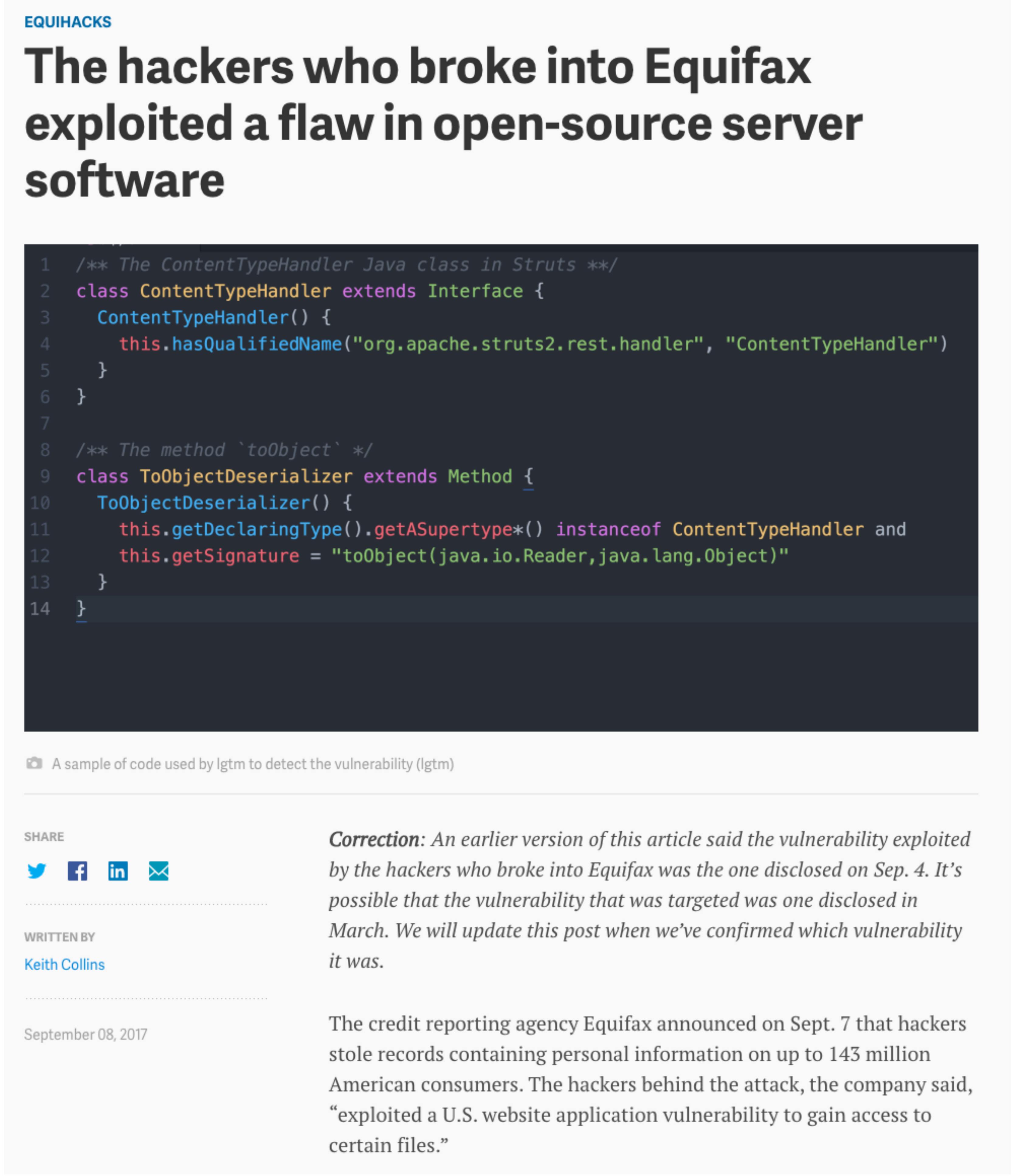
# Backend Development

SWE 432, Fall 2017

Design and Implementation of Software for the Web

GEORGE MASON UNIVERSITY

# Real World Example



EQUIHACKS

## The hackers who broke into Equifax exploited a flaw in open-source server software

```
/** The ContentTypeHandler Java class in Struts **/
class ContentTypeHandler extends Interface {
  ContentTypeHandler() {
    this.hasQualifiedName("org.apache.struts2.rest.handler", "ContentTypeHandler")
  }
}

/** The method `toObject` */
class ToObjectDeserializer extends Method {
  ToObjectDeserializer() {
    this.getDeclaringType().getASupertype*() instanceof ContentTypeHandler and
    this.getSignature = "toObject(java.io.Reader,java.lang.Object)"
  }
}
```

A sample of code used by lgtm to detect the vulnerability (lgtm)

SHARE

WRITTEN BY
Keith Collins

September 08, 2017

***Correction**: An earlier version of this article said the vulnerability exploited by the hackers who broke into Equifax was the one disclosed on Sep. 4. It's possible that the vulnerability that was targeted was one disclosed in March. We will update this post when we've confirmed which vulnerability it was.*

The credit reporting agency Equifax announced on Sept. 7 that hackers stole records containing personal information on up to 143 million American consumers. The hackers behind the attack, the company said, "exploited a U.S. website application vulnerability to gain access to certain files."

https://qz.com/1073221/the-hackers-who-broke-into-equifax-exploited-a-nine-year-old-security-flaw/

## Today

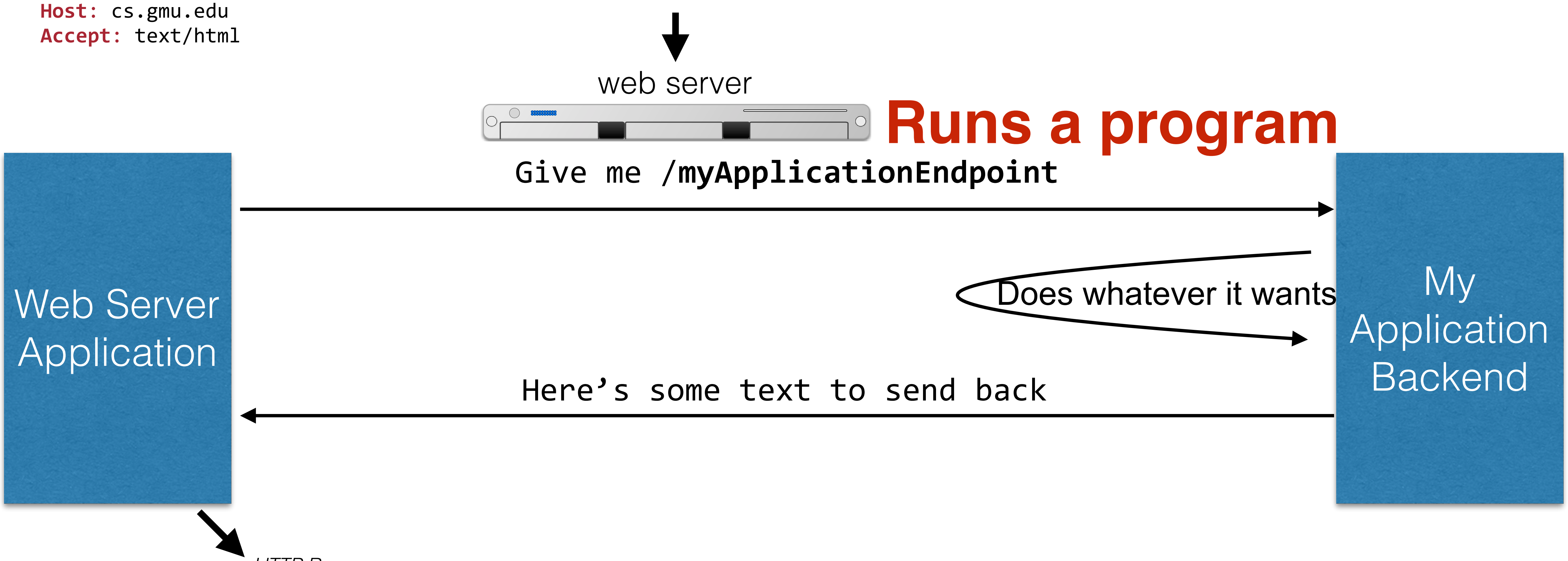
- HW2 out, due next Tues before class

- Why do we need backends?
- Building backend web service with Node.js and Express

# The “good” old days of backends

*HTTP Request*

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



*HTTP Response*

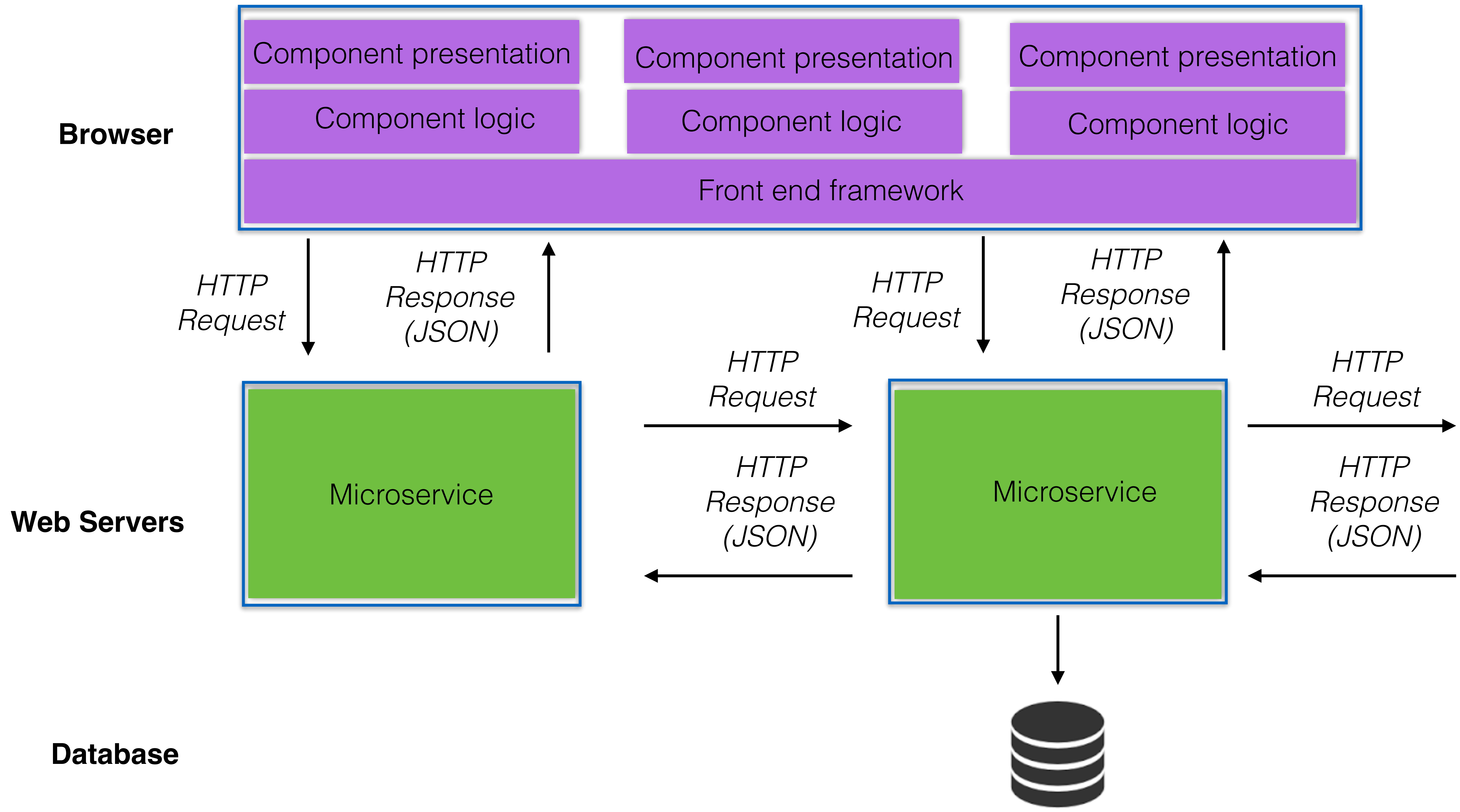
```
HTTP/1.1 200 OK
Content-Type: text/html; charset=UTF-8

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

# 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

# Backends today: Microservices



# Microservices

- Rather than horizontally scale identical web servers, vertically scale server infrastructure into many, small focused servers
- Some advantages
  - Fine-grained scalability: scale what services you need
  - Data-locality: data can be cached close to service providing functionality
  - Fault tolerance: restart only failing service rather than whole system
  - Reuse: use same micro service in multiple apps; use 3rd party rather than first party services

## Why write a backend at all?

## 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

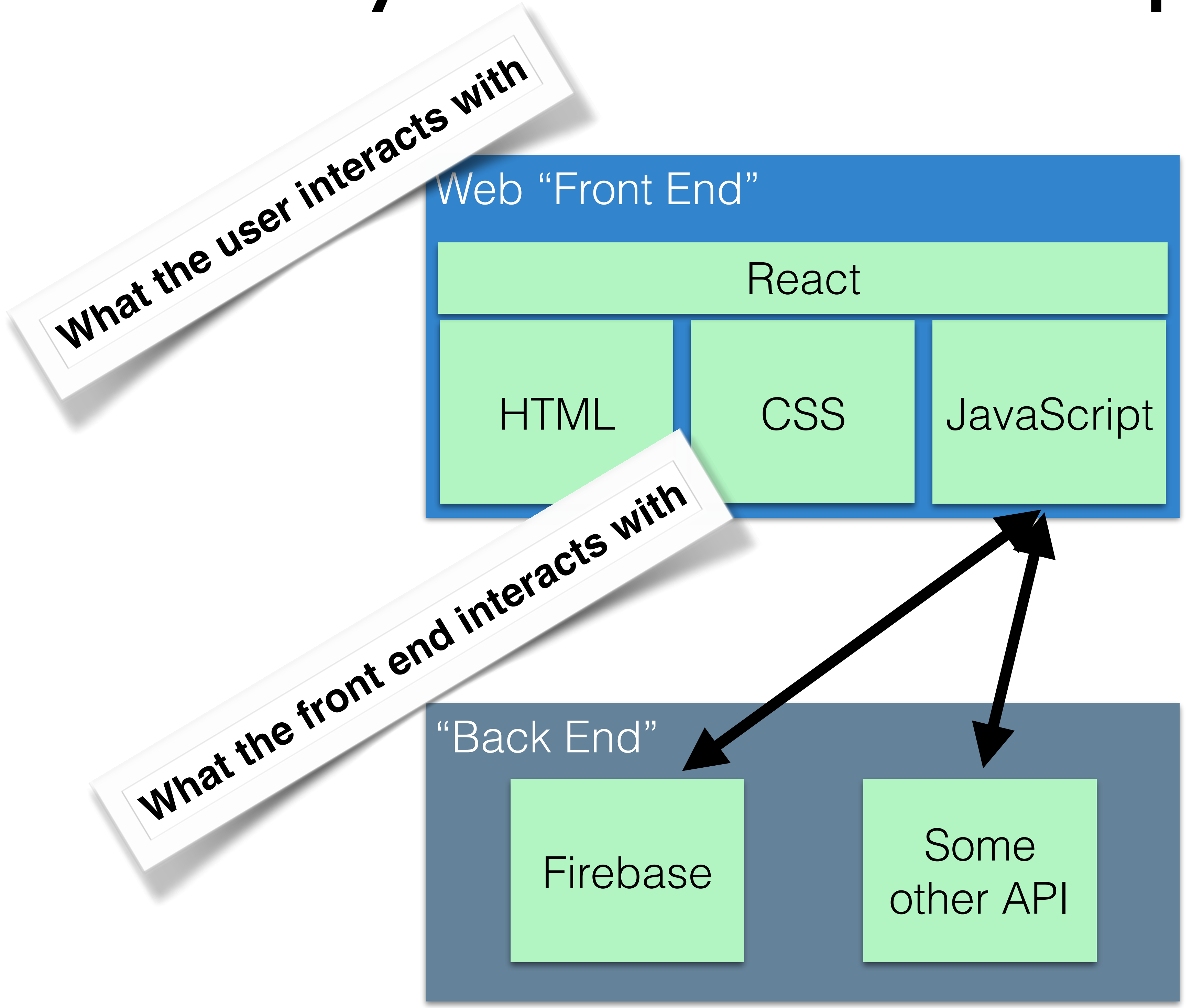
## Why Trust Matters

- Example: Transaction app

```
function updateBalance(user, amountToAdd)
{
    user.balance = user.balance + amountToAdd;
    fireRef.child(user.username).child("balance").set(user.balance);
}
```

- What’s wrong?
- How do you fix that?

# Dynamic Web Apps



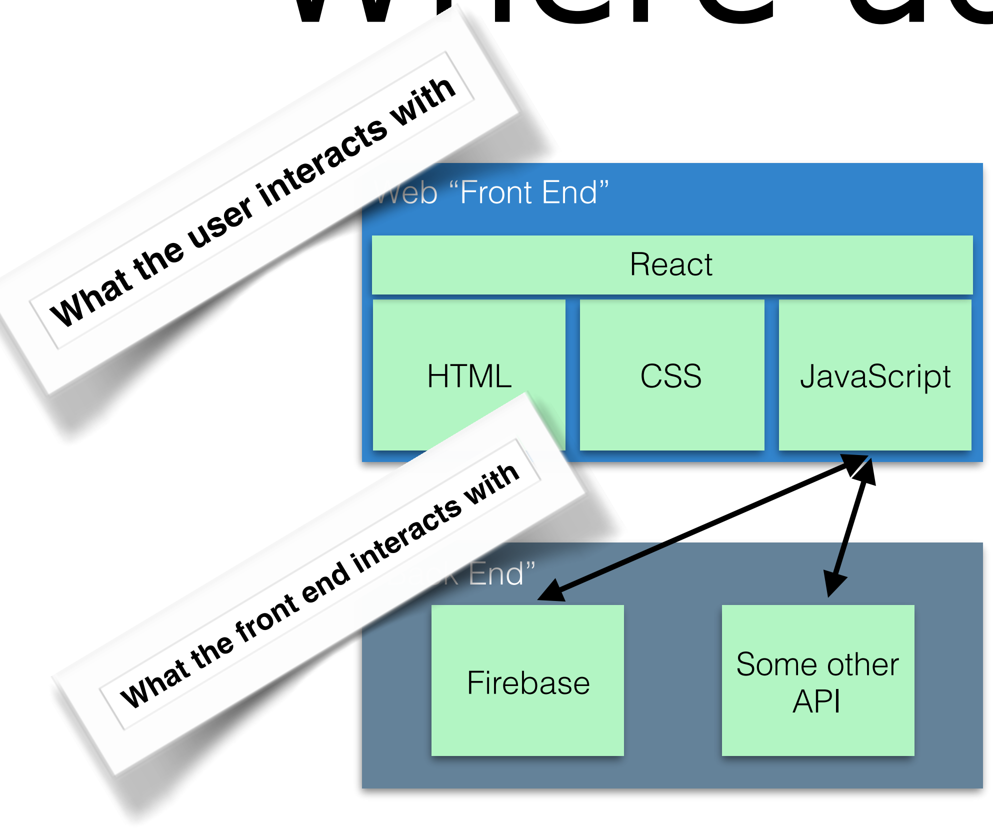
Presentation

Some logic

Data storage

Some other logic

# Where do we put the logic?



Presentation

**Some logic**

Data storage

**Some other logic**

**Frontend**

**Pros**

Very responsive (low latency)

**Cons**

Security

Performance

Unable to share between front-ends

**Backend**

**Pros**

Easy to refactor between multiple clients

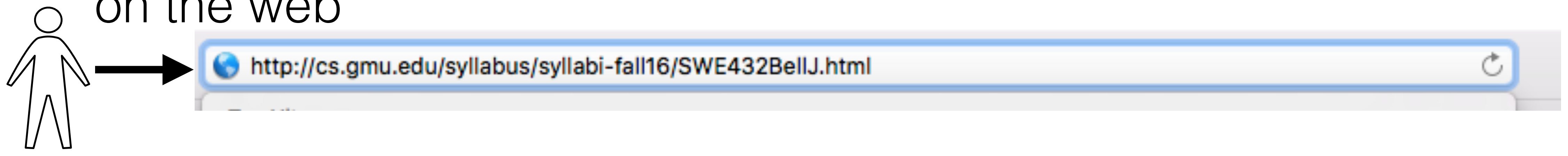
Logic is hidden from users (good for security, compatibility, and intensive computation)

**Cons**

Interactions require a round-trip to server

# HTTP: HyperText Transfer Protocol

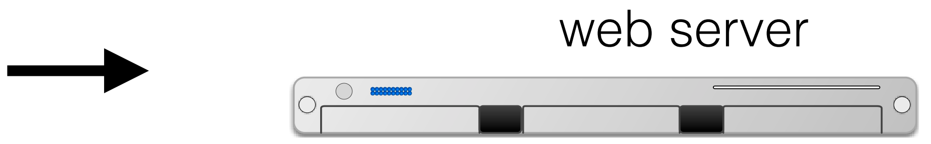
High-level protocol built on TCP/IP that defines how data is transferred on the web



http://cs.gmu.edu/syllabus/syllabi-fall16/SWE432BellJ.html

*HTTP Request*

```
GET /syllabus/syllabi-fall16/SWE432BellJ.html HTTP/1.1
Host: cs.gmu.edu
Accept: text/html
```

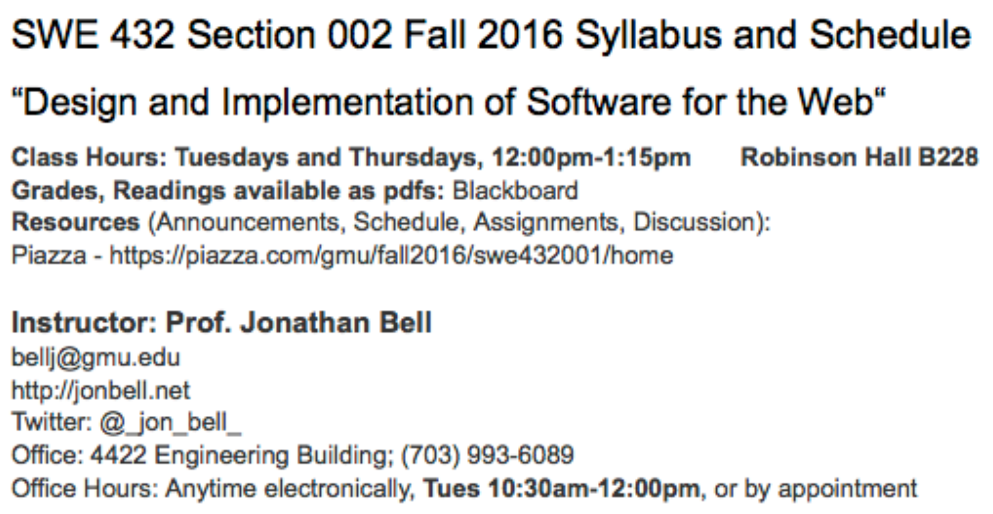


Reads file from disk

*HTTP Response*

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

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



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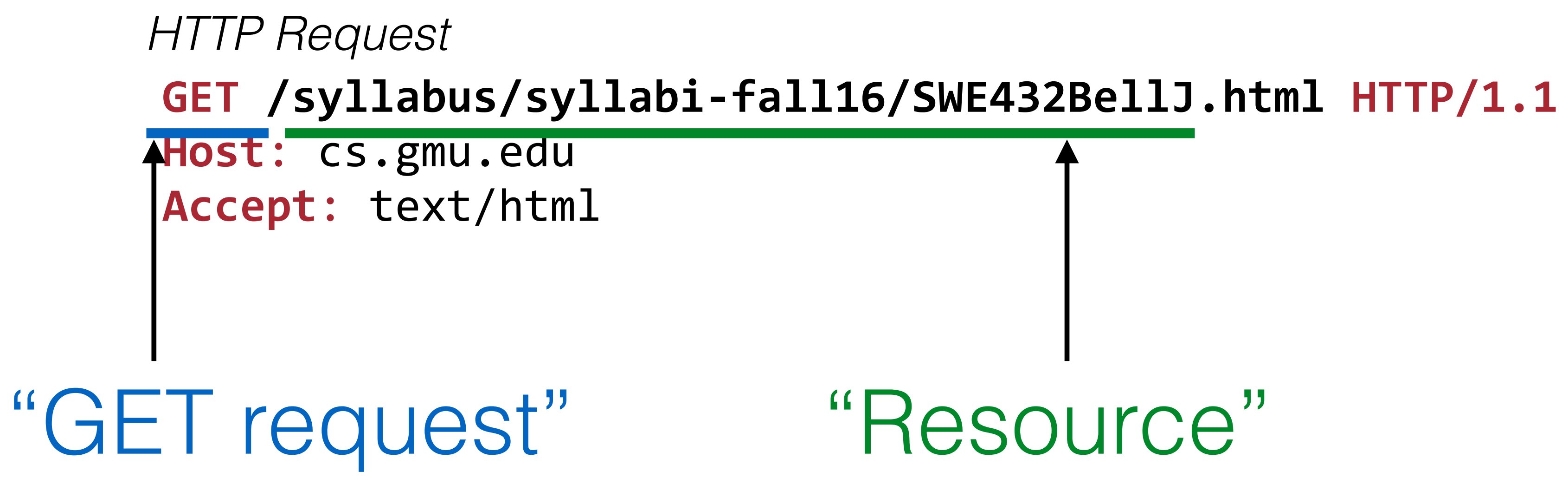
# HTTP Requests



*HTTP Request*

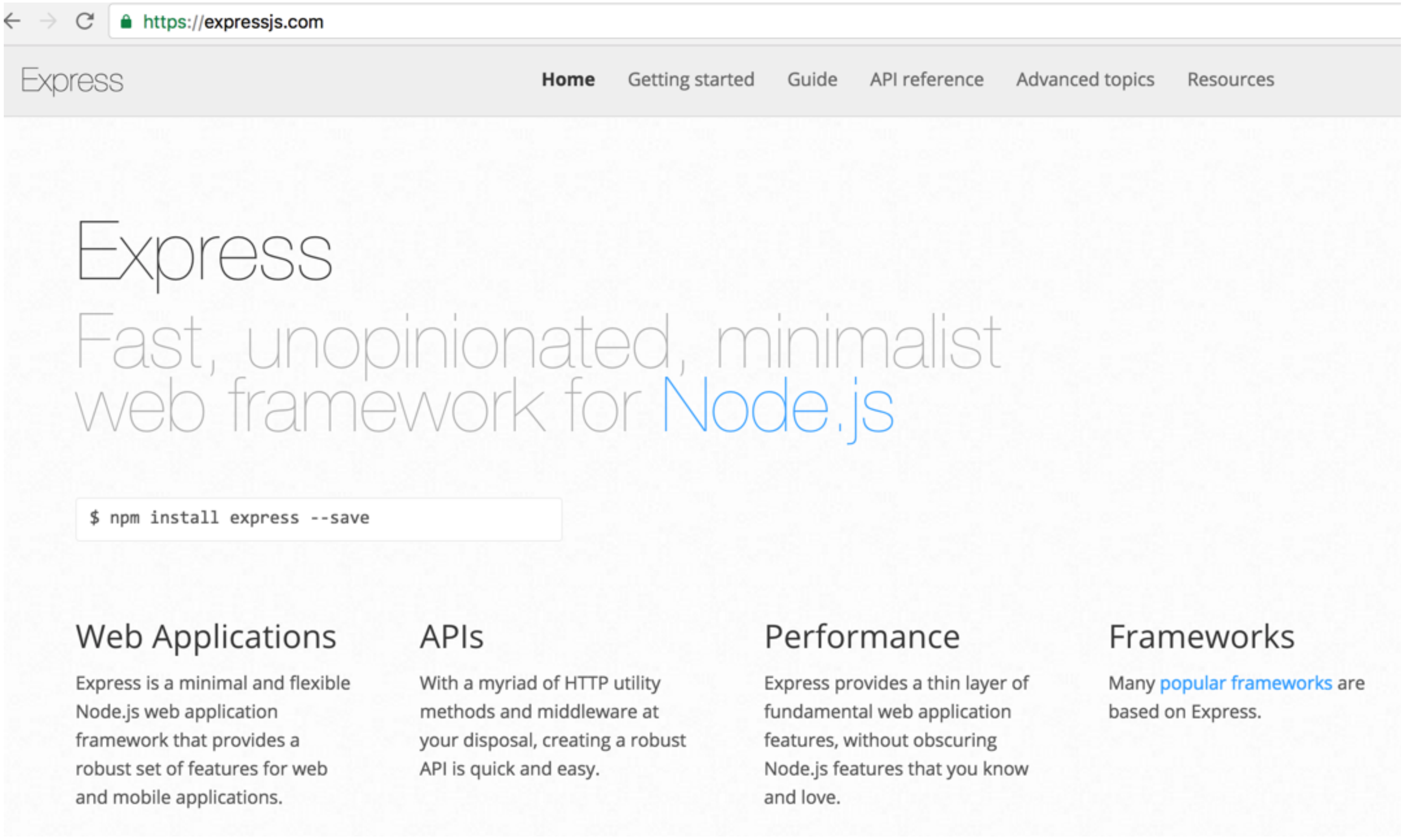
```
GET /syllabus/syllabi-fall16/SWE432BellJ.html HTTP/1.1
Host: cs.gmu.edu
Accept: text/html
```

Other popular types:
POST, PUT, DELETE, HEAD

- Request may contain additional *header lines* specifying, e.g. client info, parameters for forms, cookies, etc.
- Ends with a carriage return, line feed (blank line)
- May also contain a message body, delineated by a blank line

# Handling HTTP Requests in Express

- Node.js package for expressing rules about how to handle HTTP requests



Express

Fast, unopinionated, minimalist web framework for Node.js

```
$ npm install express --save
```

**Web Applications**

Express is a minimal and flexible Node.js web application framework that provides a robust set of features for web and mobile applications.

**APIs**

With a myriad of HTTP utility methods and middleware at your disposal, creating a robust API is quick and easy.

**Performance**

Express provides a thin layer of fundamental web application features, without obscuring Node.js features that you know and love.

**Frameworks**

Many popular frameworks are based on Express.

# Handling requests with Express

*HTTP **GET** Request*

```
GET /myResource/endpoint HTTP/1.1
Host: myHost.net
Accept: text/html
```

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

*HTTP **POST** Request*

```
POST /myResource/endpoint HTTP/1.1
Host: myHost.net
Accept: text/html
```

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

# Demo: Hello World Server

```
const express = require('express');
```

Import the module express

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

Create a new instance of express

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

Decide what port we want express to listen on

```
app.get('/', (req, res) => {
    var course = { name: 'SWE 432' };
    res.send(`Hello ${ course.name }!`);
});
```

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 () { });
```

Tell our new instance of express to listen on `port`.

# 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" }`

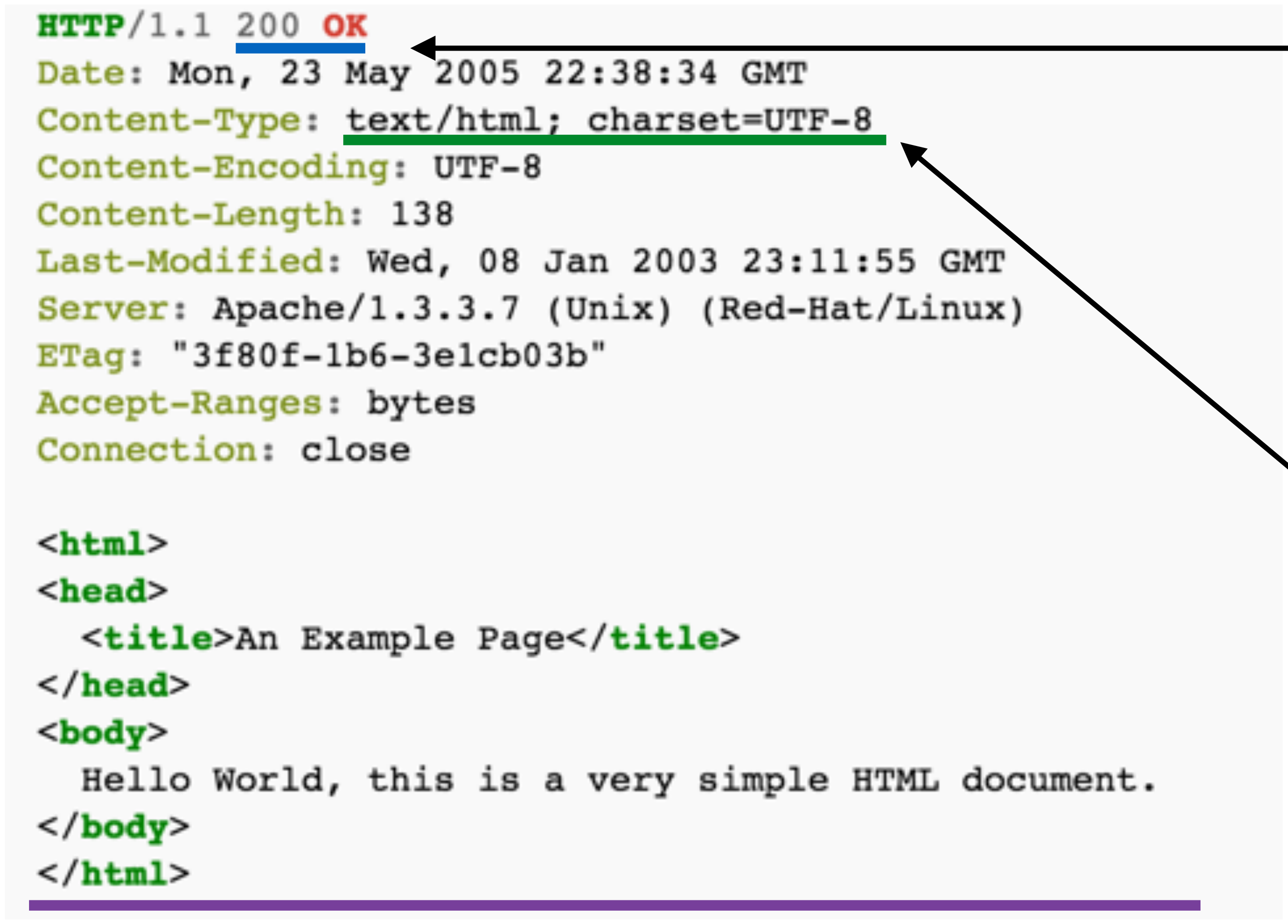
```
app.get('/users/:userId/books/:bookId', function(req, res) {
  res.send(req.params);
});
```

# 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)
- Message body only allowed with certain response status codes



```
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

"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

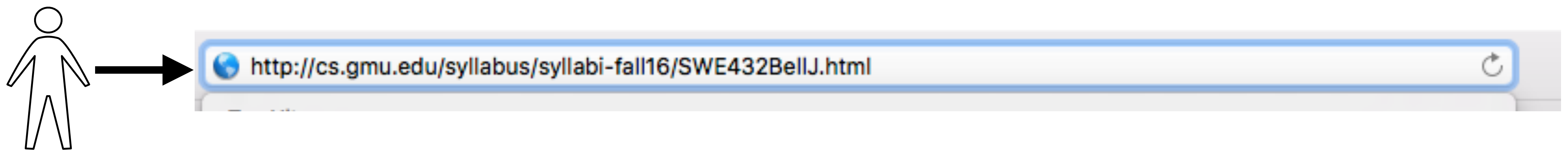
- 5xx Server Error: The server failed to fulfill an apparently valid request.
  - 500 Internal Server Error: generic error message
  - 501 Not Implemented
  - 503 Service Unavailable: server is currently unavailable

# Error handling in Express

- Express offers a default error handler

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

# Making a request….



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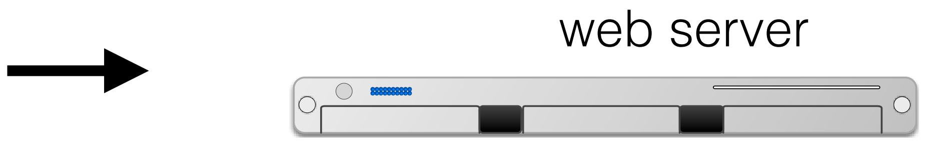

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*HTTP Response*

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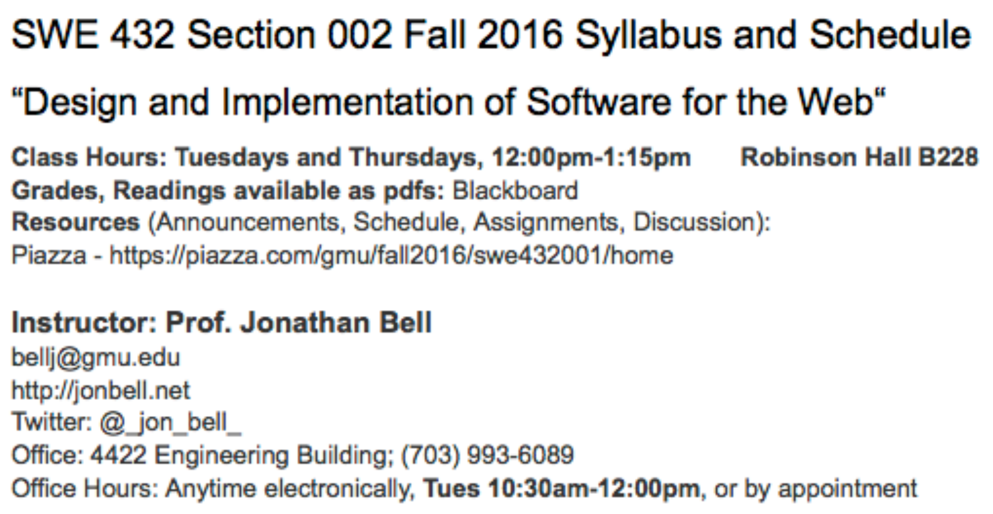

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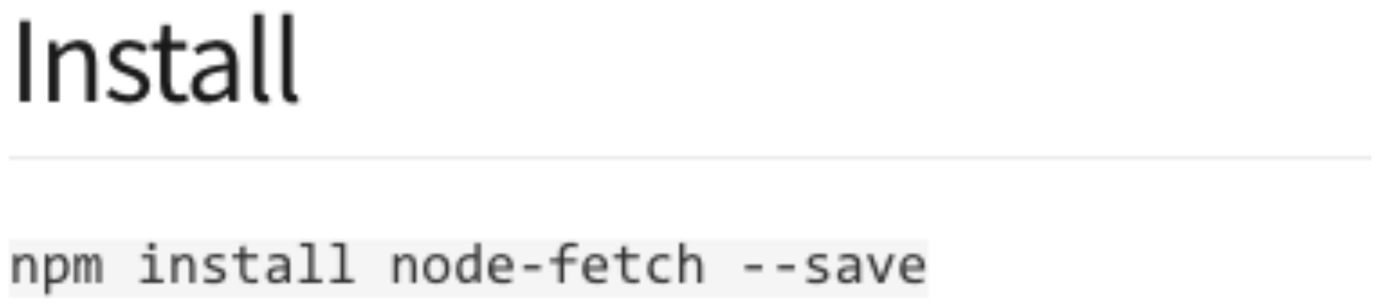
# Making HTTP Requests w/ fetch



## Install

```
npm install node-fetch --save
```

```
var fetch = require('node-fetch');

fetch('https://api.github.com/users/
github')
    .then(function(res) {
        return res.json();
    }).then(function(json) {
        console.log(json);
    });
```

```
var fetch = require('node-
fetch');

fetch('https://github.com/')
    .then(function(res) {
        return res.text();
    }).then(function(body) {
        console.log(body);
    });
```

https://www.npmjs.com/package/node-fetch

https://developer.mozilla.org/en-US/docs/Web/API/Fetch_API/Using_Fetch

## Demo: Example Express Microservice

# Readings for next time

- Overview of HTTP: https://developer.mozilla.org/en-US/docs/Web/HTTP/Overview

- Intro to REST: https://www.infoq.com/articles/rest-introduction