IN4MATX 133: User Interface Software

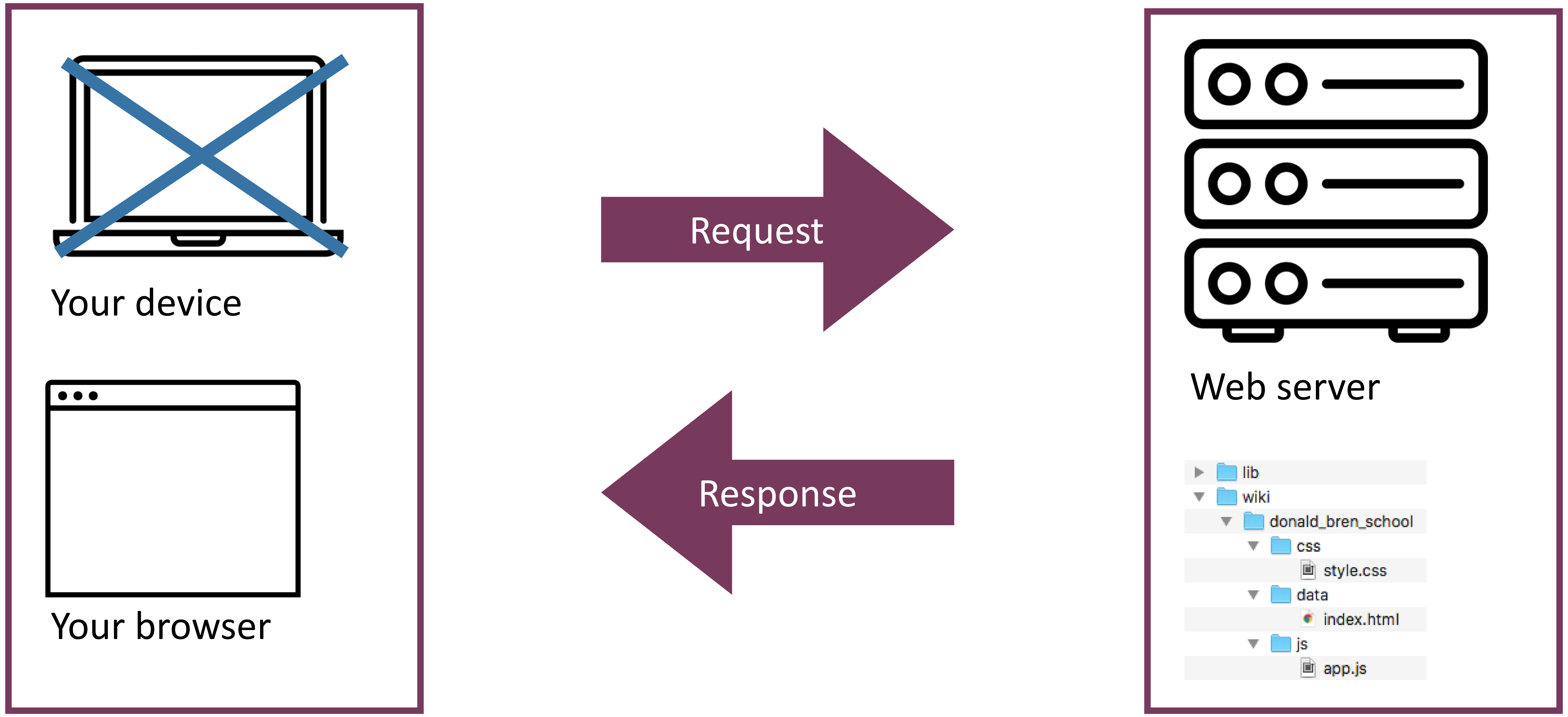
Lecture:
Server-Side Development

Goals for this Lecture

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

- Explain the advantages and disadvantages of different tools for server-side development
- A basic understanding of Node.js

Client-side and server-side JavaScript



Edit what's being rendered
Trigger or react to events

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

Client-side

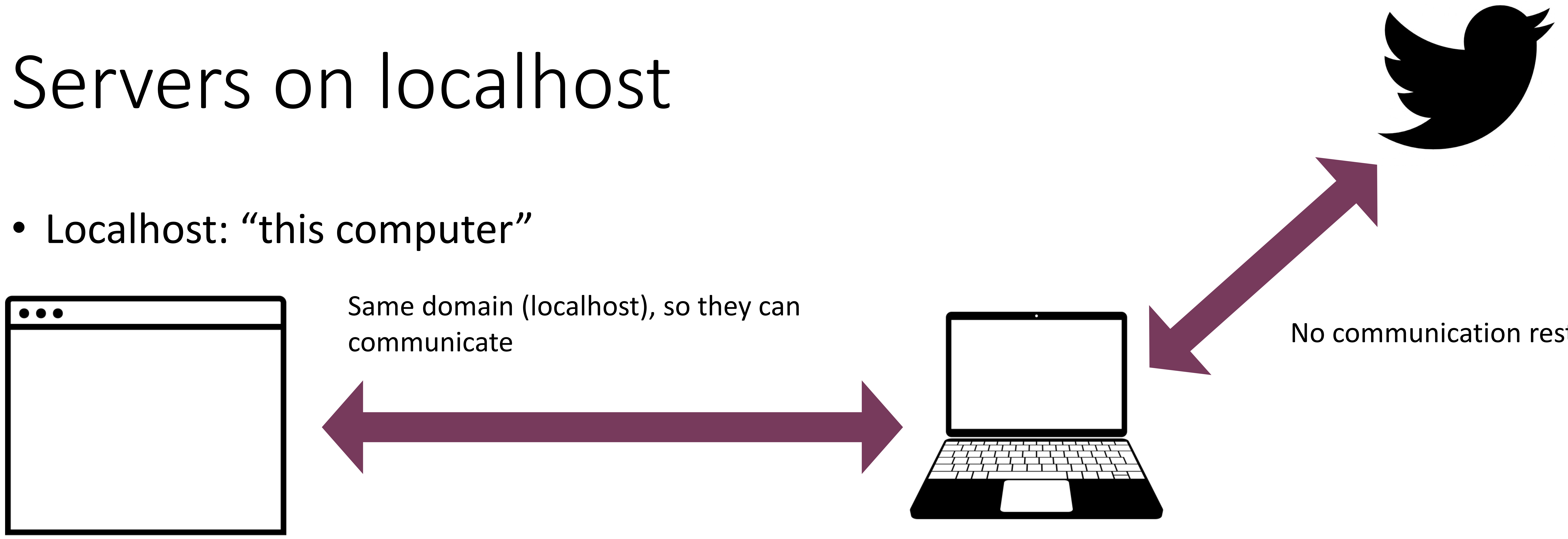
- Runs in the browser
- Changes happen in real-time in the browser
- Cannot make HTTP requests to many APIs
- Examples: AJAX, Angular, React, Vue.js

Server-side

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

Servers on localhost

- Localhost: “this computer”



Same domain (localhost), so they can communicate

No communication restrictions

Live server: localhost:8080

Twitter proxy: localhost:7890

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

No same-origin policy restrictions, can communicate with Twitter

Server-side development: Node.js

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

Other server-side environments

- Ruby, via Ruby on Rails
- Python, via Django or web2py
- These days, you can create a dynamic website in almost any language

Node package manager (npm)

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

Node.js hello world

```
var http = require('http');
```
Require the http library

Node.js hello world

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


});
```

Require the http library

Anonymous function with
request and response parameters

Node.js hello world

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

Require the http library

Anonymous function with
request and response parameters

“Ok” status in the header,
write hello world text

Node.js hello world

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

Require the http library

Anonymous function with request and response parameters

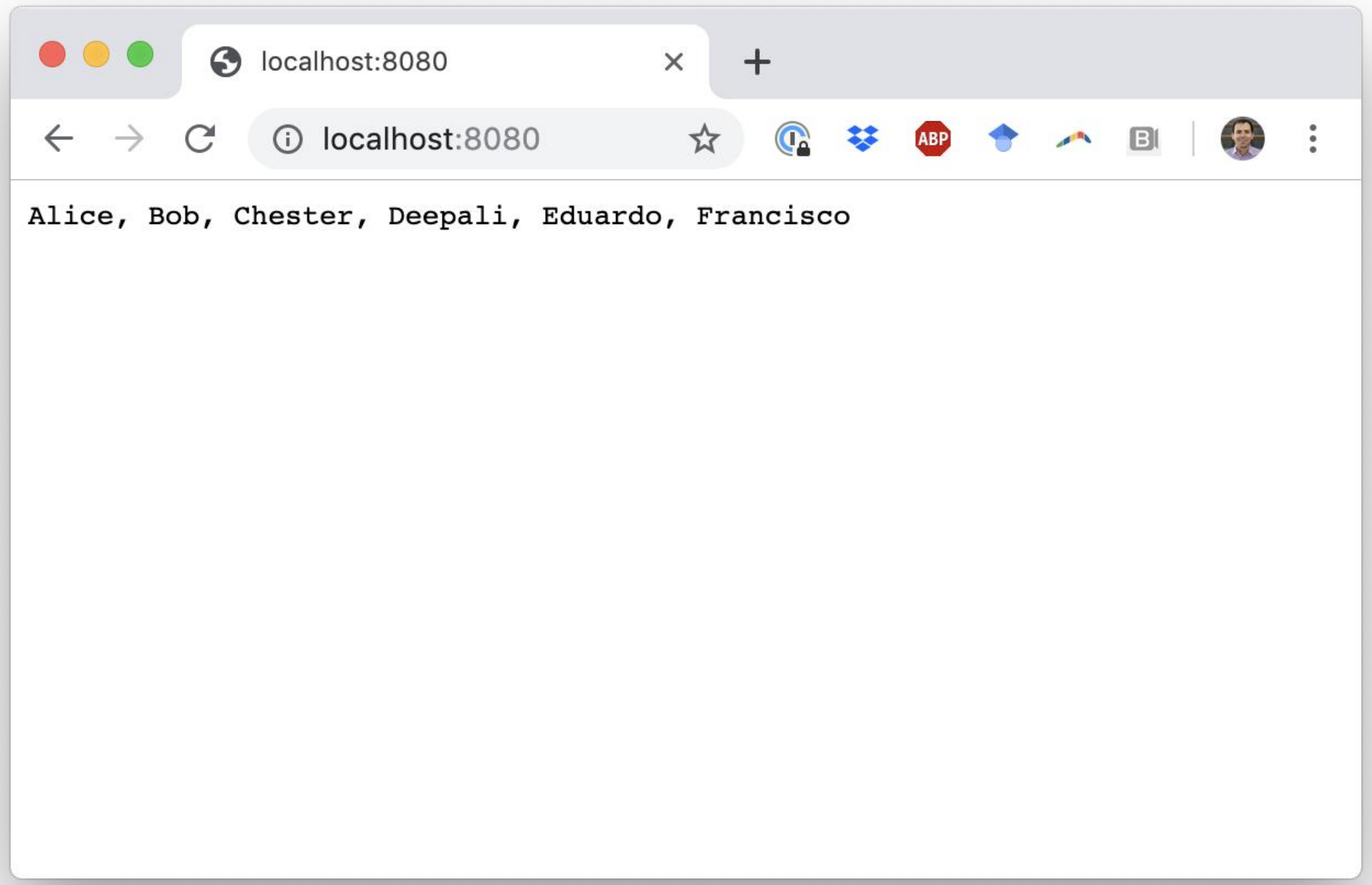
"Ok" status in the header, write hello world text

Listen on port 8080

Running Node.js

- `node file.js`

Node.js



```
Alice, Bob, Chester, Deepali, Eduardo, Francisco
```

Remember,
Node.js is server-side JavaScript

Where is the JavaScript running?

Server-side

```
node hello.js
```

hello.js:

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

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

Where is the JavaScript running?

Client-side

`live-server`

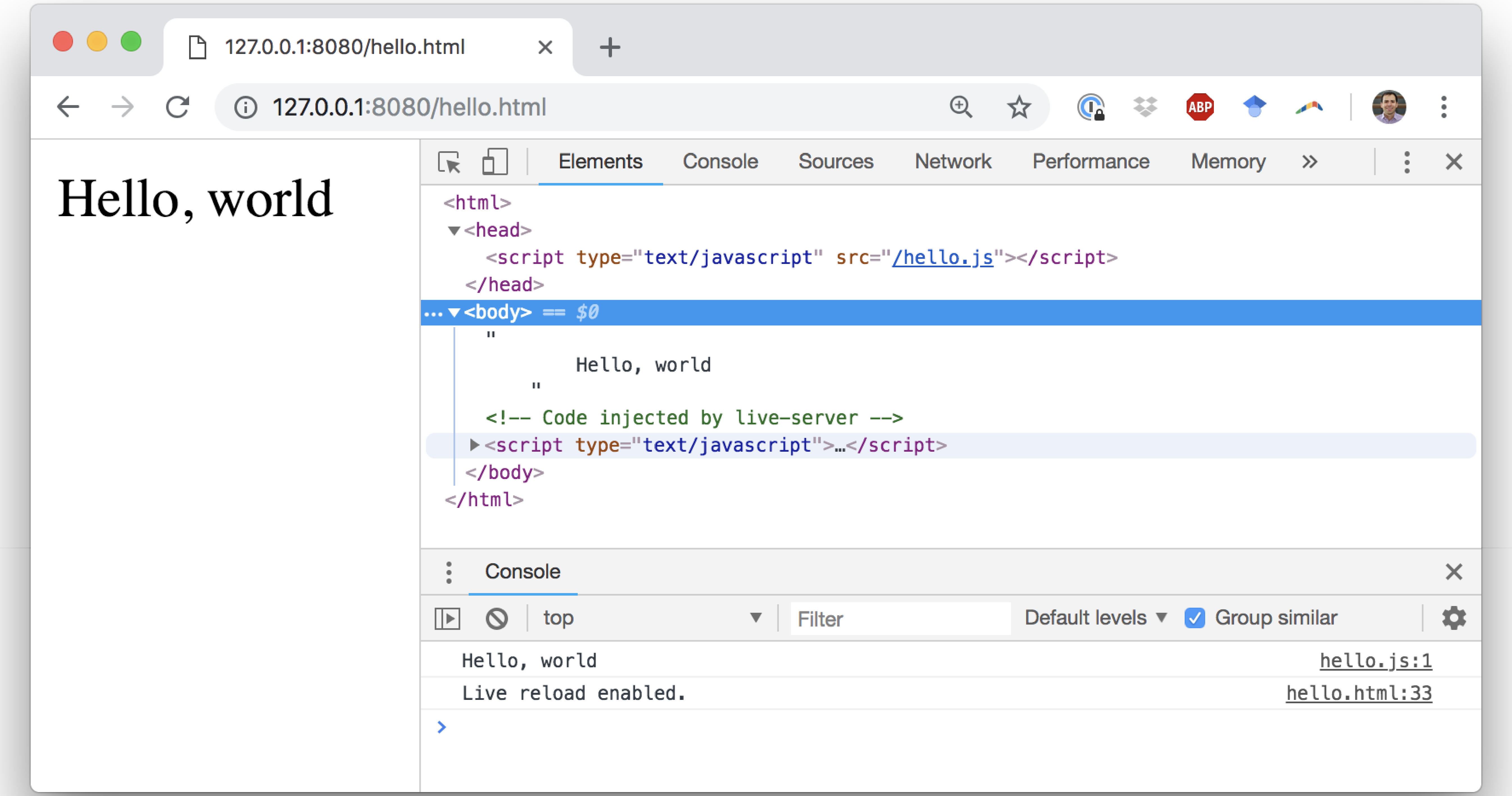
hello.html:

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

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

hello.js:

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



127.0.0.1:8080/hello.html

Hello, world

```
<html>
▼<head>
    <script type="text/javascript" src="/hello.js"></script>
  </head>
…▼<body> == $0
    "
          Hello, world
      "
    <!-- Code injected by live-server -->
  ▶<script type="text/javascript">…</script>
  </body>
</html>
```

```
Hello, world                                          hello.js:1
Live reload enabled.                                  hello.html:33
```

What does Node.js add?

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

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

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

Goals for this Lecture

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

- Explain the advantages and disadvantages of different tools for server-side development
- A basic understanding of Node.js

More on Node and Express

Node file system

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

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

Require the file system library

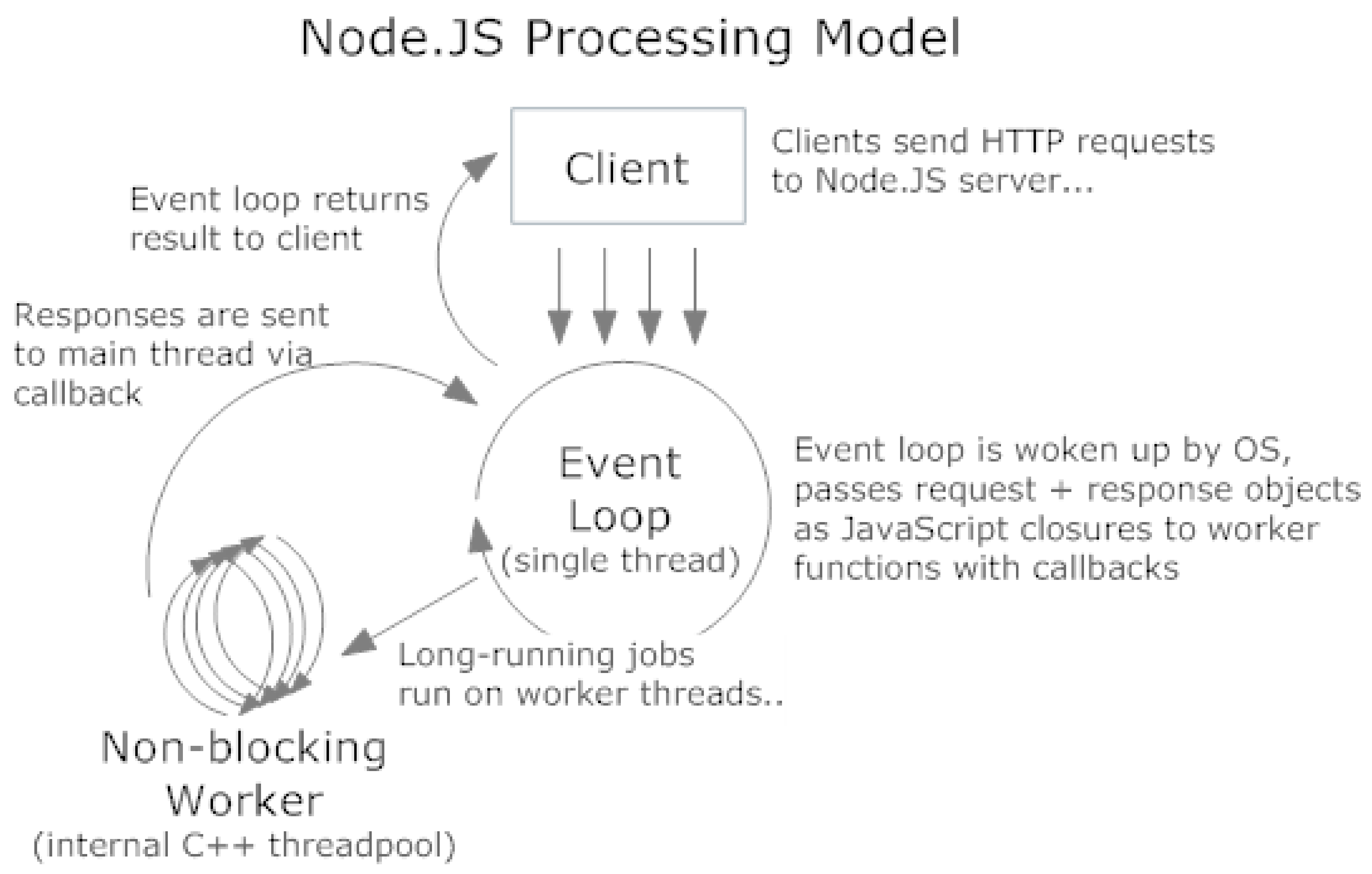
Read file, wait for
asynchronous response

Node file system

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

Node processing model

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



Node.JS Processing Model
Client
Clients send HTTP requests to Node.JS server...
Event loop returns result to client
Responses are sent to main thread via callback
Event Loop (single thread)
Event loop is woken up by OS, passes request + response objects as JavaScript closures to worker functions with callbacks
Long-running jobs run on worker threads..
Non-blocking Worker (internal C++ threadpool)

Express.js

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

```
var expressApp = express();

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

Express installation

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

Express routing

- By HTTP method

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

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

httpRequest object

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

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

httpResponse object

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

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

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

Middleware

- Give other software the ability to manipulate requests

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

Middleware

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

Example Express server

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

Example Express user list

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

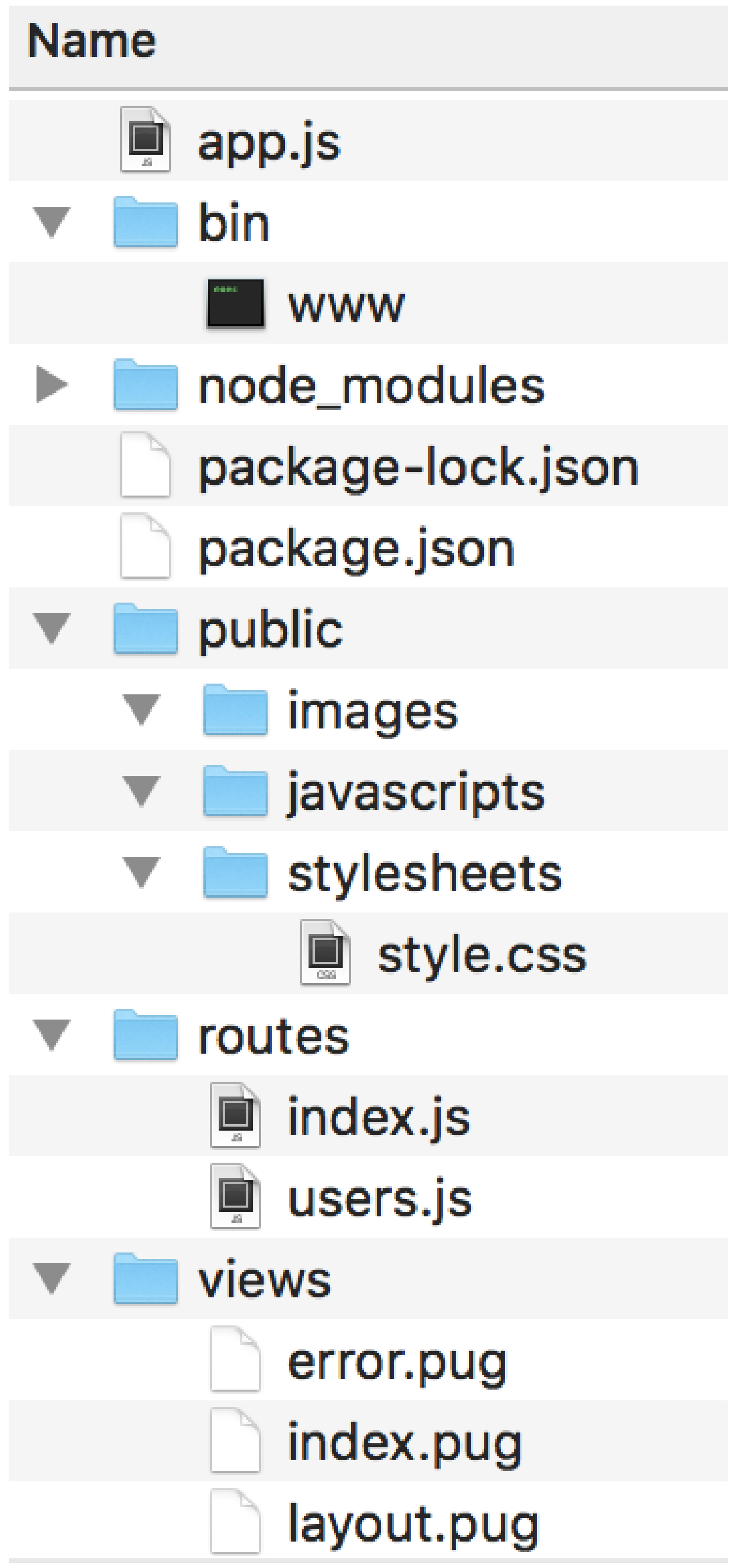
Express generator

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

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

Express generator

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

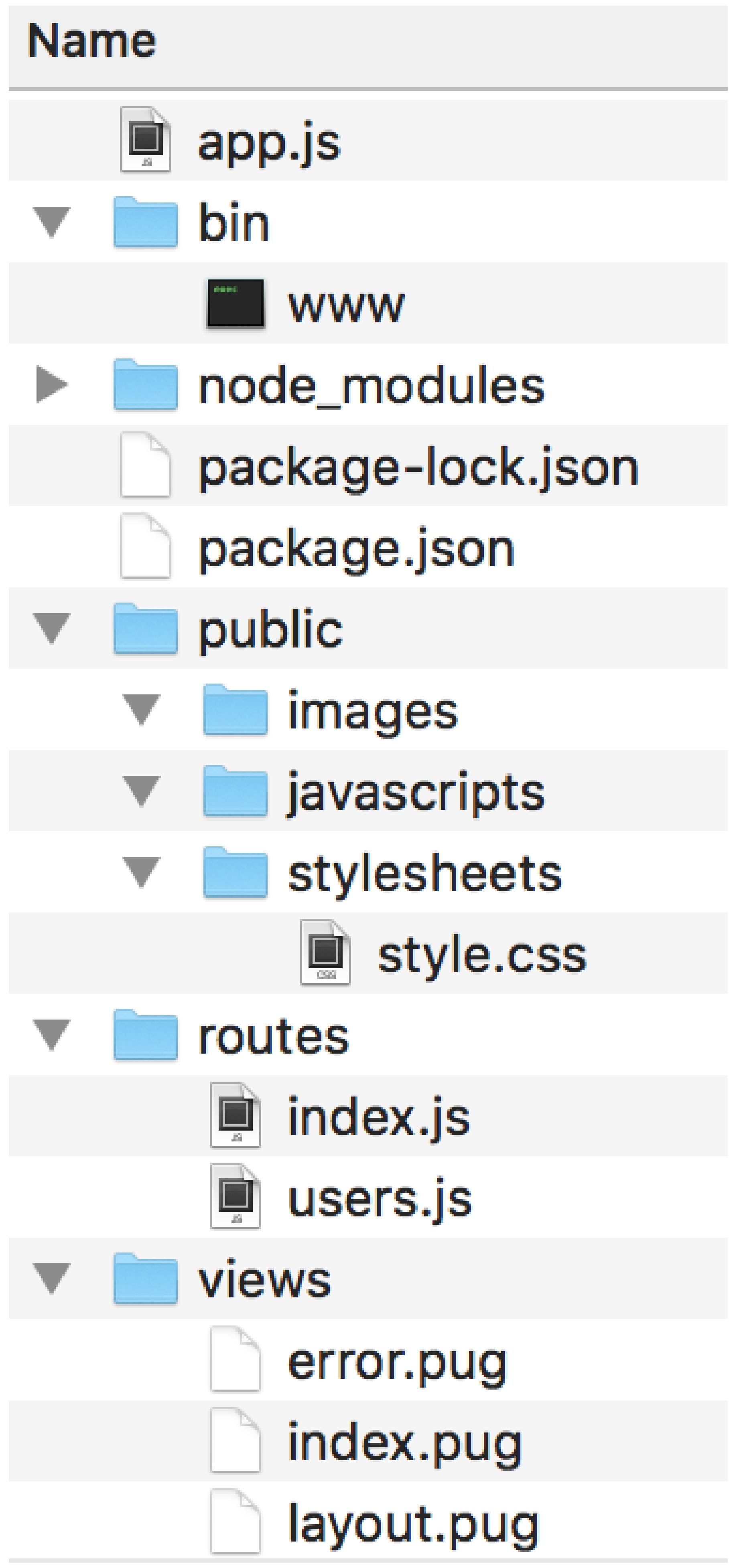


```
Name
app.js
bin
    www
node_modules
package-lock.json
package.json
public
    images
    javascripts
    stylesheets
        style.css
routes
    index.js
    users.js
views
    error.pug
    index.pug
    layout.pug
```

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

Express generator

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


```
Name
  app.js
▼ bin
    www
▶ node_modules
  package-lock.json
  package.json
▼ public
  ▼ images
  ▼ javascripts
  ▼ stylesheets
      style.css
▼ routes
    index.js
    users.js
▼ views
    error.pug
    index.pug
    layout.pug
```

Express generator

- Routes folder: files which handle your URL mappings

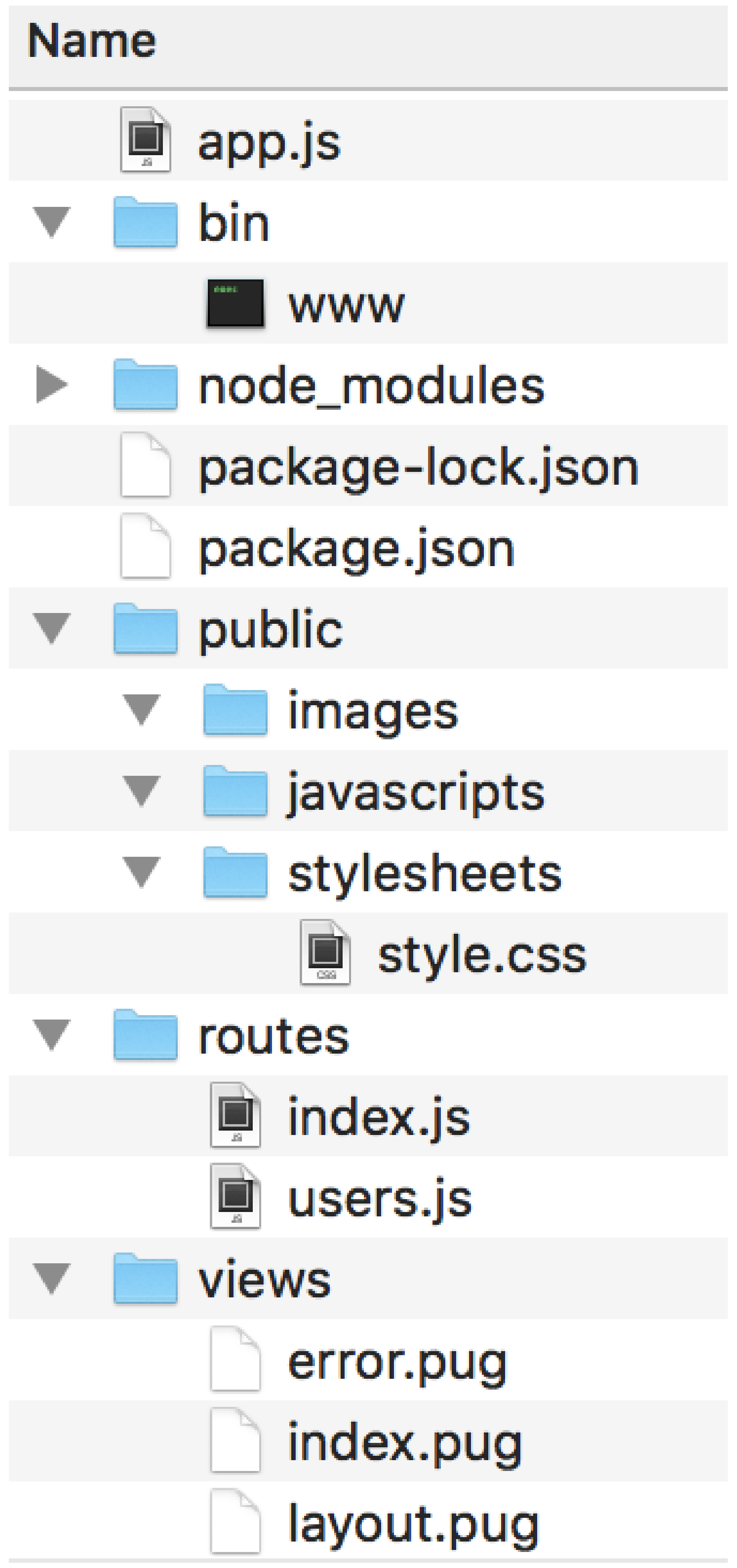
```
var express = require('express');
var router = express.Router();

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

module.exports = router;
```

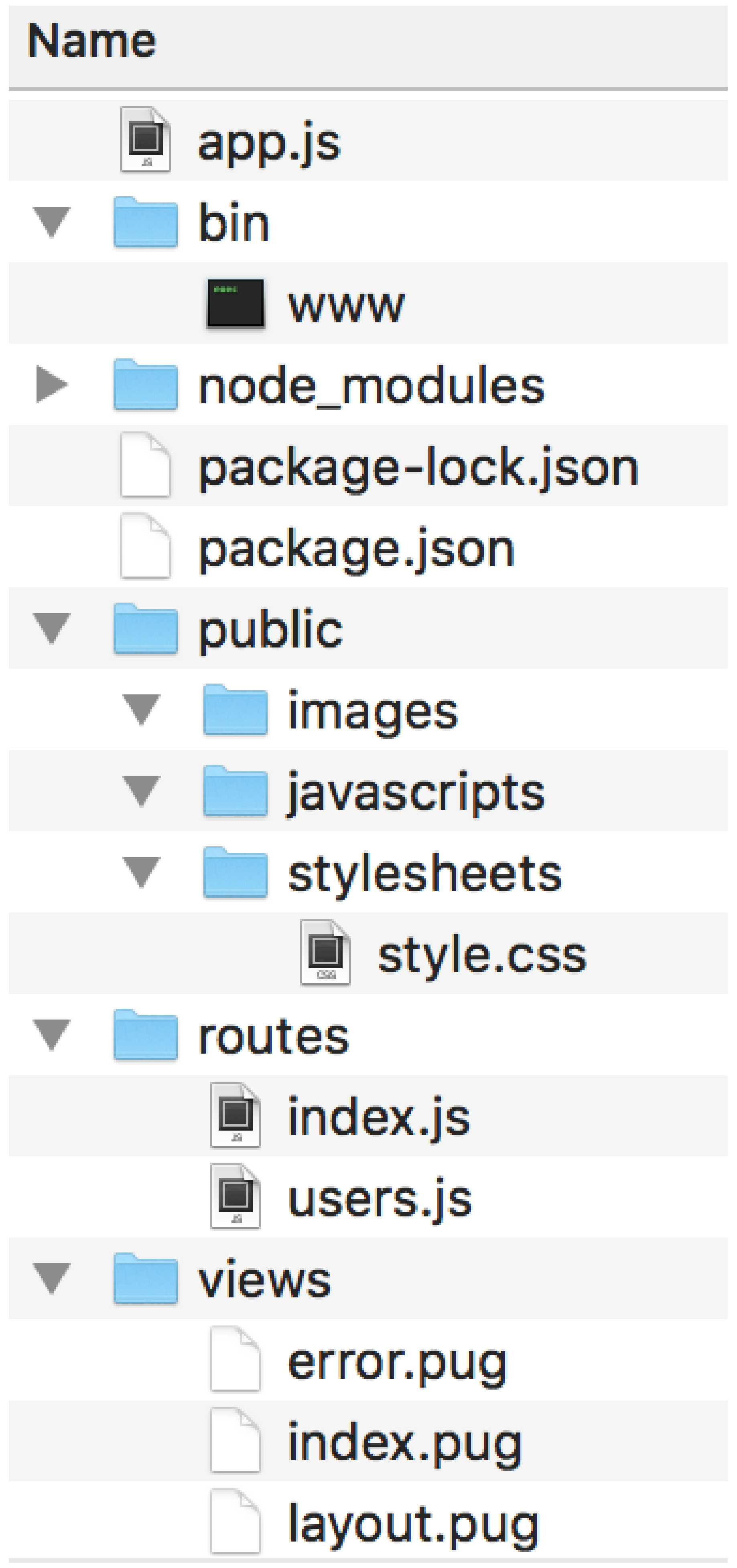
Variable passed to renderer

So another page can import your router



Express generator

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



```
Name
    app.js
▼   bin
        www
▶   node_modules
    package-lock.json
    package.json
▼   public
    ▼   images
    ▼   javascripts
    ▼   stylesheets
            style.css
▼   routes
        index.js
        users.js
▼   views
        error.pug
        index.pug
        layout.pug
```

Pug view engine

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

- **layout.pug**

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

- **index.pug**

```
extends layout
```

Imports other file

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

Parses variable passed

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

Express generator

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

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

var app = express();

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

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

Import route files

To parse content as json

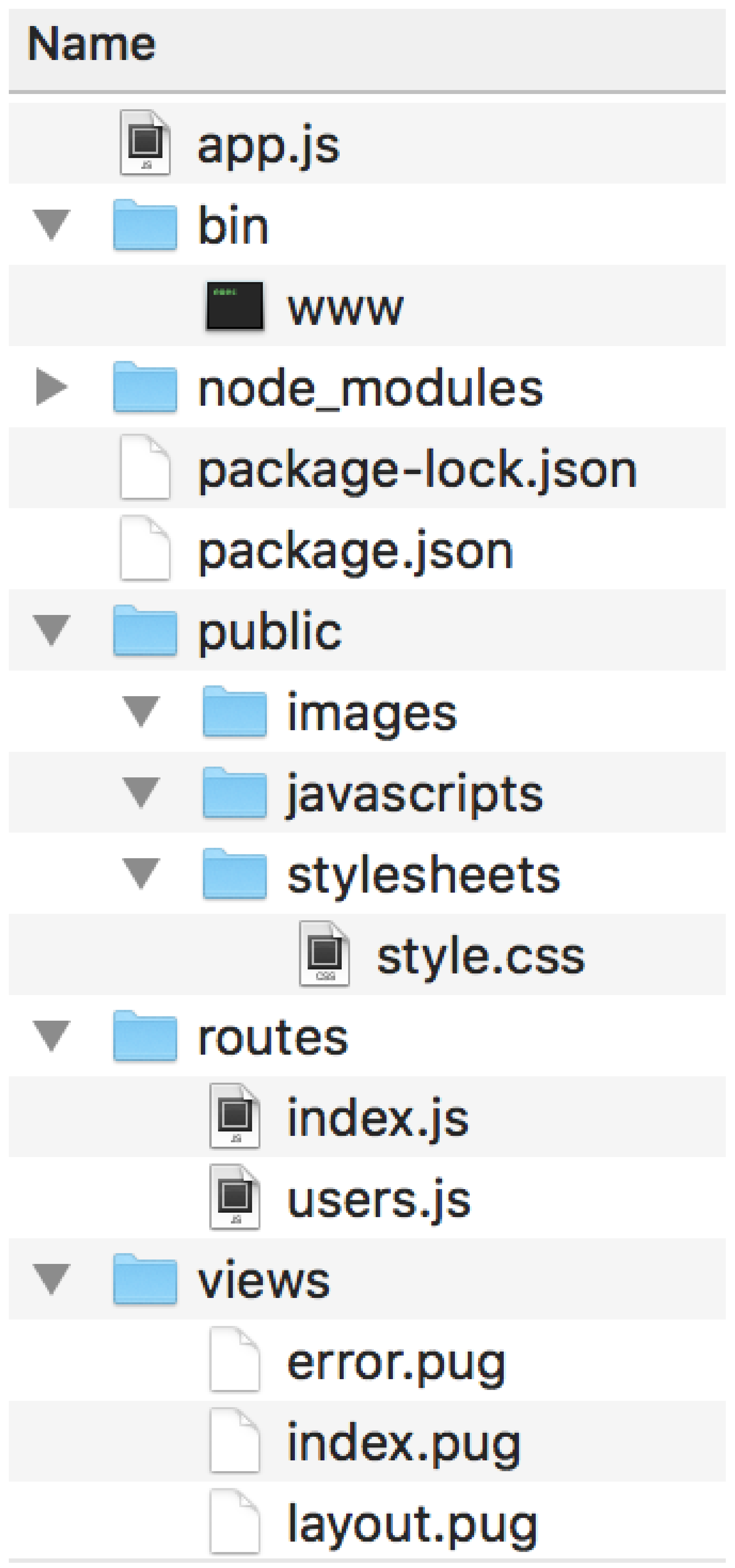
To encode URLs

To handle cookies (user state)

To treat the public folder as static content

Use route files

Middle



```
Name
app.js
▼ bin
    www
▶ node_modules
  package-lock.json
  package.json
▼ public
  ▼ images
  ▼ javascripts
  ▼ stylesheets
      style.css
▼ routes
    index.js
    users.js
▼ views
    error.pug
    index.pug
    layout.pug
```

Express generator

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

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

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

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