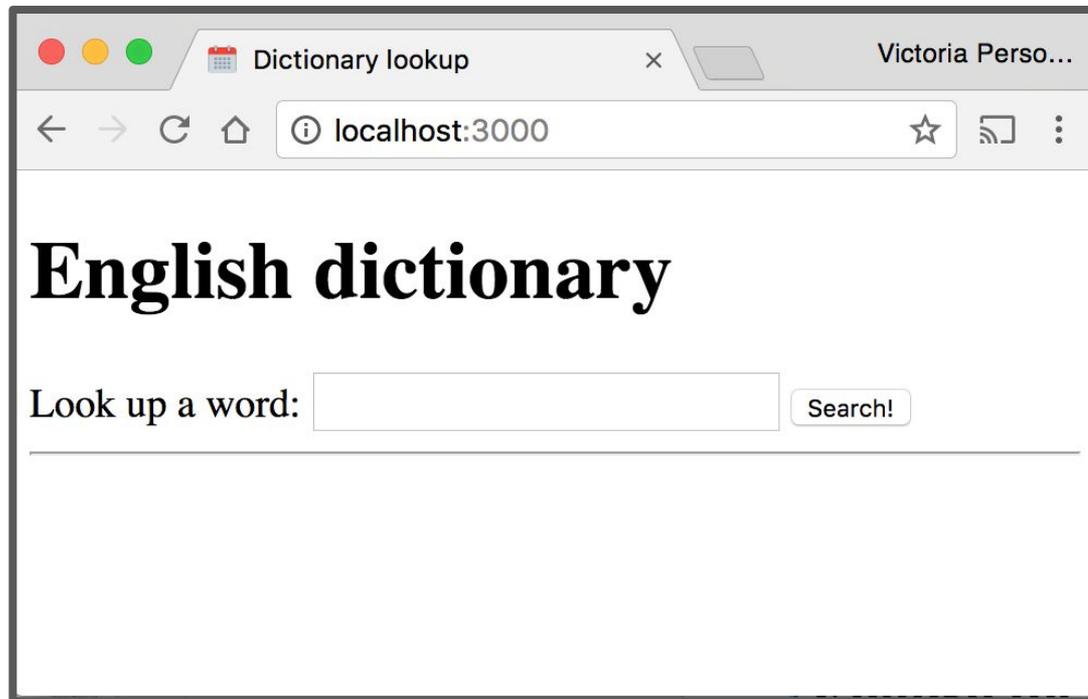


- Our NodeJS server.js program checks the public directory to see if "index.html" exists, which it does, so it replies with that file.
- It similarly provides fetch.js and style.css, embedded in index.html.

# Current code: Static routes

We've defined our server to:

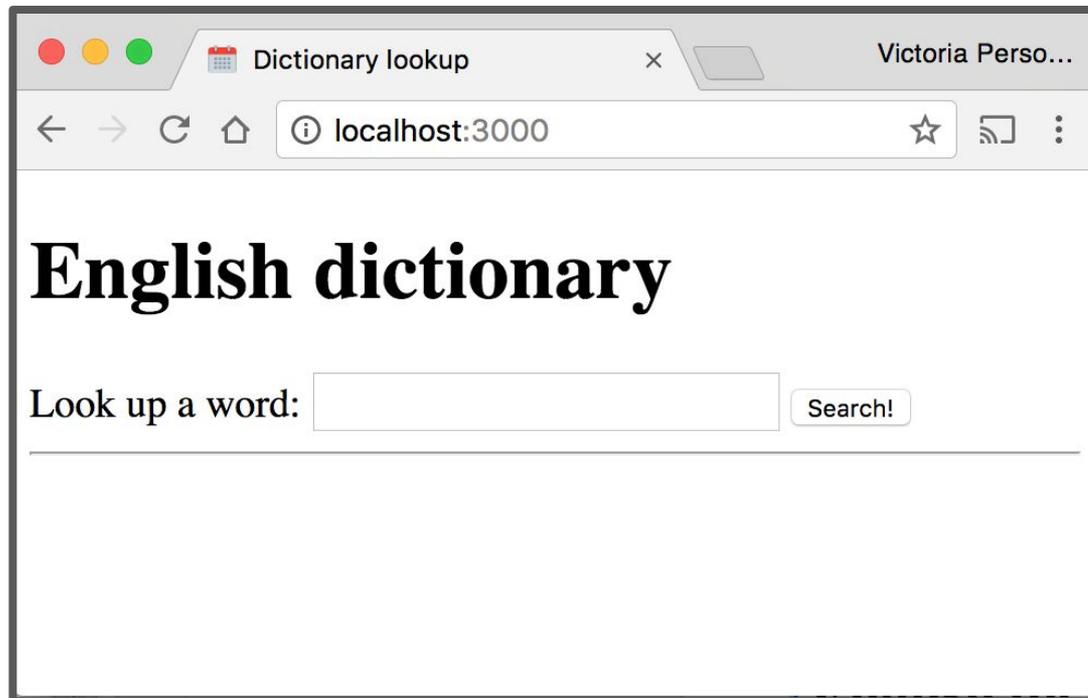
1. Statically serve index.html / style.css / fetch.js



# 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>

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

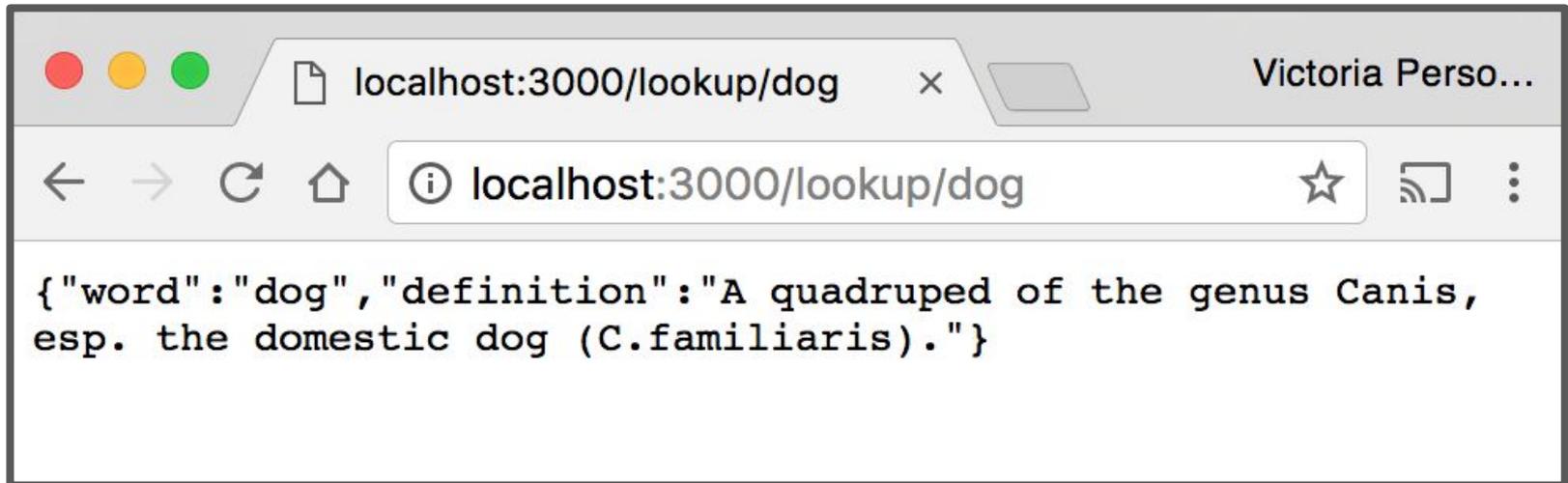
  const query = { word: word.toLowerCase() };
  const result = await collection.findOne(query);

  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.

# Current code: JSON route

We've also defined our server to:

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

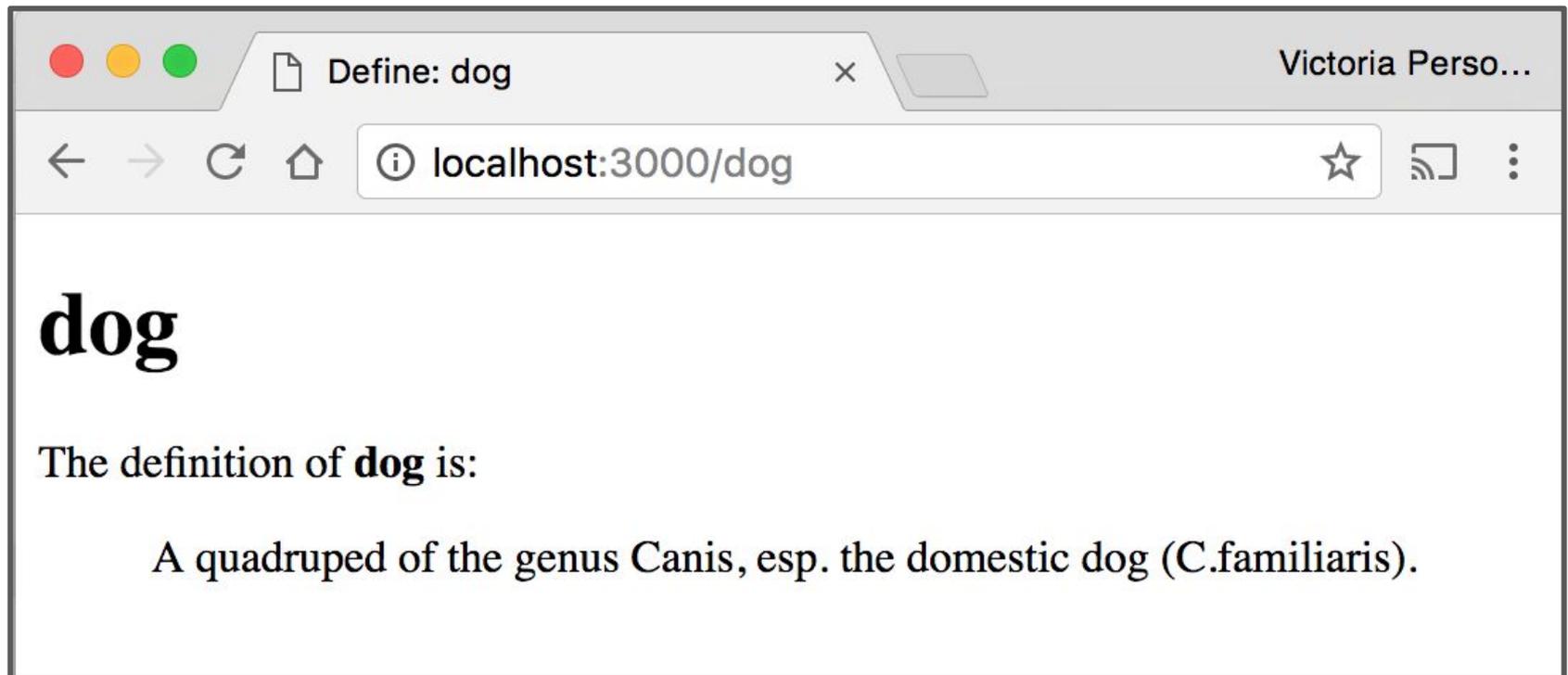
But how we  
actually query  
our JSON  
route is  
through  
fetch().

```
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>** should show a web page with the definition of "dog:"



# Naive solution: static files

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

## cat/index.html

```
1 <!DOCTYPE html>
2 <html>
3   <head>
4     <meta charset="utf-8">
5     <title>Define: cat</title>
6     <link rel="stylesheet" href="/css/style.css">
7   </head>
8   <body>
9     <h1>cat</h1>
10    <div id="results" class="hidden">
11      The definition of <strong id="word">cat</strong> is:
12      <blockquote id="definition">An animal of various species of the genera Felis
and Lynx. Thedomestic cat is Felis domestica. The European wild cat (Felis
catus)is much larger than the domestic cat. In the United States the namewild cat
is commonly applied to the bay lynx (Lynx rufus) See Wildcat, and Tiger cat.
</blockquote>
13    </div>
14  </body>
15 </html>
```

# Naive solution: static files

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

## category/index.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 orthought can be reduced, and by which they can be arranged in
asystem; an ultimate or undecomposable conception; a predicament.The categories or
predicaments -- the former a Greek word, the latterits literal translation in the
Latin language -- were intended byAristotle and his followers as an enumeration of
all things capableof being named; an enumeration by the summa genera i.e., the
mostextensive classes into which things could be distributed. J. S. Mill.
</blockquote>
    </div>
  </body>
</html>
```

# Naive solution: static files

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

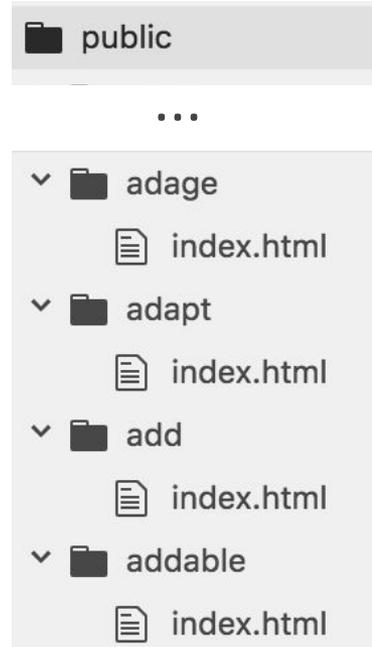
## catastrophe/index.html

```
<!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 theearth, as, an elevation or subsidence of some part of it, effected
byinternal 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.

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
  </head>
</html>
<!-- ... -->
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
  </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 theearth, as, an elevation or subsidence of some part of it, effected
      byinternal causes. Whewell.</blockquote>
    </div>
  </body>
</html>
```

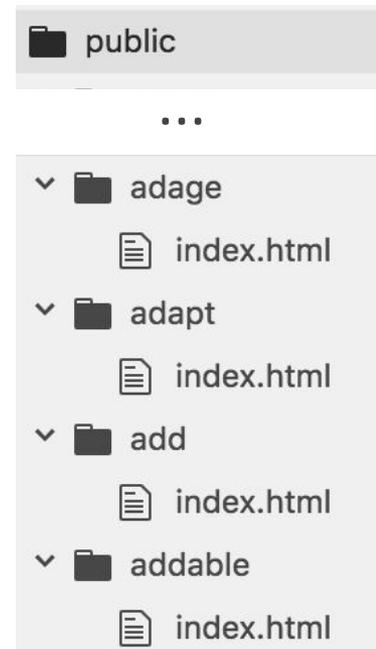


# Naive solution: static files

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.

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
  </head>
</html>
<!--
and
catu
is c
</bl
</ht
surfac
byinte
-->
<!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 theearth, as, an elevation or subsidence of some part of it, effected
      byinternal causes. Whewell.</blockquote>
    </div>
  </body>
</html>
```



# 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



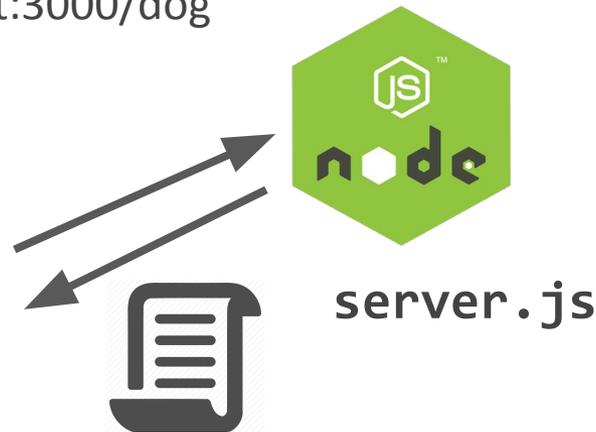
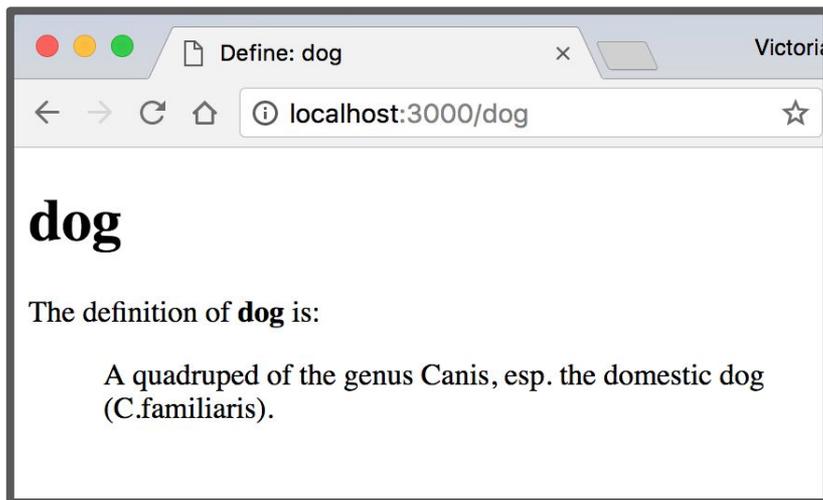
...

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.

# Dynamically generated pages

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

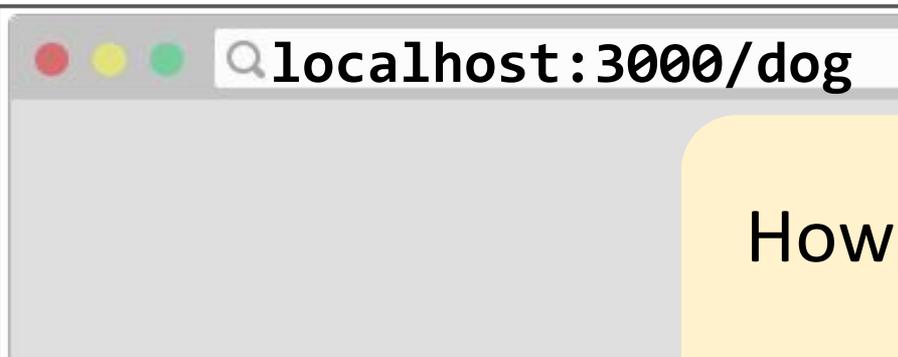
GET localhost:3000/dog



...

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

How does this step work?



Recall: Web app architectures

# 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

→ Let's start with this one.

# Dynamically generated pages

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...

# HTML Strings

We start with defining a dummy route:

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

  const result = `

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


```

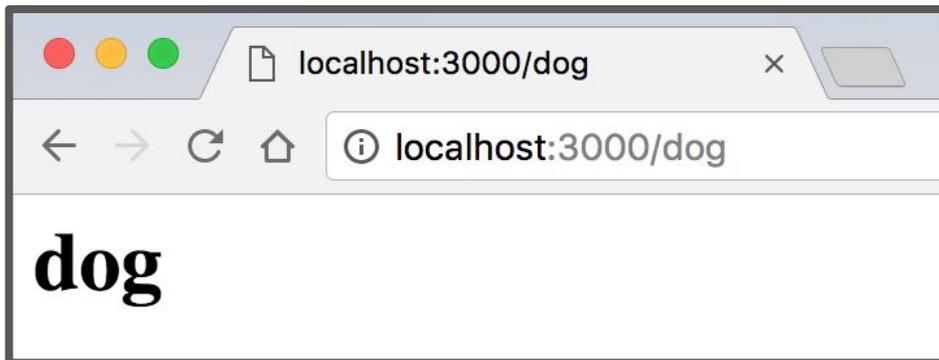
# HTML Strings

We start with defining a dummy route:

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

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


```



This just echoes what we passed in as a query parameter.

# HTML Strings

Now we look up and show the definition too:

```
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 = `

# ${word}</h1>`; response += ` ${definition}</p>`; res.end(response); } app.get('/:word', onViewWord);


```

# HTML Strings

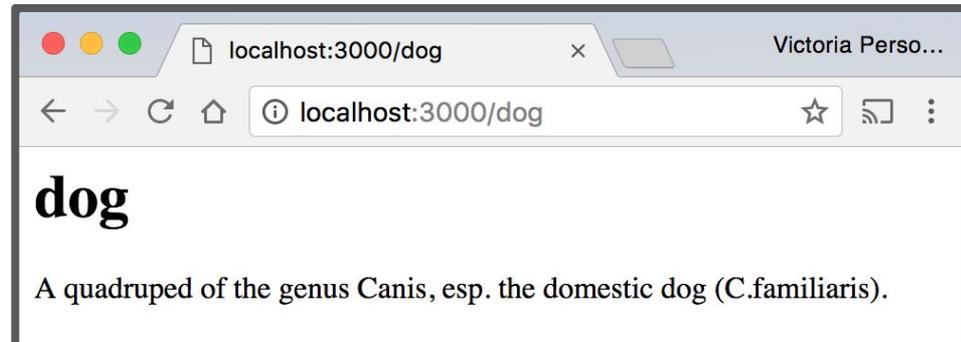
```
async function onViewWord(req, res) {
  const routeParams = req.params;
  const word = routeParams.word;

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

  let response = `

# ${word}</h1>`; response += ` ${definition}</p>`; res.end(response); } app.get('/:word', onViewWord);


```



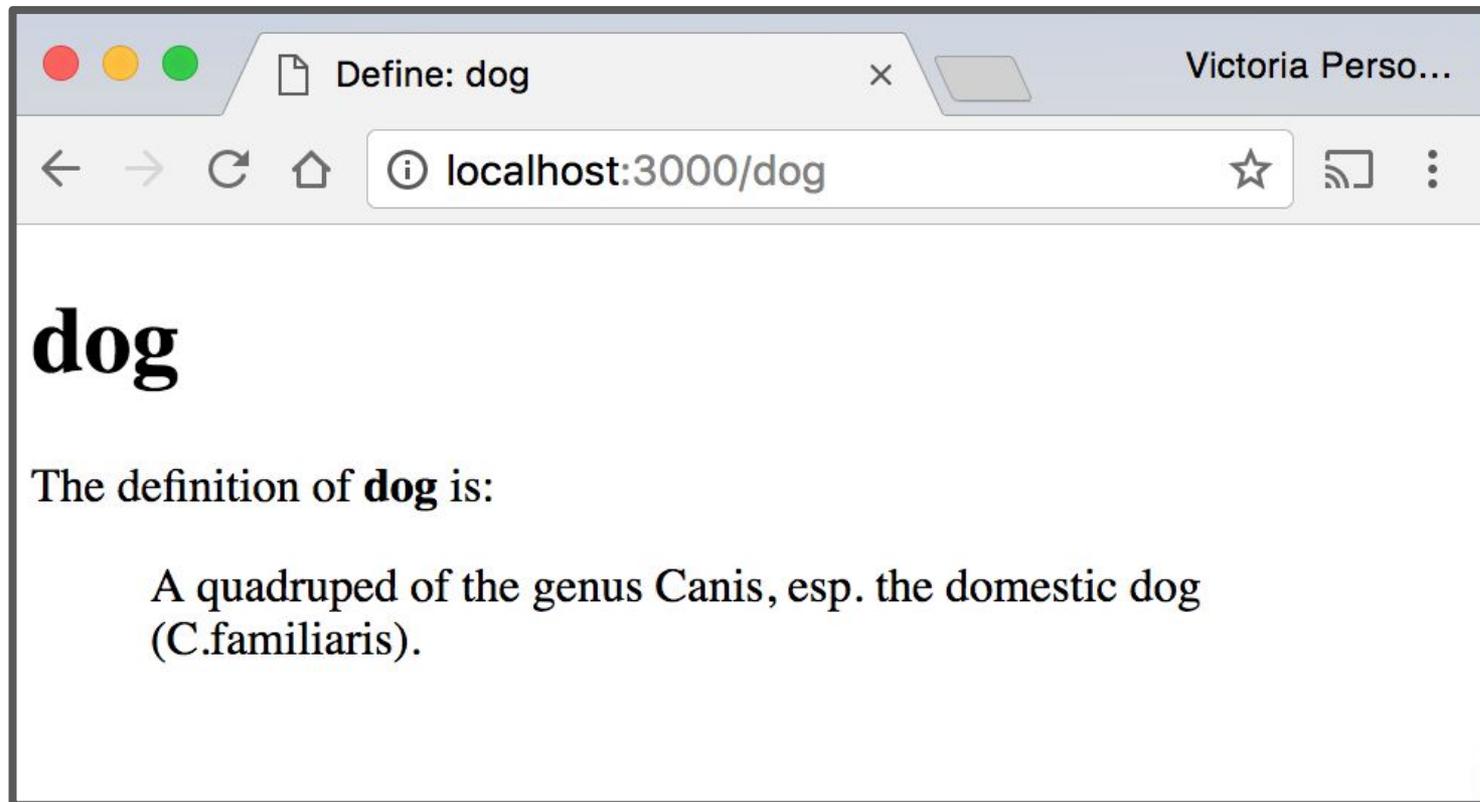
# HTML Strings

We can make our HTML response a little fancier:

```
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);
}
```

# HTML Strings

We can make our HTML response a little fancier:



# HTML Strings

This works, but now we have a big HTML string in our server code:

```
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

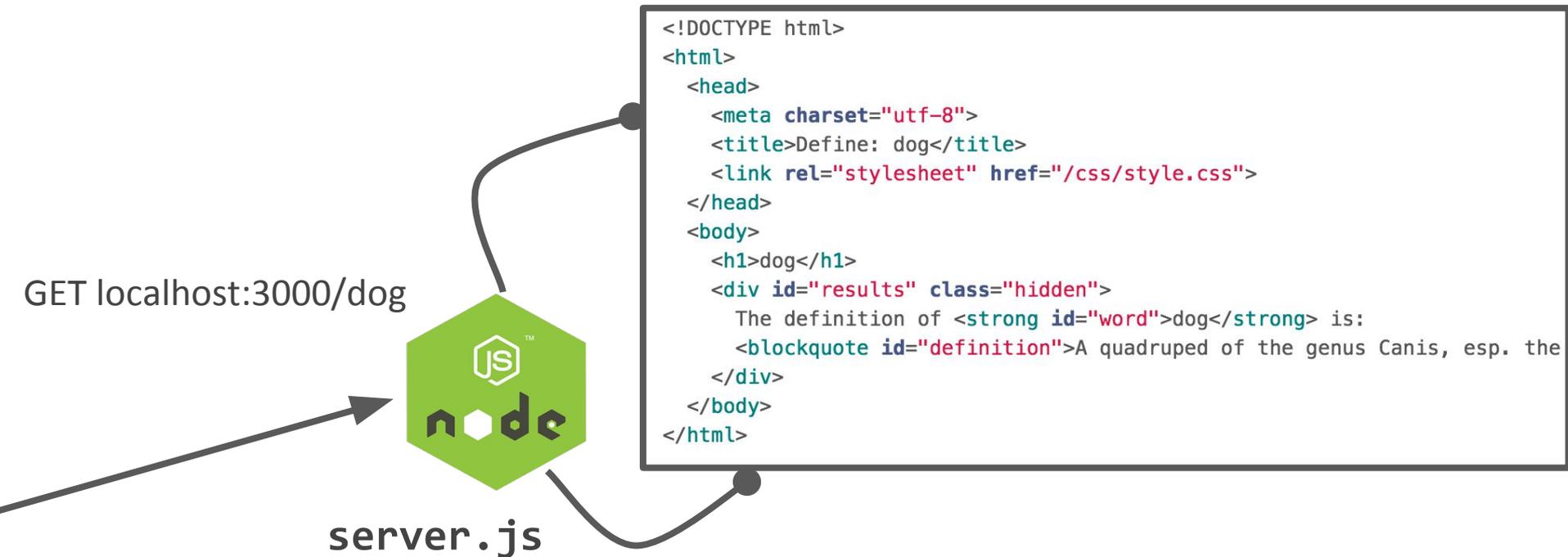


server.js

**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:



# 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: Template engine

- 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

```
<div class="entry">
  <h1>{{title}}</h1>
  <div class="body">
    {{body}}
  </div>
</div>
```

# Handlebars and NodeJS

You can setup Handlebars and NodeJS using the `express-handlebars` NodeJS library:

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

```
...
```

```
const app = express();
```

```
const hbs = exphbs.create();
```

```
app.engine('handlebars', hbs.engine);
```

```
app.set('view engine', 'handlebars');
```

# Dictionary example

So instead of our large template string:

```
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

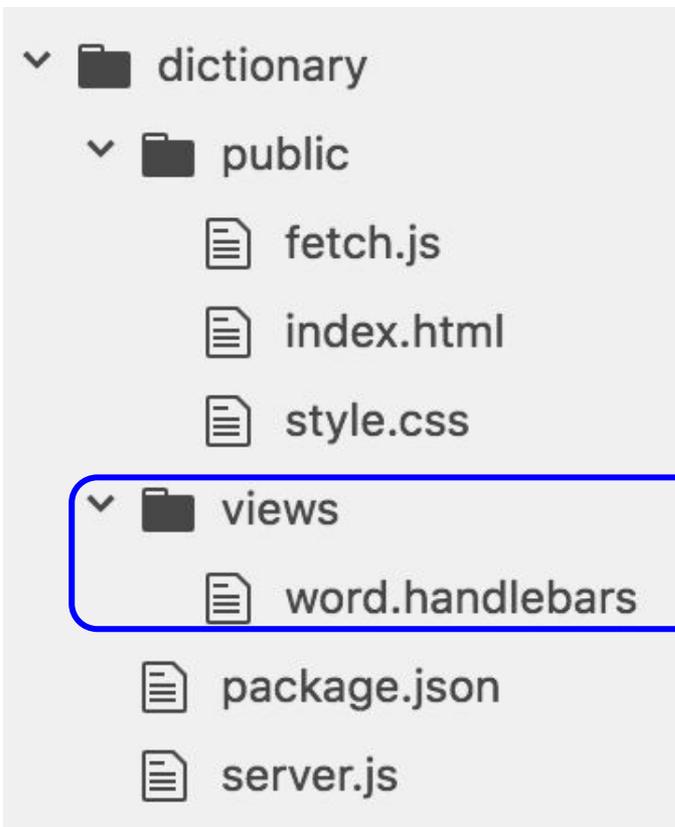
We can create a template in a file `words.handlebars`:

```
<!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

Now instead of  
returning a long string  
on the server side:

```
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:

```
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`

```
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);
```

We call [`res.render`](#) to fill in the "word" Handlebars template.

# Call `res.render`

▼ dictionary

▼ public

fetch.js

index.html

style.css

▼ views

word.handlebars

package.json

server.js

```
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.

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

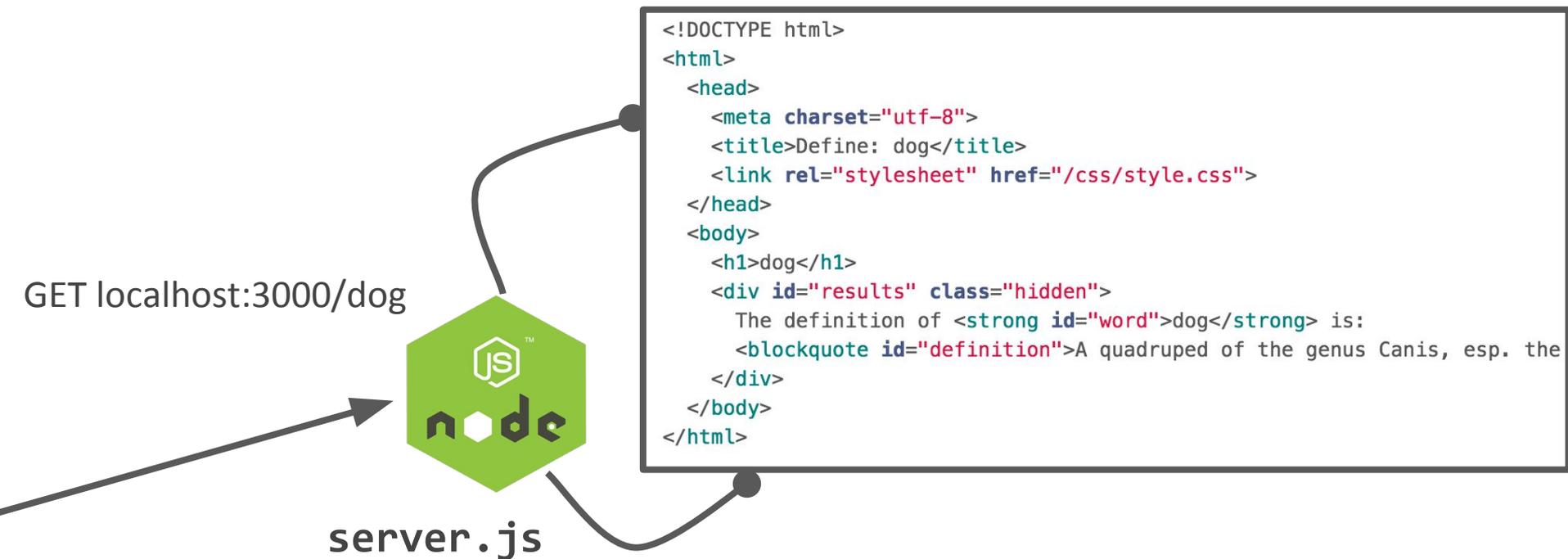
...

```
<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>
```

...

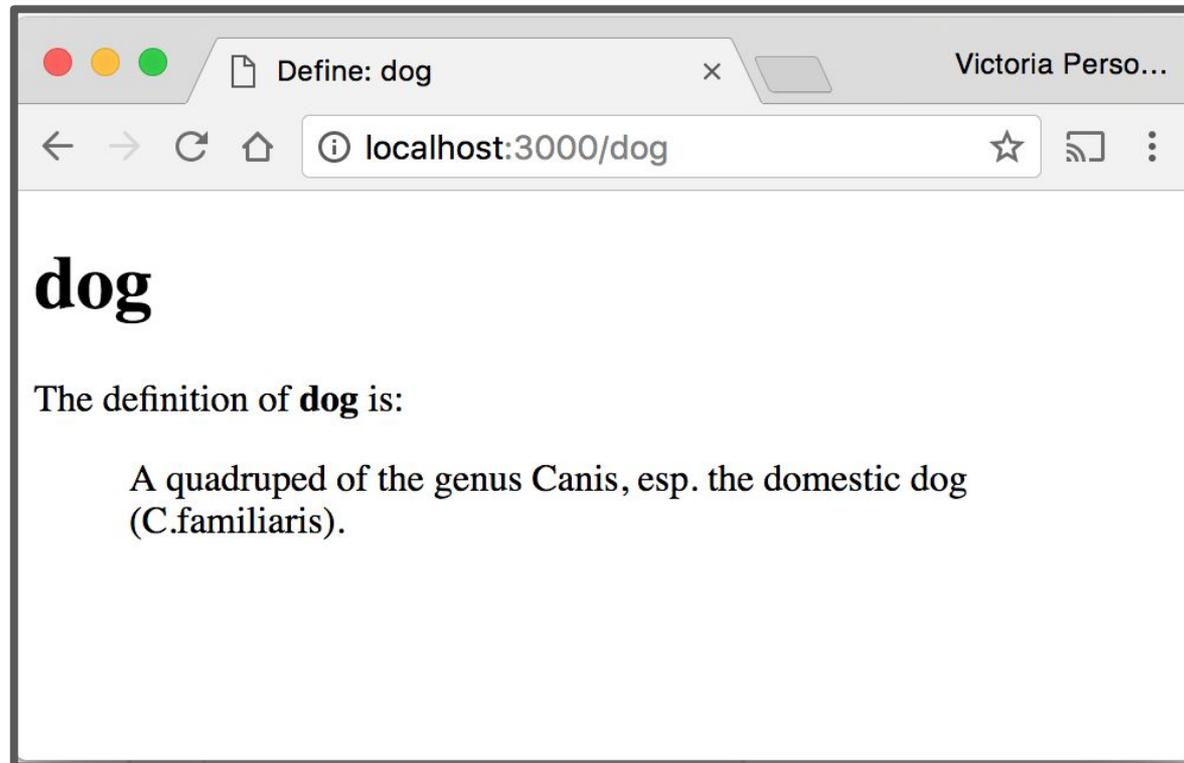
# HTML Template

The Handlebars templating engine will return to the client the filled in template as HTML:

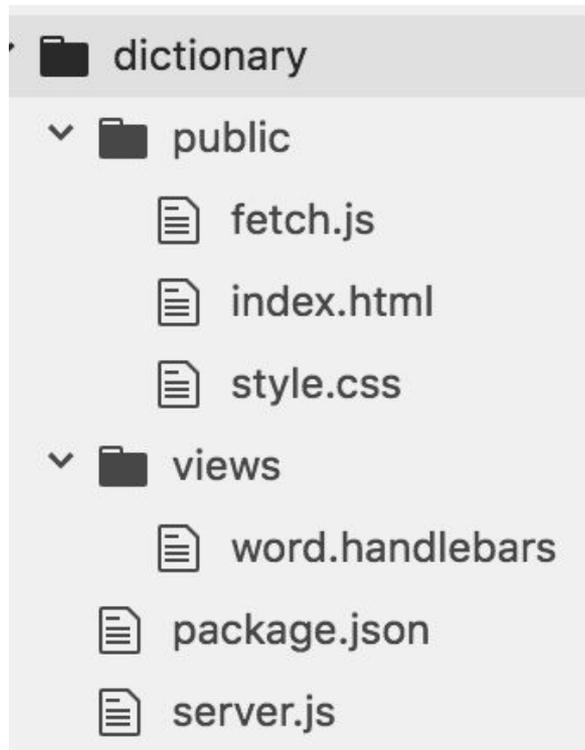


# HTML Template

The Handlebars templating engine will return to the client the filled in template as HTML:



# Note on templates



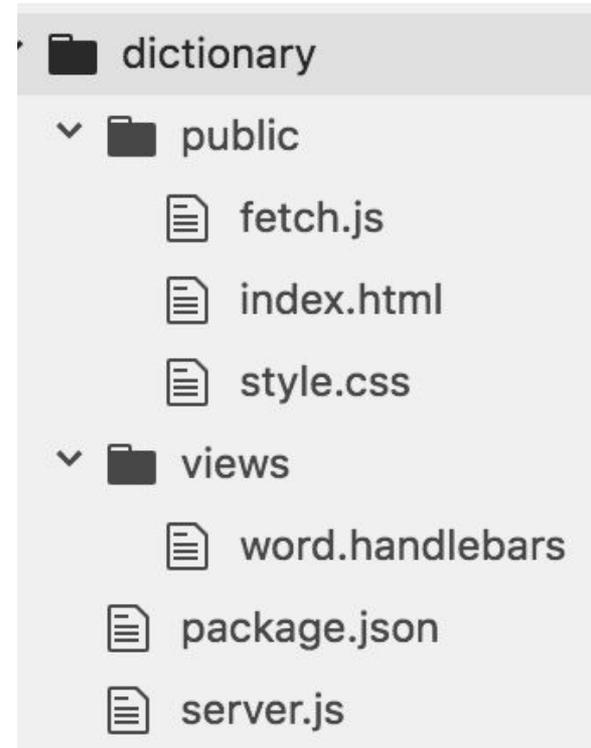
- The server is dynamically generating HTML files to return back to the client, but these HTML files **aren't** saved on the server; they are just passed directly to the client from memory.

# 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:

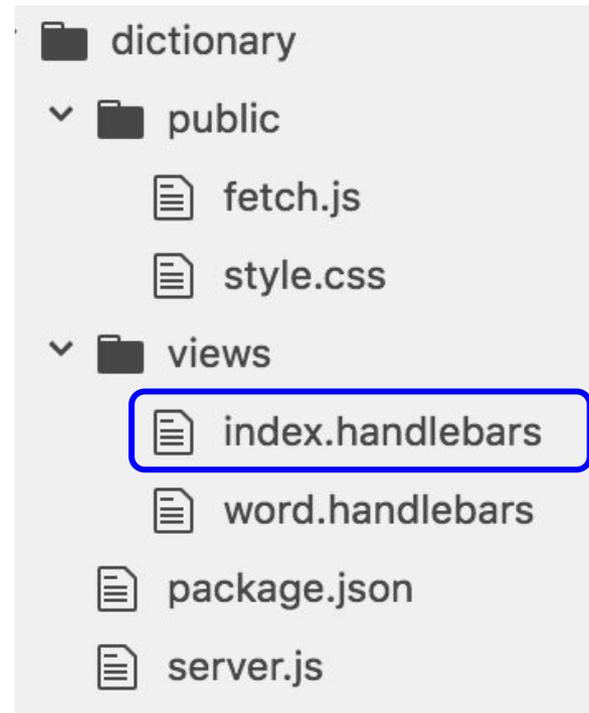
```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>Dictionary lookup</title>
    <link rel="stylesheet" href="style.css">
    <script src="fetch.js" defer</script>
  </head>
  <body>
    <h1>English dictionary</h1>

    <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>
      <hr />
    </div>

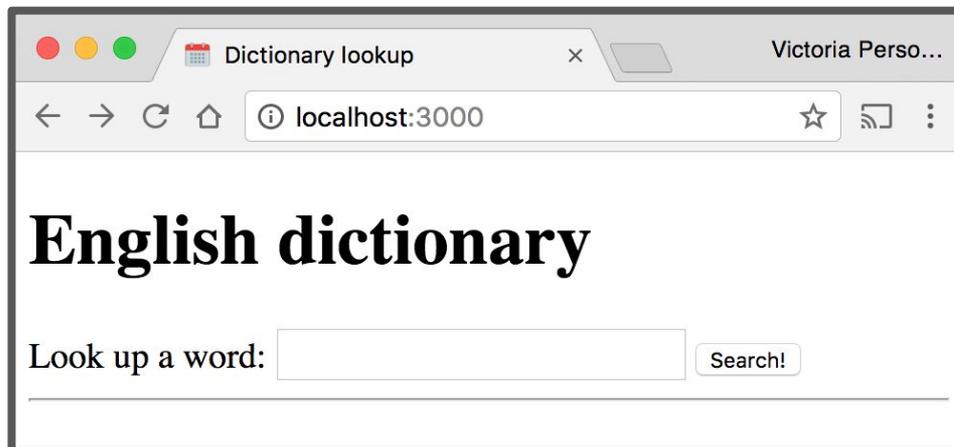
  </body>
</html>
```



# Note on style

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

```
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.

```
1 const express = require('express');
2 const MongoClient = require('mongodb').MongoClient;
3
4 const exphbs = require('express-handlebars');
5
6 const app = express();
7 const hbs = exphbs.create();
8 app.engine('handlebars', hbs.engine);
9 app.set('view engine', 'handlebars');
10
11 app.use(express.static('public'));
12
13 const DATABASE_NAME = 'eng-dict2';
14 const MONGO_URL = `mongodb://localhost:27017/${DATABASE_NAME}`;
15
16 let db = null;
17 let collection = null;
18
19 async function startServer() {
20   // Set the db and collection variables before starting the server.
21   db = await MongoClient.connect(MONGO_URL);
22   collection = db.collection('words');
23   // Now every route can safely use the db and collection objects.
24   await app.listen(3000);
25   console.log('Listening on port 3000');
26 }
27 startServer();
28
29 ///////////////////////////////////////////////////
30 // JSON-returning route
31
32
33 async function onLookupWord(req, res) {
34   const routeParams = req.params;
35   const word = routeParams.word;
36
37   const query = { word: word.toLowerCase() };
38   const result = await collection.findOne(query);
39
40   const response = {
41     word: word,
42     definition: result ? result.definition : ''
43   };
44   res.json(response);
45 }
46 app.get('/lookup/:word', onLookupWord);
47
48 ///////////////////////////////////////////////////
49 // HTML-returning route
50
51
52 async function onViewWord(req, res) {
53   const routeParams = req.params;
54   const word = routeParams.word;
55
56   const query = { word: word.toLowerCase() };
57   const result = await collection.findOne(query);
58   const definition = result ? result.definition : '';
59
60   const placeholders = {
61     word: word,
62     definition: definition
63   };
64   res.render('word', placeholders);
65 }
66 app.get('/:word', onViewWord);
67
68 function onViewIndex(req, res) {
69   res.render('index');
70 }
71 app.get('/', onViewIndex);
72
```

# 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.

# NodeJS modules

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:

```
silly-module.js
1  // This is a *poor* style and a bad example of a module;
2  // you should NOT write modules like this.
3
4  // This runs immediately, as soon as it is included.
5  console.log('hello');
6
```

# 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

silly-module.js

```
1 // This is a *poor* style and a bad example of a module;
2 // you should NOT write modules like this.
3
4 // This runs immediately, as soon as it is included.
5 console.log('hello');
6
```

scripts.js

```
1 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:

broken-module.js

```
1  // This is a private variable that is not shared.
2  let helloCounter = 0;
3
4  // This is a private function that is not shared.
5  function printHello() {
6    helloCounter++;
7    console.log('hello');
8  }
```

# Private variables

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

```
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:

```
scripts.js
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.

*broken-module.js*

```
1 // This is a private variable that is not shared.
2 let helloCounter = 0;
3
4 // This is a private function that is not shared.
5 ✓ function printHello() {
6     helloCounter++;
7     console.log('hello');
8 }
```

*scripts.js*

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

```
$ node scripts.js
{}
```

Prints an empty object because we didn't modify `module.exports` in `broken-module.js`.

string-module.js

```
1 // This is a pretty silly module as well.  
2 module.exports = 'hello there';  
3
```

scripts.js

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

```
$ 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`

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;
11
```

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

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;
11
```

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

print-util.js

```
1 let i = 0;
2 function printCount() {
3     i++;
4     console.log(`count is now ${i}`);
5 }
6 module.exports.printCount = printCount;
7
```

scripts.js

```
1 const printUtil = require('./print-util.js');
2 printUtil.printCount();
3 printUtil.printCount();
4 printUtil.printCount();
```

**\$ node scripts.js**

count is now 1

count is now 2

count is now 3

- 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

# 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.

```
1 const express = require('express');
2 const MongoClient = require('mongodb').MongoClient;
3
4 const exphbs = require('express-handlebars');
5
6 const app = express();
7 const hbs = exphbs.create();
8 app.engine('handlebars', hbs.engine);
9 app.set('view engine', 'handlebars');
10
11 app.use(express.static('public'));
12
13 const DATABASE_NAME = 'eng-dict2';
14 const MONGO_URL = `mongodb://localhost:27017/${DATABASE_NAME}`;
15
16 let db = null;
17 let collection = null;
18
19 async function startServer() {
20   // Set the db and collection variables before starting the server.
21   db = await MongoClient.connect(MONGO_URL);
22   collection = db.collection('words');
23   // Now every route can safely use the db and collection objects.
24   await app.listen(3000);
25   console.log('Listening on port 3000');
26 }
27 startServer();
28
29 ////////////////////////////////////////////////////
30 // JSON-returning route
31
32
33 async function onLookupWord(req, res) {
34   const routeParams = req.params;
35   const word = routeParams.word;
36
37   const query = { word: word.toLowerCase() };
38   const result = await collection.findOne(query);
39
40   const response = {
41     word: word,
42     definition: result ? result.definition : ''
43   };
44   res.json(response);
45 }
46 app.get('/lookup/:word', onLookupWord);
47
48 ////////////////////////////////////////////////////
49 // HTML-returning route
50
51
52 async function onViewWord(req, res) {
53   const routeParams = req.params;
54   const word = routeParams.word;
55
56   const query = { word: word.toLowerCase() };
57   const result = await collection.findOne(query);
58   const definition = result ? result.definition : '';
59
60   const placeholders = {
61     word: word,
62     definition: definition
63   };
64   res.render('word', placeholders);
65 }
66 app.get('/:word', onViewWord);
67
68 function onViewIndex(req, res) {
69   res.render('index');
70 }
71 app.get('/', onViewIndex);
72
```

# 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

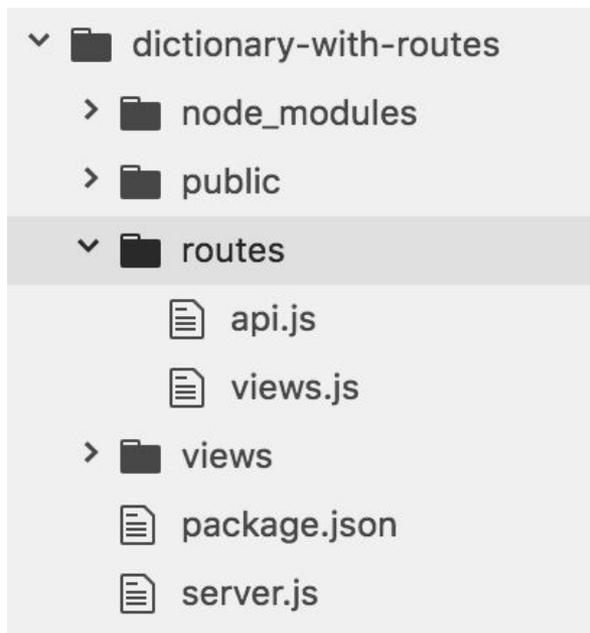
→ We'll try to move JSON routes to **api.js**

→ 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:



# 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();
```

We'd like to keep all  
set-up stuff in  
server.js...

# 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:

```
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?**

# Router

Express lets you create Router objects, on which you can define modular routes:

api.js

```
1  const express = require('express');
2  const router = express.Router();
3
4  async function onLookupWord(req, res) {
5    ...
6  }
7  router.get('/lookup/:word', onLookupWord);
8
9  module.exports = router;
10
```

# Router

```
1  const express = require('express');
2  const router = express.Router();
3
4  async function onLookupWord(req, res) {
5    ...
6  }
7  router.get('/lookup/:word', onLookupWord);
8
9  module.exports = router;
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

```
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...

# MongoDB variables

We need to access the MongoDB collection in our route...

```
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()

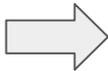
Now if we load this middleware on each request:

```
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?**

```
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 c
  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:

```
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()`:

```
// 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:

```
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:

```
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`:

```
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`:

```
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:

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

-
app.use(setCollection);
app.use(api);
app.use(views);
```

# Views router

```
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:**

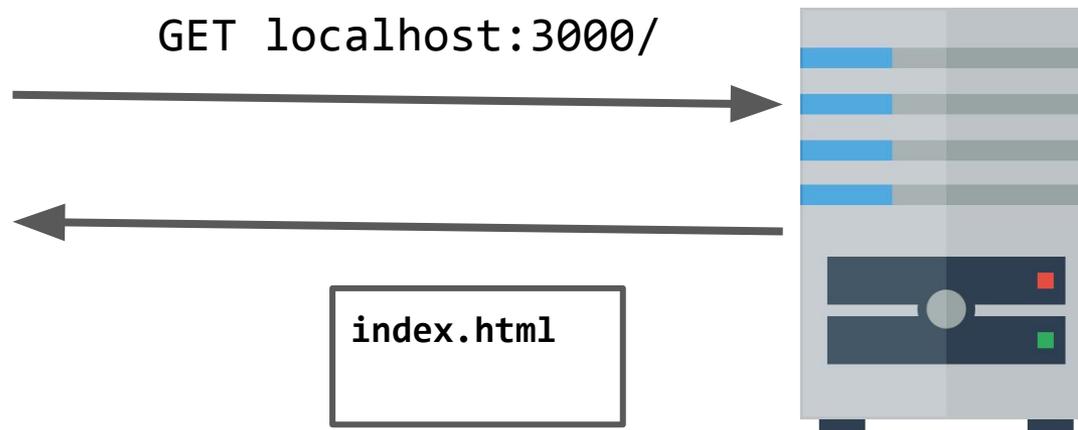
Server sends the exact same web page for every unique path (and the page runs JS to change what it look like)

→ Let's talk about this one now

Single-page web app

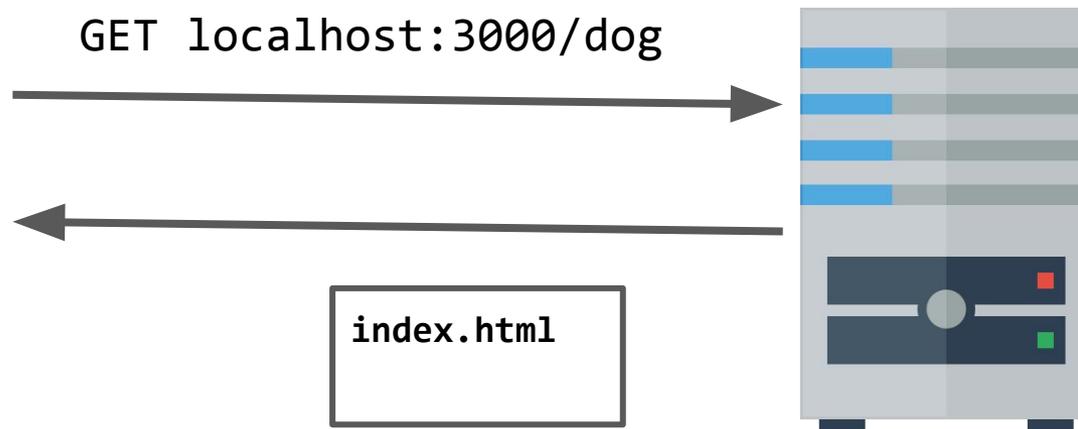
# Single page web app

- 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.



# Single page web app

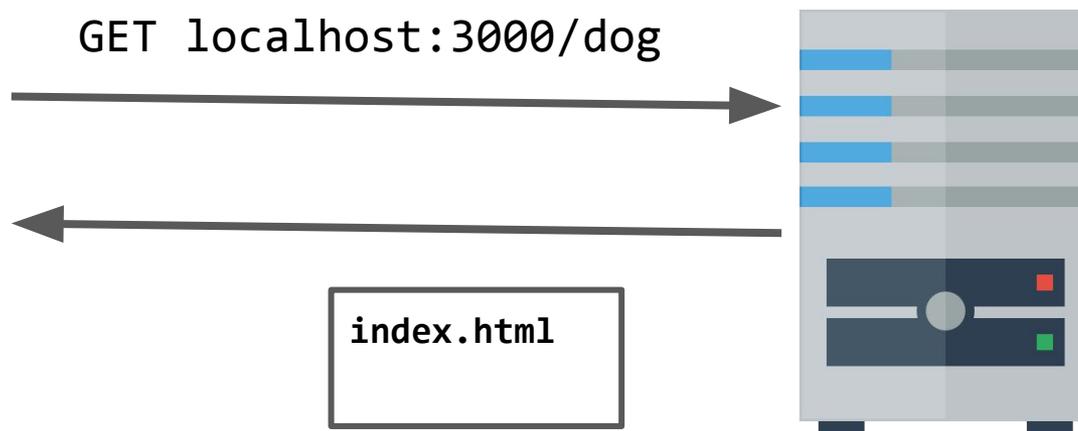
- The server always sends the **same one HTML file** for all requests to the web server.
- The server is configured so that requests to `/<word>` would still return e.g. `index.html`.
- The client JavaScript parses the URL to get the route parameters and initialize the app.



# Single page web app

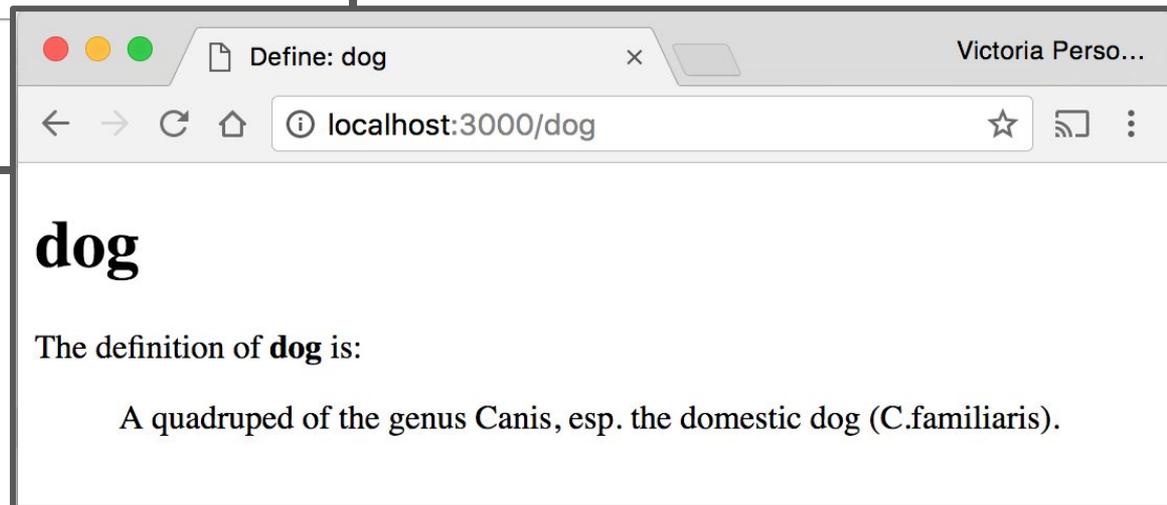
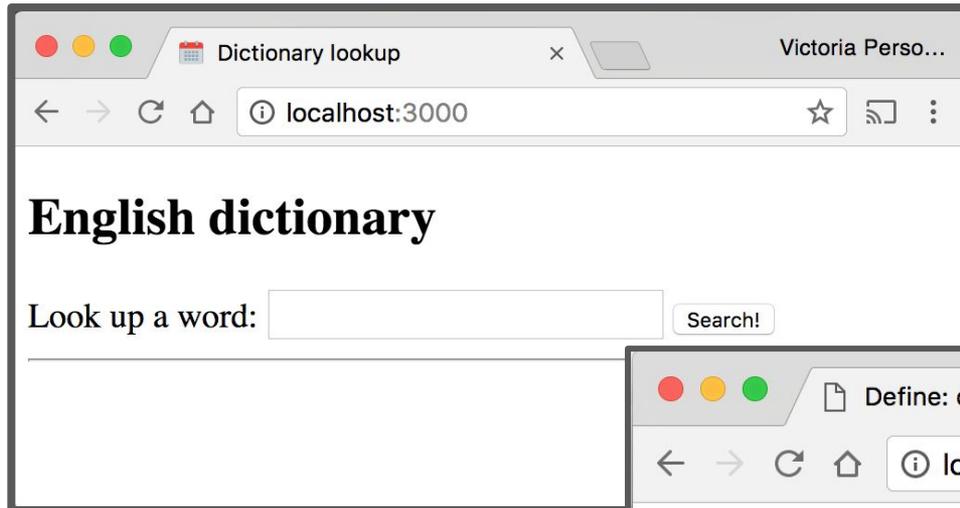
Another way to think of it:

- 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



# Dictionary example

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



# Recall: Handlebars

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

```
<!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>
      <hr />
    </div>

  </body>
</html>
```

index.handlebars

```
<!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>
```

word.handlebars

# SPA

In a single-page web app, the HTML for both the Search page and the Word page are in index.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>
    <hr />
  </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"

```
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.

```
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.

---

```
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

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:

**CS193x e-cards**

Preview



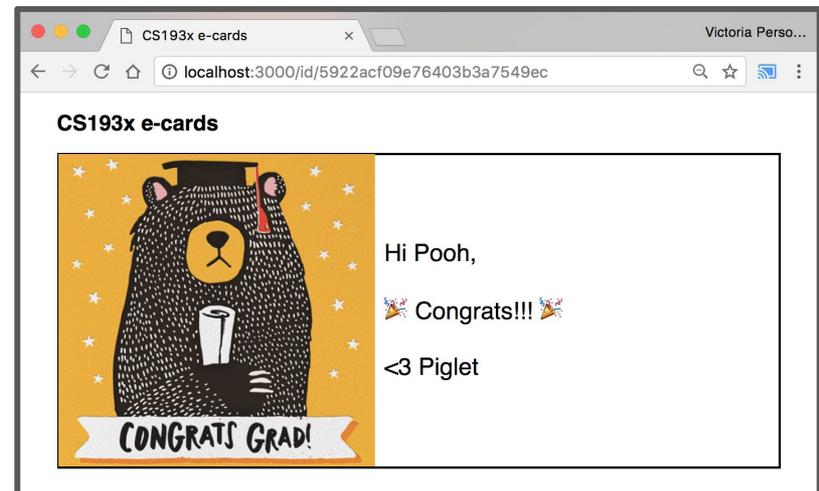
Hi Pooh,  
🎉 Congrats!!! 🎉  
<3 Piglet

Choose a style:  
Happy Graduation ▾

Write a message:

Hi Pooh,  
🎉 Congrats!!! 🎉  
<3 Piglet

Create card



# Example: E-cards

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

**CS193x e-cards**

Preview



Hi Pooh,  
🎉 Congrats!!! 🎉  
<3 Piglet

**Choose a style:**

Happy Graduation ▾

**Write a message:**

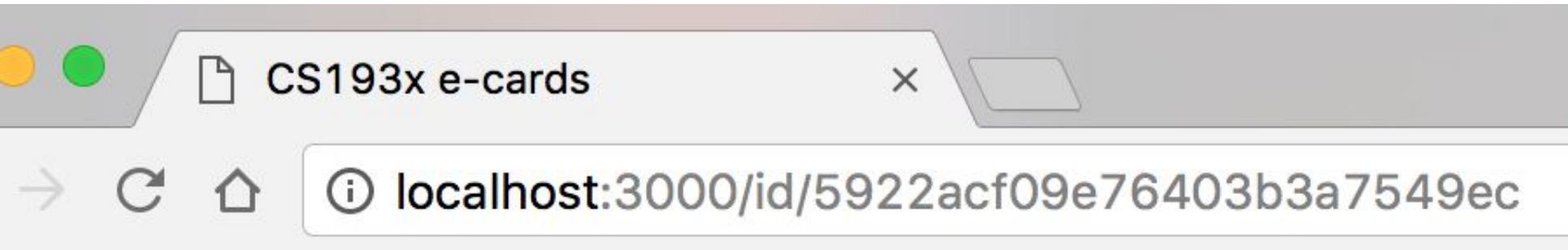
Hi Pooh,  
🎉 Congrats!!! 🎉  
<3 Piglet

Create card

# 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

**Choose a style:**

Happy Graduation ▾

**Write a message:**

Hi Pooh,

🎉 Congrats!!! 🎉

<3 Piglet

Create card

# Example: E-card saving data

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

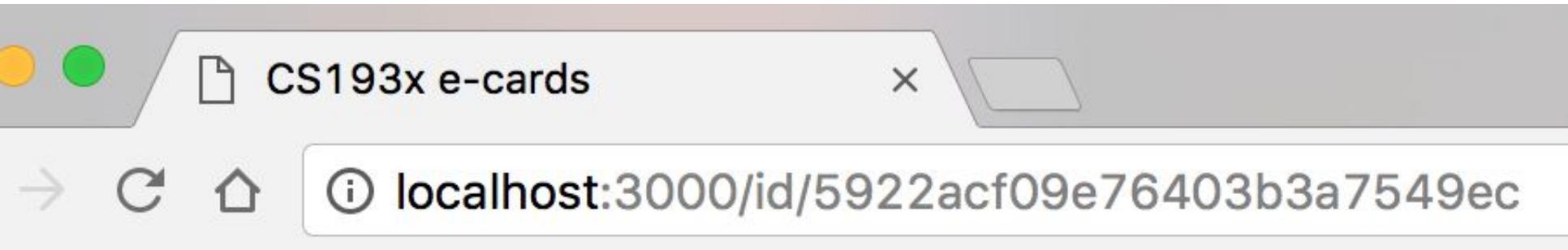
  const collection = db.collection('card');
  const response = await collection.insertOne(doc);

  res.json({ cardId: response.insertedId });
}
app.post('/save', bodyParser, onSaveCard);
```

# 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>`

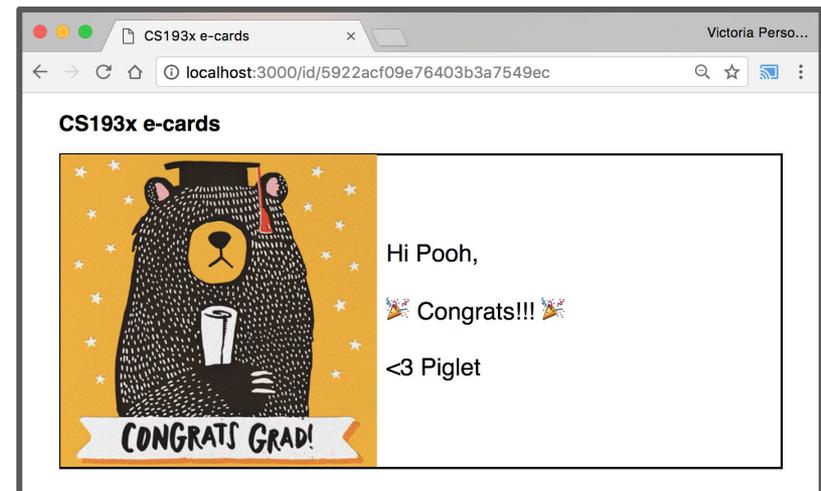


# Web app architecture

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**

# (Short take on these)

## 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

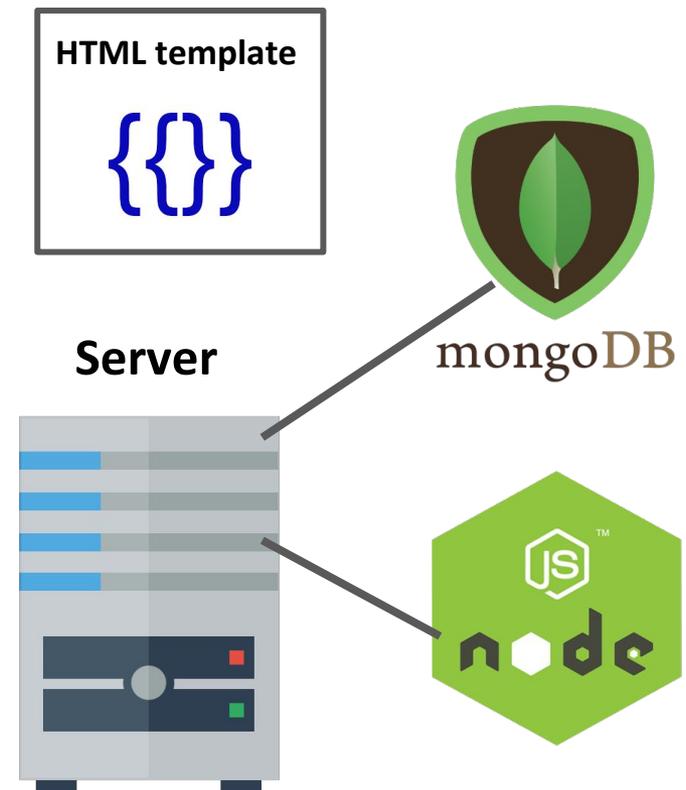
- This is probably the future (but it's complex)
- **CS193X:** We will talk about this but won't show you how to code it

# Server-side rendering

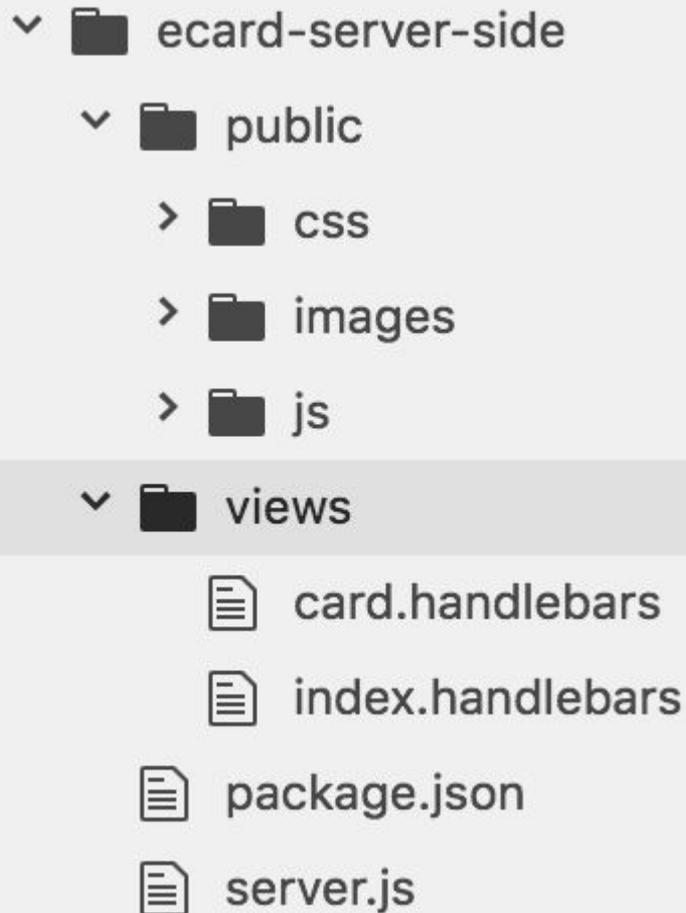
# Server-side rendering

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:

```
<!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>
```

# card.handlebars

But for the card-view, we want a different card style and message depending on the card:

```
<!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>
```

# card.handlebars

But for the card-view, we want a different card style and message depending on the card:

```
<!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>
```

# E-cards: Server-side rendering

Setting up NodeJS to use Handlebars and adding templates does nothing on its own. To use the templates, we need to call [res.render](#):

```
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:

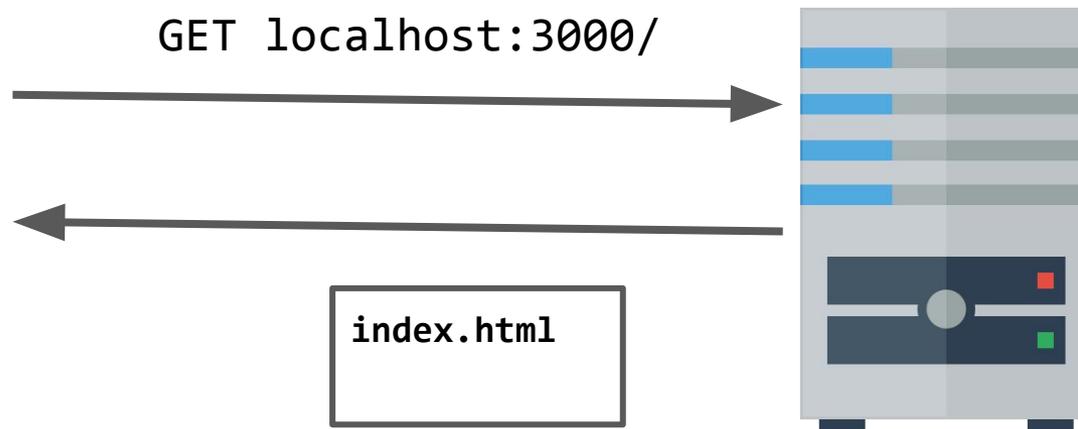
```
async function onGetCard(req, res) {
  const cardId = req.params.cardId;
  const collection = db.collection('card');
  const doc = await collection.findOne({ _id: ObjectID(cardId) });

  res.render('card', { message: doc.message, style: doc.style });
}
app.get('/id/:cardId', onGetCard);
```

Single-page web app

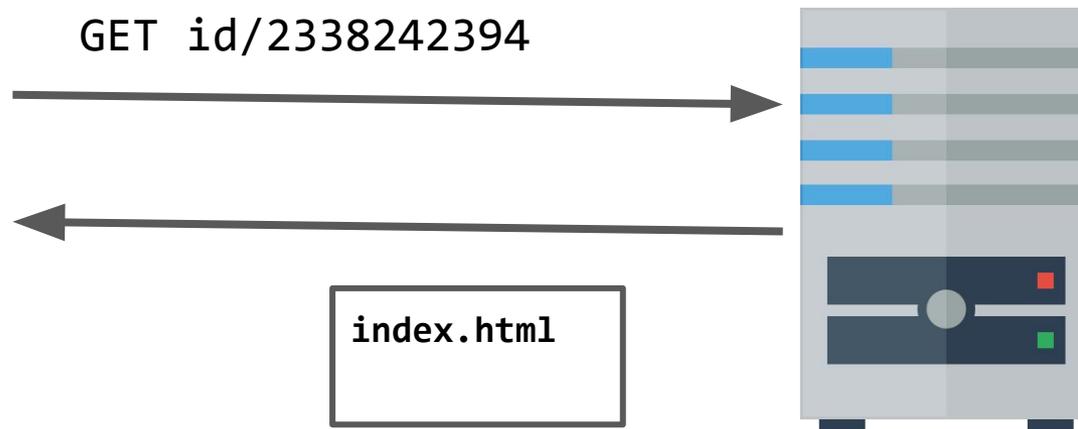
# Single page web app

- 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.



# Single page web app

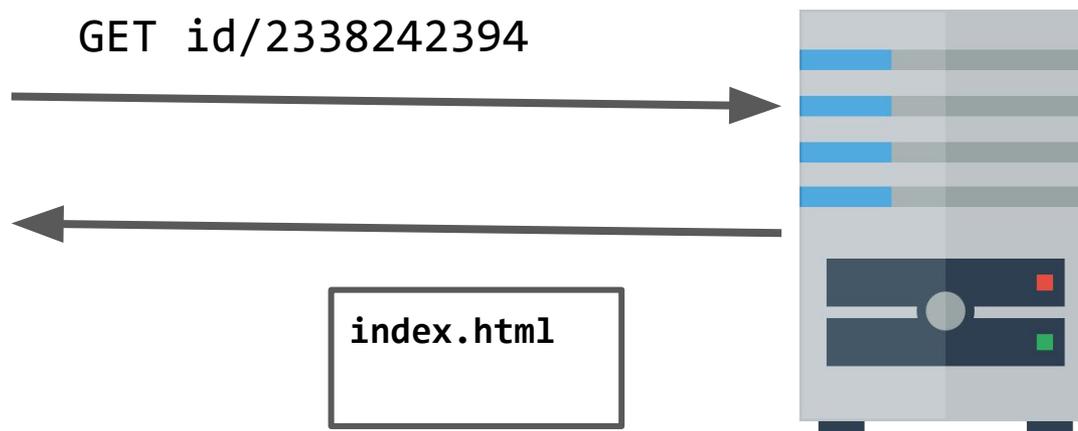
- The server always sends the **same one HTML file** for all requests to the web server.
- The server is configured so that requests to `/id/<card_id>` would still return e.g. `index.html`.
- The client JavaScript parses the URL to get the route parameters and initialize the app.



# 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



# E-card example code

E-cards written with Handlebar templates

- [simple-middleware](#)

E-cards written in Single-Page-App style

- [dictionary-with-routes](#)