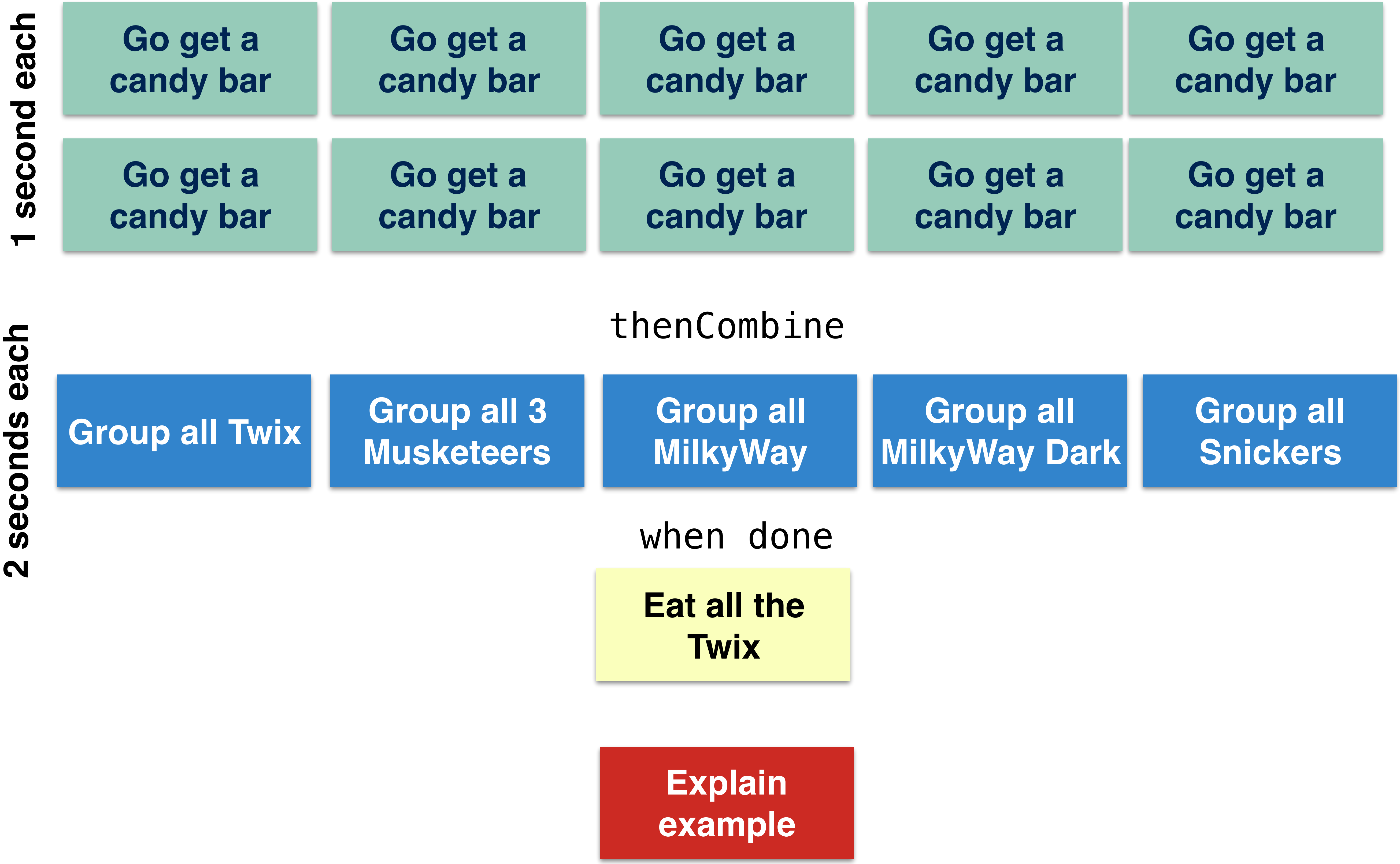
Backend Development

SWE 432, Fall 2018

Web Application Development

Review: Async Programming Example



1 second each

Go get a candy bar

Go get a candy bar

Go get a candy bar

Go get a candy bar

Go get a candy bar

Go get a candy bar

Go get a candy bar

Go get a candy bar

Go get a candy bar

Go get a candy bar

2 seconds each

`thenCombine`

Group all Twix

Group all 3 Musketeers

Group all MilkyWay

Group all MilkyWay Dark

Group all Snickers

`when done`

Eat all the Twix

Explain example

Review: Async/Await

- Rules of the road:
  - You can only call **await** from a function that is **async**
  - You can only **await** on functions that return a **Promise**
  - Beware: await makes your code synchronous!

```
async function getAndGroupStuff() {
...
    ts = await lib.groupPromise(stuff,"t");
...
}
```

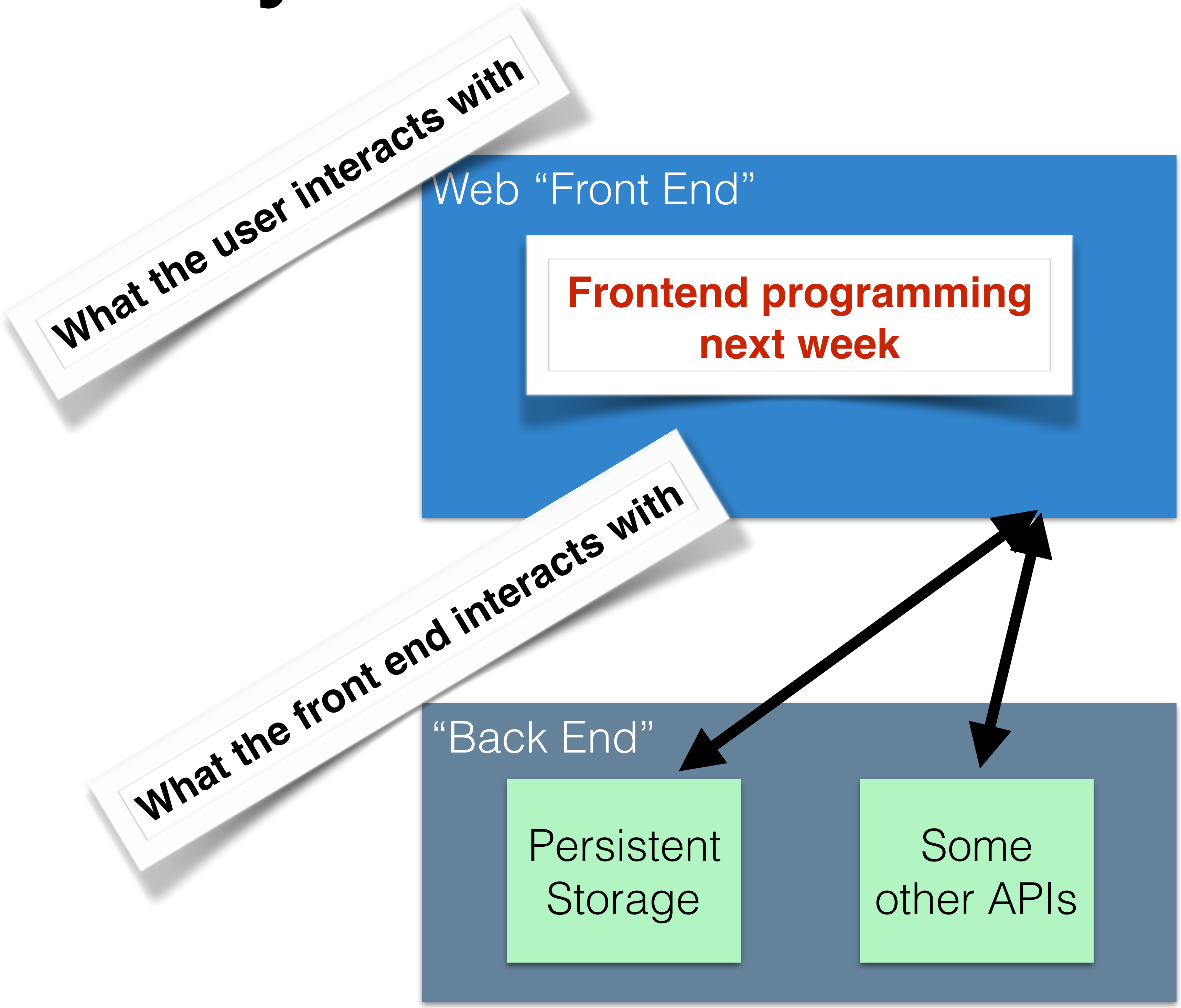
Today

- What is a backend for?
- History of backend web programming
- NodeJS backends with Express

Why we need backends

- Security: *SOME* part of our code needs to be “trusted”
  - Validation, security, etc. that we don’t want to allow users to bypass
- Performance:
  - Avoid duplicating computation (do it once and cache)
  - Do heavy computation on more powerful machines
  - Do data-intensive computation “nearer” to the data
- Compatibility:
  - Can bring some dynamic behavior without requiring much JS support

Dynamic Web Apps



What the user interacts with

Web "Front End"

Frontend programming next week

What the front end interacts with

"Back End"

Persistent Storage

Some other APIs

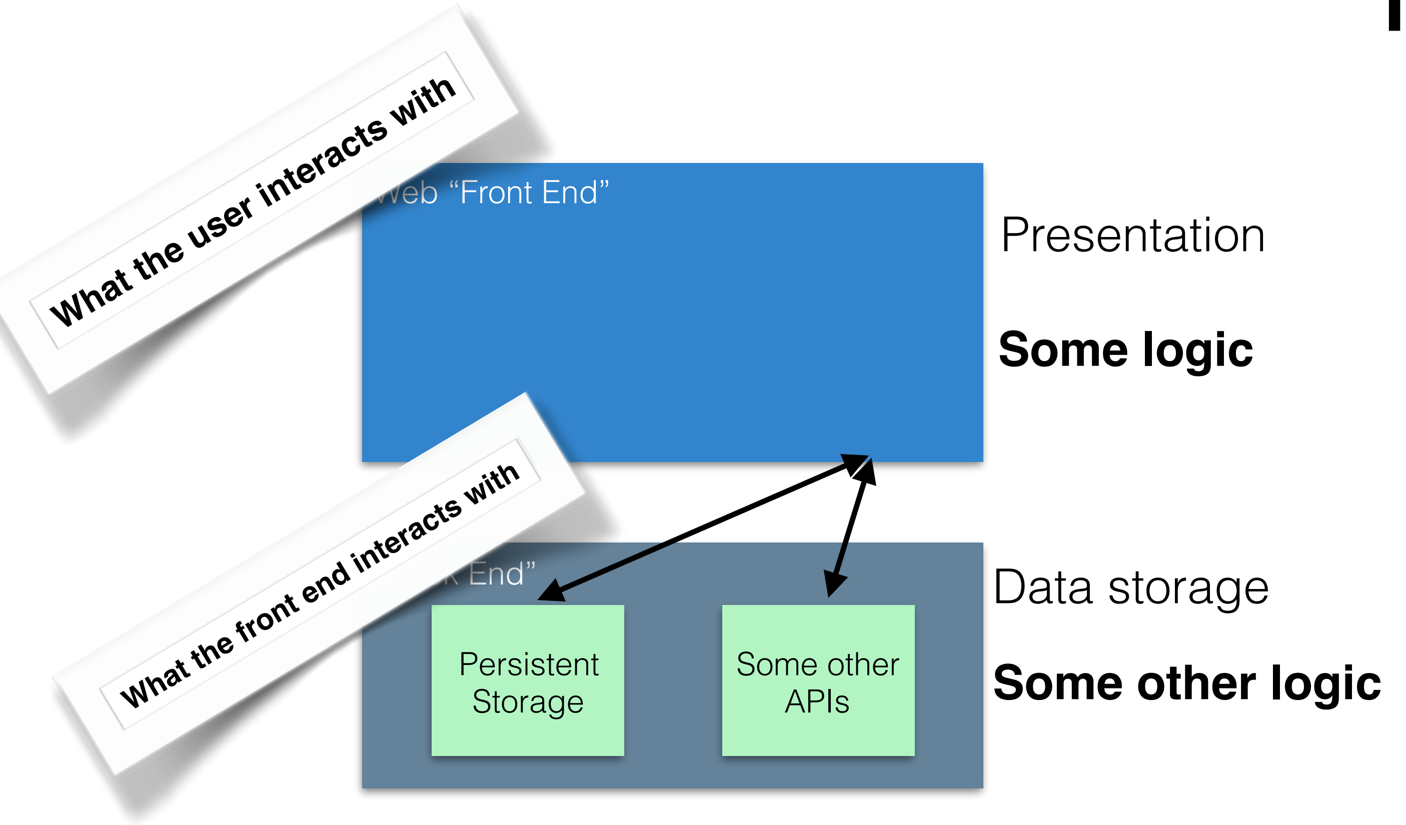
Presentation

Some logic

Data storage

Some other logic

Where do we put the logic?



Frontend

Pros

Very responsive (low latency)

Cons

Security

Performance

Unable to share between front-ends

Backend

Pros

Easy to refactor between multiple clients

Logic is hidden from users (good for security, compatibility, and intensive computation)

Cons

Interactions require a round-trip to server

Why Trust Matters

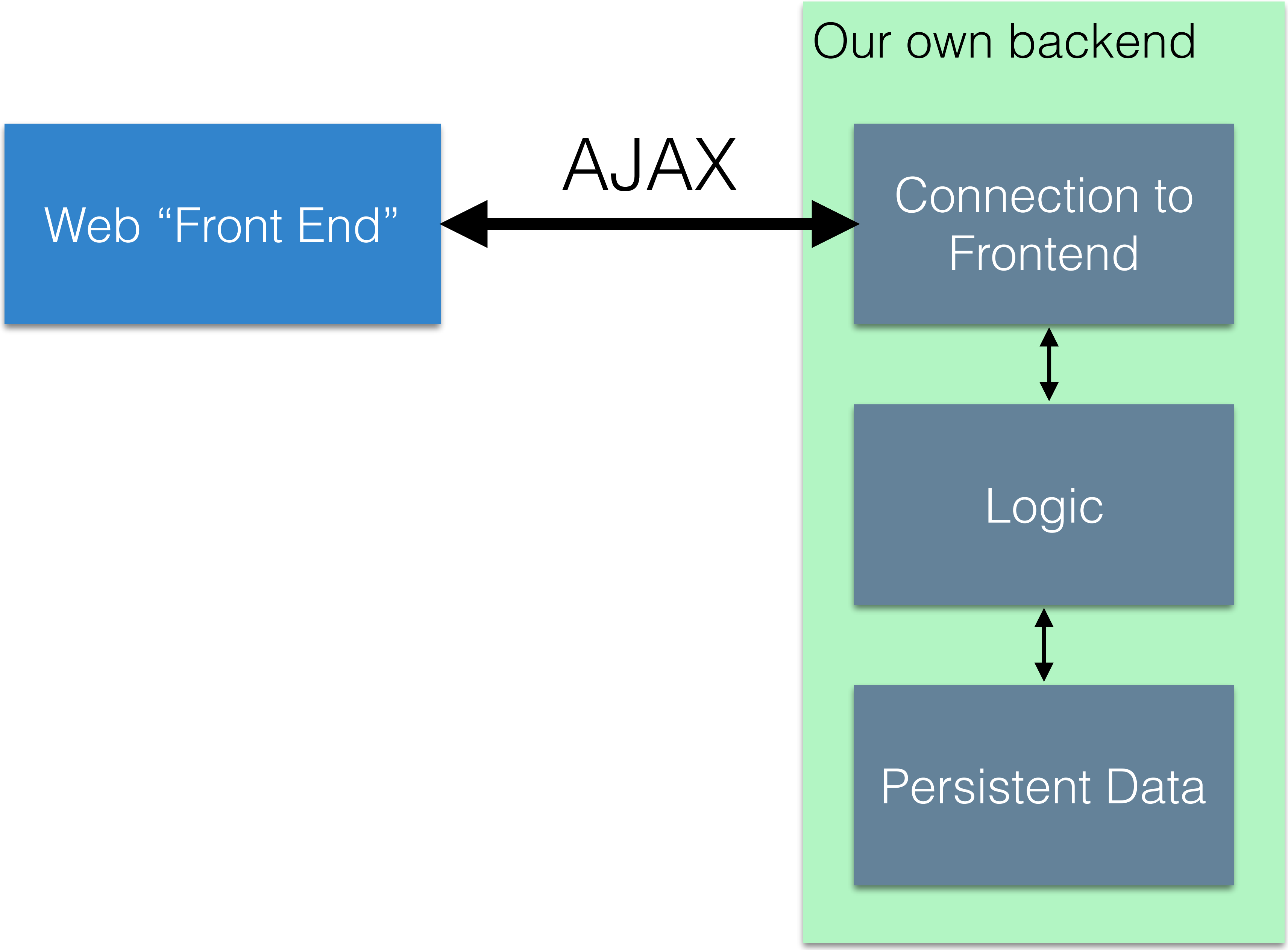
- Example: Transaction app

```
function updateBalance(user, amountToAdd)
{
    user.balance = user.balance + amountToAdd;
}
```

- What’s wrong?

- How do you fix that?

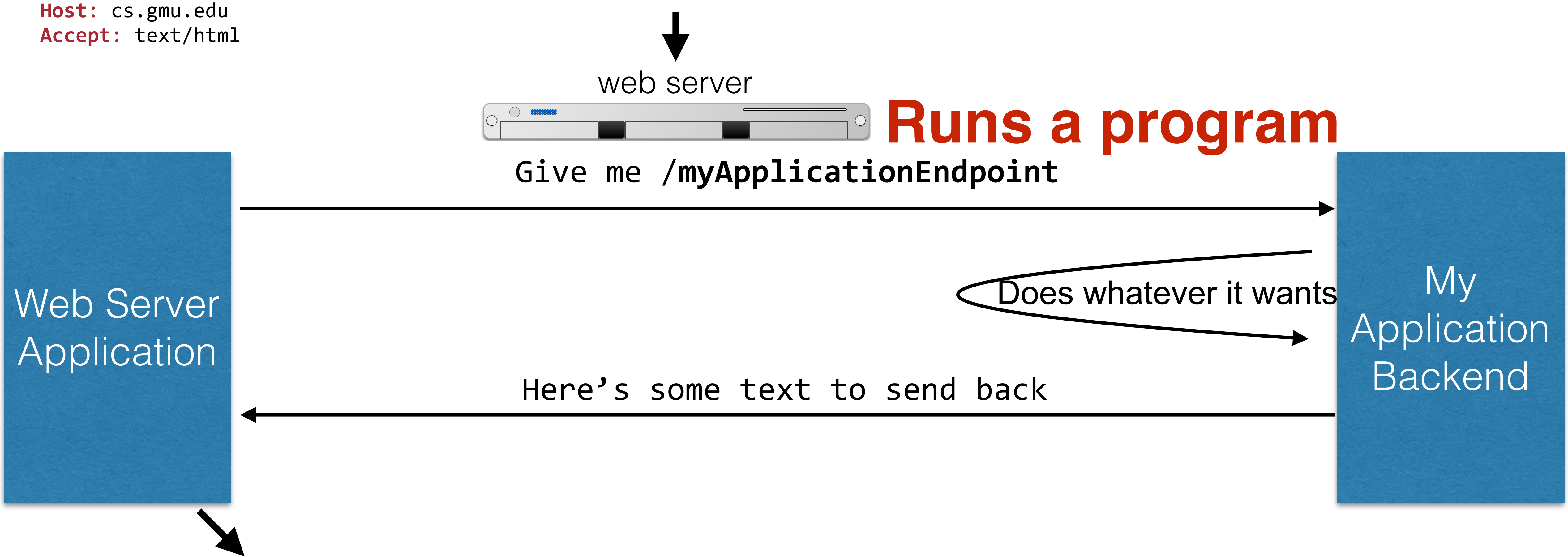
What does our backend look like?



The “good” old days of backends

HTTP Request

```
GET /myApplicationEndpoint HTTP/1.1
Host: cs.gmu.edu
Accept: text/html
```



web server

Runs a program

Web Server Application

`Give me /myApplicationEndpoint`

Does whatever it wants

`Here’s some text to send back`

My Application Backend

HTTP Response

```
HTTP/1.1 200 OK
Content-Type: text/html; charset=UTF-8

<html><head>...
```

What’s wrong with this picture?

History of Backend Development

- In the beginning, you wrote whatever you wanted using whatever language you wanted and whatever framework you wanted
- Then… PHP and ASP
  - Languages “designed” for writing backends
  - Encouraged spaghetti code
  - A lot of the web was built on this
- A whole lot of other languages were also springing up in the 90’s…
  - Ruby, Python, JSP

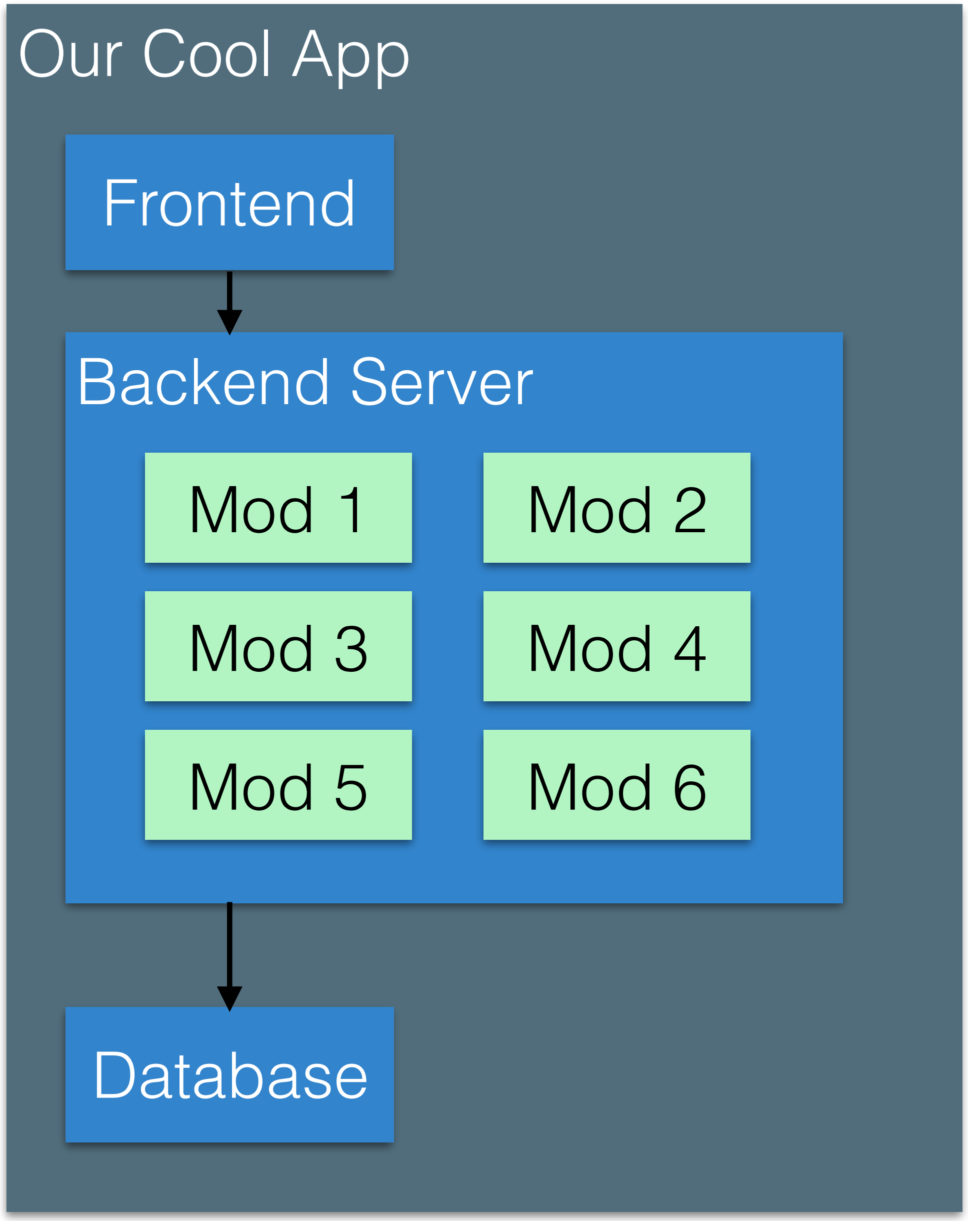
MVC & Backend Servers

- There are a ton of backend frameworks that support MVC
  - SailsJS, Ruby on Rails, PHP Symfony, Python Django, ASP.NET, EJB…
- Old days: View was server-generated HTML
- New days: View is an API
- Today we'll talk about Node.JS backend development
- We will **not** talk about making MVC backends and will **not** require you to do so

Microservices vs. Monoliths

- Advantages of microservices over monoliths include
    - Support for scaling
        - Scale vertically rather than horizontally
    - Support for change
        - Support hot deployment of updates
    - Support for reuse
        - Use same web service in multiple apps
        - Swap out internally developed web service for externally developed web service
    - Support for separate team development
        - Pick boundaries that match team responsibilities
    - Support for failure

Support for scaling


Our Cool App

Frontend

Backend Server

Mod 1

Mod 2

Mod 3

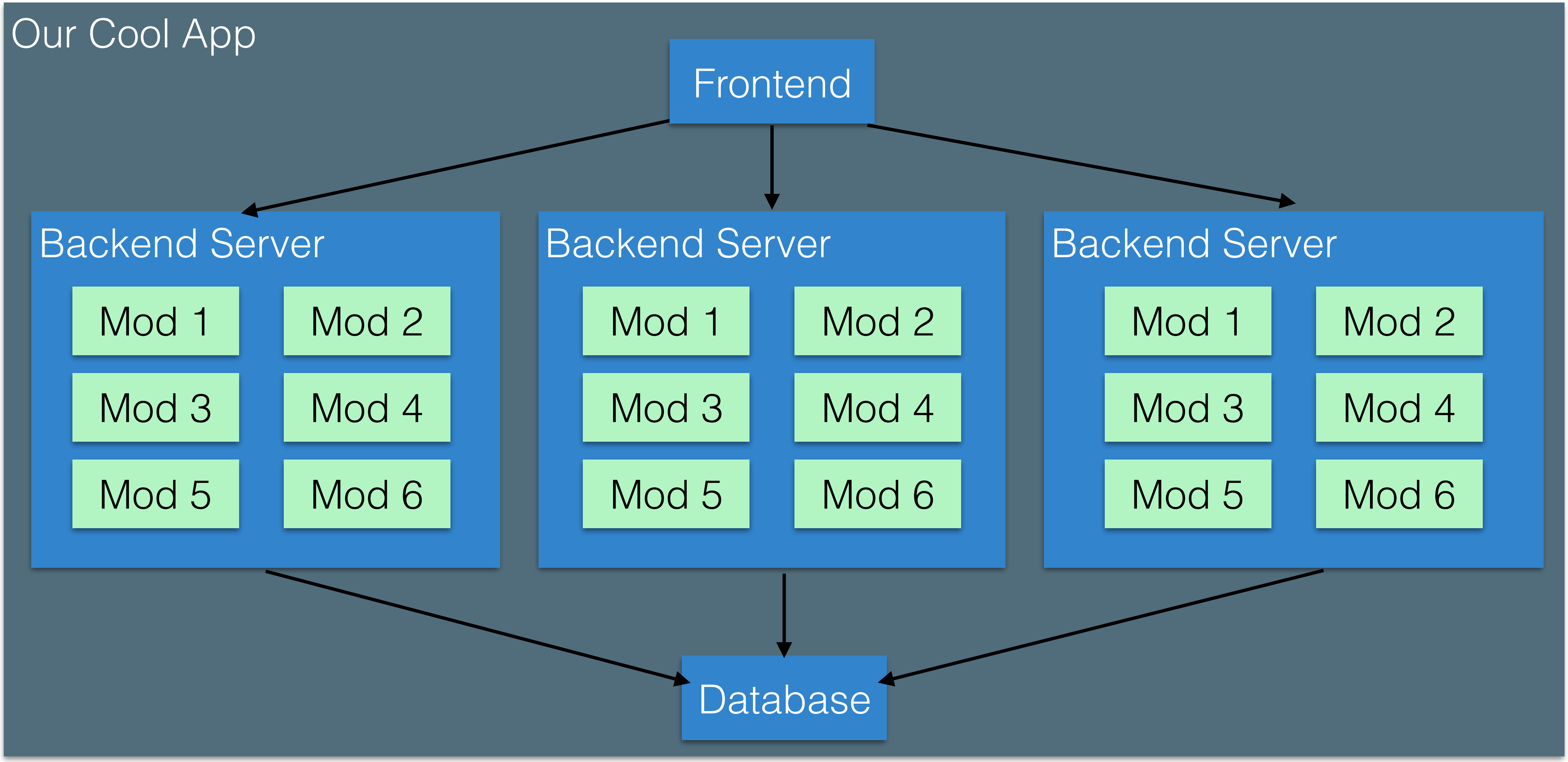
Mod 4

Mod 5

Mod 6

Database

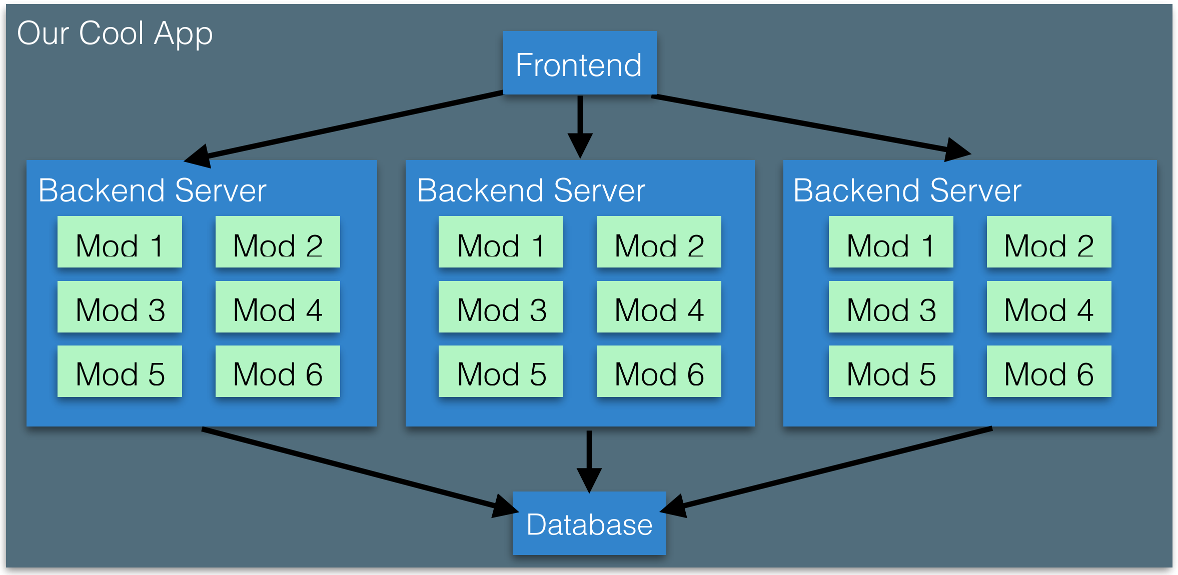
Now how do we scale it?



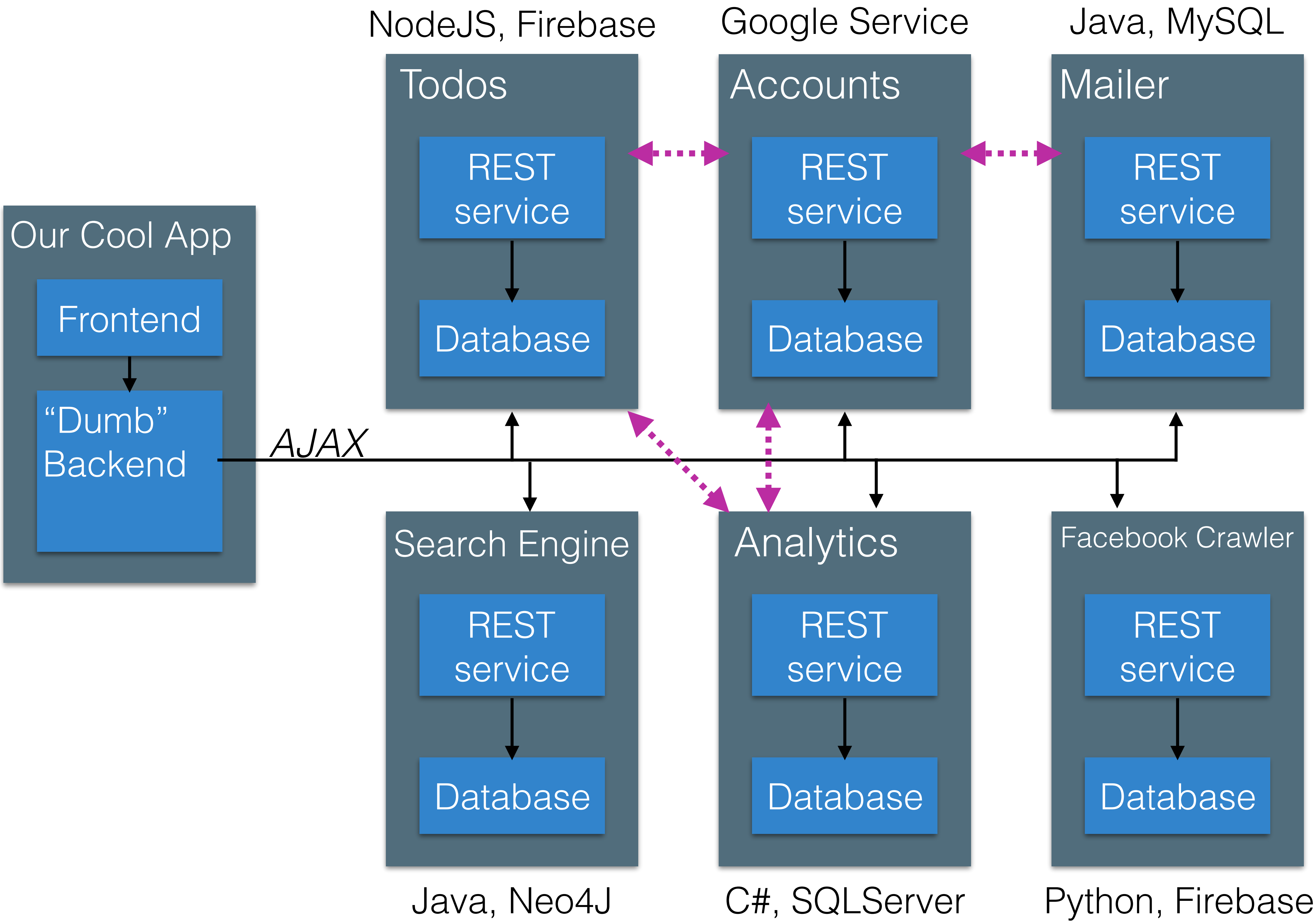
We run multiple copies of the backend, each with each of the modules

What's wrong with this picture?

- This is called the “monolithic” app
- If we need 100 servers…
- Each server will have to run EACH module
- What if we need more of some modules than others?



Microservices



Goals of microservices

- Add them independently
- Upgrade the independently
- Reuse them independently
- Develop them independently

- ==> Have ZERO coupling between microservices, aside from their shared interface

Node.JS

- We're going to write backends with Node.JS
- Why use Node?
  - Event based: really efficient for sending lots of quick updates to lots of clients
- Why not use Node?
  - Bad for CPU heavy stuff
  - It's relatively immature

Node.JS

- Node.JS is a *runtime* that lets you run JS outside of a browser
- How we've been running JS so far, mostly (browser will start next week)
- Node.JS has a very large ecosystem of packages as we've seen
    - Very relevant example here: express (web server)

Express

- Basic setup:
  - For get:

```
app.get("/somePath", function(req, res){
    //Read stuff from req, then call res.send(myResponse)
});
```

  - For post:

```
app.post("/somePath", function(req, res){
    //Read stuff from req, then call res.send(myResponse)
});
```

  - Serving static files:

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

    - Make sure to declare this *last*
- Additional helpful module - bodyParser (for reading POST data)

Demo: Hello World Server

1: Make a directory, myapp

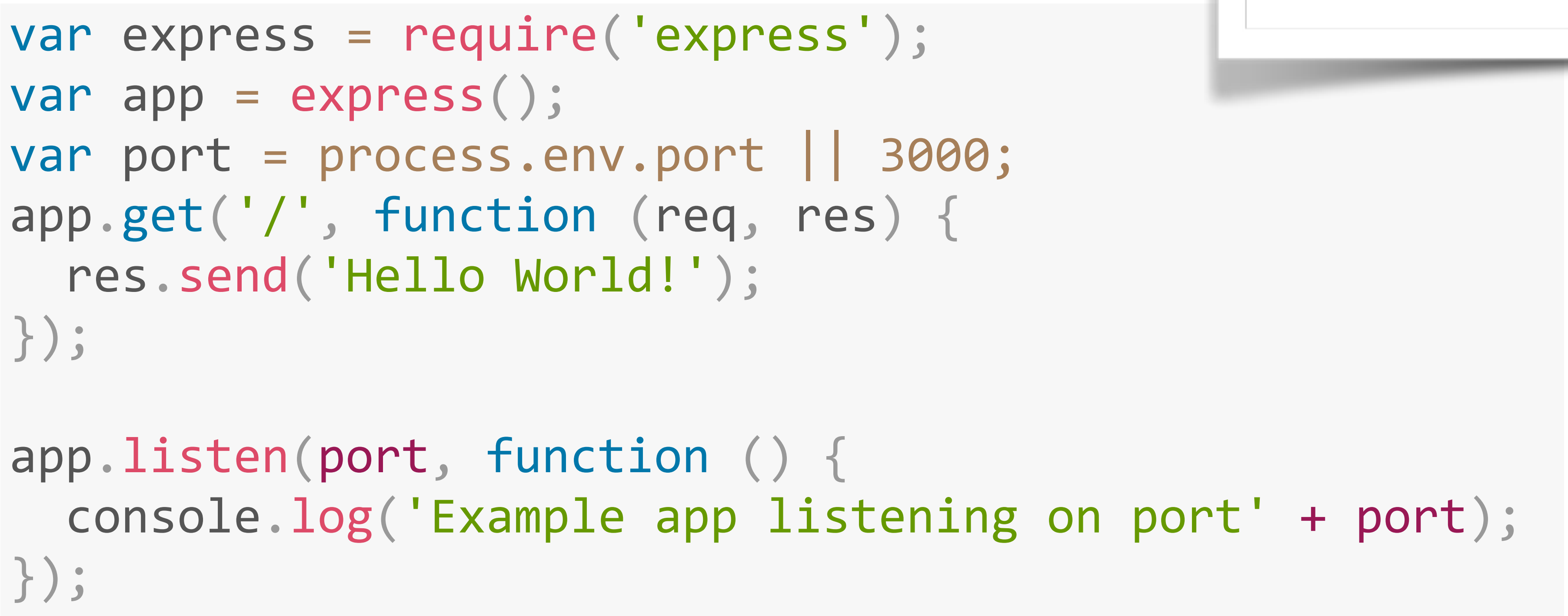
2: Enter that directory, type **`npm init`** (accept all defaults)

Creates a configuration file for your project

3: Type **`npm install express --save`**

Tells NPM that you want to use express, and to save that in your project config

4: Create text file app.js:



```
var express = require('express');
var app = express();
var port = process.env.port || 3000;
app.get('/', function (req, res) {
  res.send('Hello World!');
});

app.listen(port, function () {
  console.log('Example app listening on port' + port);
});
```

5: Type **`node app.js`**

Runs your app

6: Point your browser to http://localhost:3000

Demo: Hello World Server

```
var express = require(‘express');
```

Import the module express

```
var app = express();
```

Create a new instance of express

```
var port = process.env.port || 3000;
```

Decide what port we want express to listen on

```
app.get('/', function (req, res) {
  res.send('Hello World!');
});
```

Create a *callback* for express to call when we have a “`get`” request to “`/`“. That callback has access to the request (`req`) and response (`res`).

```
app.listen(port, function () {
  console.log('Example app listening on port' + port);
});
```

Tell our new instance of express to listen on `port`, and print to the console once it starts successfully

reates a configuration file for your project

M that you want to use and to save that in your project config

5: Type node app.js

6: Point your browser to http://localhost:3000

Run your app

Core concept: Routing

- The definition of end points (URIs) and how they respond to client requests.
  - app.METHOD(PATH, HANDLER)
  - METHOD: all, get, post, put, delete, [and others]
  - PATH: string
  - HANDLER: call back

```
app.post('/', function (req, res) {
  res.send('Got a POST request');
});
```

Route paths

- Can specify strings, string patterns, and regular expressions
    - Can use ?, +, *, and ()
- Matches request to root route

```
app.get('/', function (req, res) {
  res.send('root');
});
```

- Matches request to /about

```
app.get('/about', function (req, res) {
  res.send('about');
});
```

- Matches request to /abe and /abcde

```
app.get('/ab(cd)?e', function(req, res) {
 res.send('ab(cd)?e');
});
```

Route parameters

- Named URL segments that capture values at specified location in URL
  - Stored into `req.params` object by name
- Example
  - Route path */users/**:userId**/books/**:bookId***
  - Request URL *http://localhost:3000/users/34/books/8989*
  - Resulting `req.params: { "userId": "34", "bookId": "8989" }`

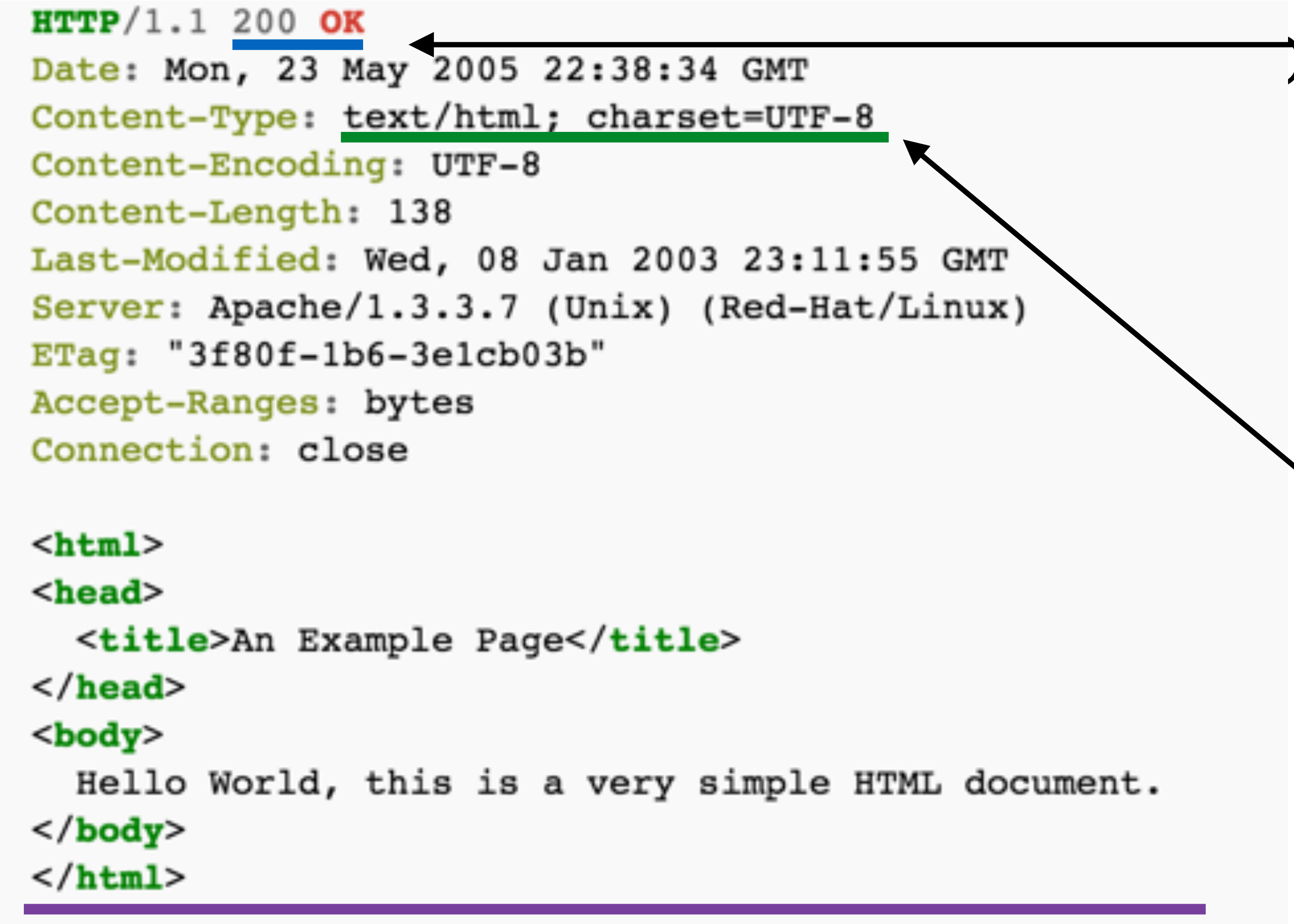
```
app.get('/users/:userId/books/:bookId', function(req, res) {
  res.send(req.params);
});
```

Request object

- Enables reading properties of HTTP request
  - `req.body`: JSON submitted in request body (*must* define body-parser to use)
  - `req.ip`: IP of the address
  - `req.query`: URL query parameters

HTTP Responses

- Larger number of response codes (200 OK, 404 NOT FOUND)



```
HTTP/1.1 200 OK
Date: Mon, 23 May 2005 22:38:34 GMT
Content-Type: text/html; charset=UTF-8
Content-Encoding: UTF-8
Content-Length: 138
Last-Modified: Wed, 08 Jan 2003 23:11:55 GMT
Server: Apache/1.3.3.7 (Unix) (Red-Hat/Linux)
ETag: "3f80f-1b6-3e1cb03b"
Accept-Ranges: bytes
Connection: close

<html>
<head>
  <title>An Example Page</title>
</head>
<body>
  Hello World, this is a very simple HTML document.
</body>
</html>
```

“OK response”

Response status codes:
1xx Informational
2xx Success
3xx Redirection
4xx Client error
5xx Server error

l with certain response

“HTML returned content”

Common MIME types:
application/json
application/pdf
image/png

[HTML data]

Response object

- Enables a response to client to be generated
  - `res.send()` - send string content
  - `res.download()` - prompts for a file download
  - `res.json()` - sends a response w/ application/json Content-Type header
  - `res.redirect()` - sends a redirect response
  - `res.sendStatus()` - sends only a status message
  - `res.sendFile()` - sends the file at the specified path

```
app.get('/users/:userId/books/:bookId', function(req, res) {
  res.json({ “id”: req.params.bookID });
});
```

Describing Responses

- What happens if something goes wrong while handling HTTP request?
  - How does client know what happened and what to try next?
- HTTP offers response status codes describing the nature of the response
  - 1xx Informational: Request received, continuing
  - 2xx Success: Request received, understood, accepted, processed
    - 200: OK
  - 3xx Redirection: Client must take additional action to complete request
    - 301: Moved Permanently
    - 307: Temporary Redirect

https://en.wikipedia.org/wiki/List_of_HTTP_status_codes

Describing Errors

- 4xx Client Error: client did not make a valid request to server. Examples:
  - 400 Bad request (e.g., malformed syntax)
  - 403 Forbidden: client lacks necessary permissions
  - 404 Not found
  - 405 Method Not Allowed: specified HTTP action not allowed for resource
  - 408 Request Timeout: server timed out waiting for a request
  - 410 Gone: Resource has been intentionally removed and will not return
  - 429 Too Many Requests

Describing Errors

- 5xx Server Error: The server failed to fulfill an apparently valid request.
  - 500 Internal Server Error: generic error message
  - 501 Not Implemented
  - 503 Service Unavailable: server is currently unavailable

Error handling in Express

- Express offers a default error handler

- Can specific error explicitly with status
  - `res.status(500);`

Making HTTP Requests

- Writing clients that talk to backends

- Two good options: request, request-promise (need to install both to use request-promise)

```
var rp = require('request-promise');


rp("http://localhost:3000/").then(v => {
    console.log("Response from server:");
    console.log(v);
}).catch(e => {
    console.log("Error");
    console.log(e);
})
```