

# IN4MATX 133: User Interface Software

## Lecture 8: AJAX, Fetch, & Promises

# Announcements

- You have everything you need in order to complete A2
- This lecture and beyond focuses on A3 content
- A3 will be posted early next week

# Today's goals

By the end of today, you should be able to...

- Explain how programs access web resources and common ways they respond
- Implement a fetch request to get a resource from a web API
- Use promises to make an asynchronous request

# Web APIs

- Many web services and data sources allow you to use HTTP (web) requests to access their data
- This is done by providing a web API.
- <https://developer.twitter.com/>



# Web APIs

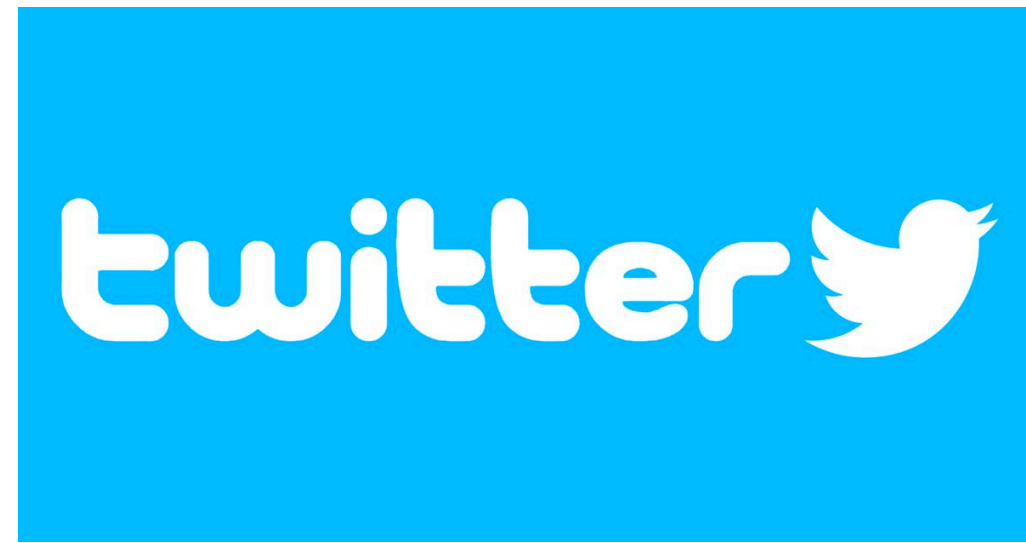
## Application Programming Interface

- The *interface* we can use to interact with an *application* through *programming*
- An interface is just a defined set of functions

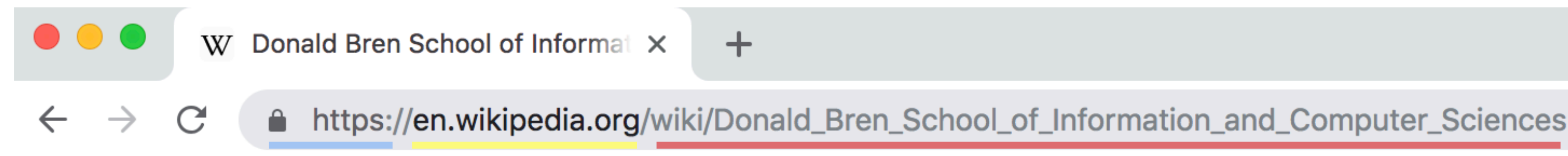
```
function doSomething(param1, param2) {  
  // ...  
}
```

          ↑          ↑  
          An interface

# Web APIs

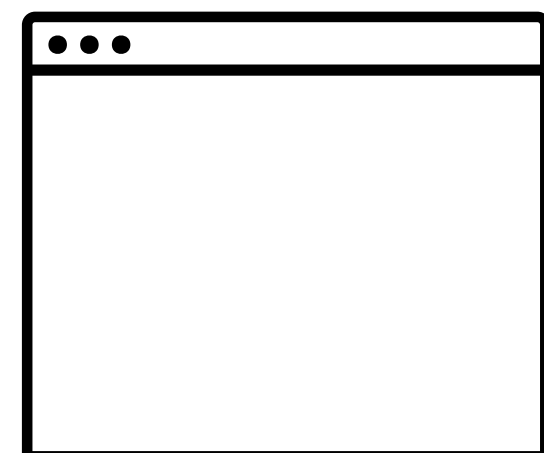


# Using the internet



Protocol	Host	Resource
(how to handle info)	(who has info)	(what info you want)

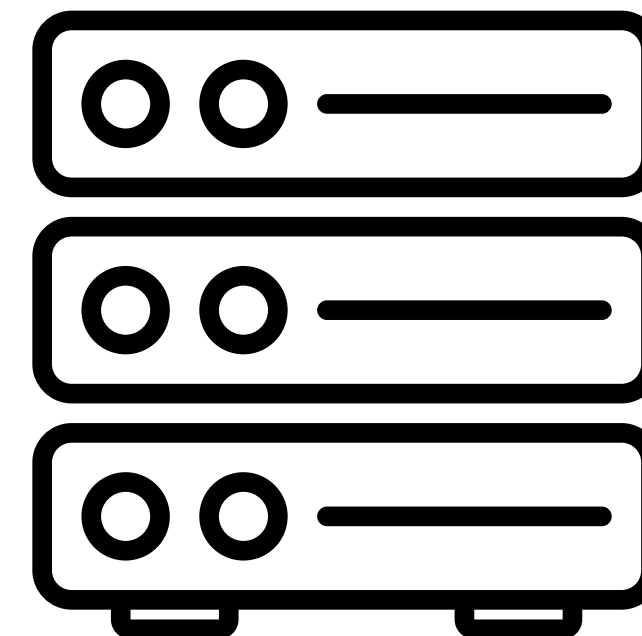
“Hey Wikipedia, I’d like to see the page for the school of ICS!”



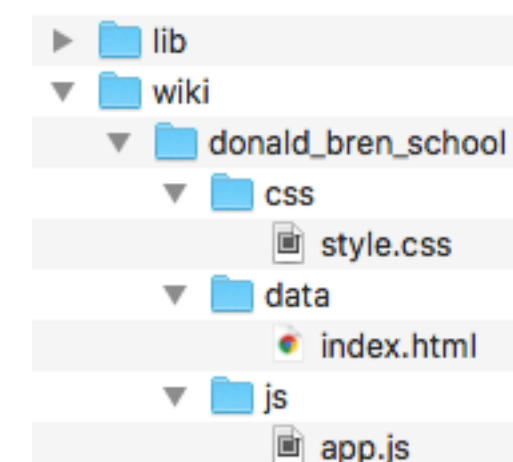
Your browser

Request

Response



Web server



# URI

## Uniform Resource Indicator

- All URLs are URIs, but URLs also specify “access mechanism”
  - `http://`, `file://`
- URIs will return a resource
  - Could be a webpage, image file etc.
  - Could also just be data



# URI

## Uniform Resource Indicator

- `http://www.domain.com/users` => returns a list of users
  - The list of users is the *resource*
- Can have sub-resources
- `http://www.domain.com/users/shawna`
  - Returns a specific user

# URI format

- Base URI:
    - How every API request for that API starts
    - `https://api.twitter.com/`
  - Endpoint
    - Specific resources which can be accessed via that api
    - `1.1/search/tweets.json`
    - `1.1/status/filter.json`
- ↑  
Endpoints often contain an API version number



<https://developer.twitter.com/en/products/tweets.html>

# Disclaimer

- Twitter introduced a new, very different version of its API
- They also locked down their API from certain types of access, so it's no longer as nice of an example
- My examples will follow the old version of Twitter's API, as I think it's a little simpler and more similar to other APIs out there

<https://developer.twitter.com/en/docs/twitter-api>

# URI queries

- Key/value pairs which follow the URI
  - Parameters for the resource, may specify exactly what to return or what format it should be in
  - `?key=value&key=value`
- `https://api.twitter.com/1.1/search/tweets.json?q=UCI&lang=en`  `language=english`  
 “query”, in Twitter this means what text or hashtag to search for

<https://developer.twitter.com/en/docs/tweets/search/api-reference/get-search-tweets.html>

# HTTP verbs

- HTTP requests include a target resource and a verb (method) specifying what to do with it
  - GET: return a representation of the current state of the resource
  - POST: add a new resource (e.g., a record, an entry)
  - PUT: update an existing resource to a new state
  - PATCH: update a portion of the resource's state
  - DELETE: remove the resource
  - OPTIONS: return a set of methods that can be performed on the resource

# HTTP responses

- Responses will include a *status code* (whether it worked as expected) and a *body* (the actual response)
  - 200: OK
  - 201: Created (for POST)
  - 400: Bad request (something is wrong with your URI)
  - 403: Forbidden (some access or authentication issue)
  - 404: Not found (resource does not exist)
  - 500: Internal server error (generic server-side error)

<https://www.restapitutorial.com/httpstatuscodes.html>

# Putting it all together

- HTTP GET `https://api.twitter.com/1.1/search/tweets.json?q=UCI&lang=en`
  - Use the “get” verb to access English-language tweets which mention UCI
  - We expect/hope for status code 200 (OK)
  - Then we access the *body*

# Escaping characters

- Some characters, like the hash (#) are reserved in URLs
  - Linking to IDs within pages
- We need to *encode* the character to search for a hashtag on Twitter
- HTTP GET `https://api.twitter.com/1.1/search/tweets.json?q=%23UCI&lang=en`

Character	From Windows-1252	From UTF-8
space	%20	%20
!	%21	%21
"	%22	%22
#	%23	%23
\$	%24	%24
%	%25	%25

[https://www.w3schools.com/tags/ref\\_urlencode.asp](https://www.w3schools.com/tags/ref_urlencode.asp)



# Question

Character	From Windows-1252	From UTF-8
space	%20	%20
!	%21	%21
"	%22	%22
#	%23	%23
\$	%24	%24
%	%25	%25

Which request would search the Twitter API for recent mentions of ice cream?

- A** HTTP GET `https://api.twitter.com/1.1/search/tweets.json?q=ice cream`
- B** HTTP GET `https://api.twitter.com/1.1/search/tweets.json?q=icecream`
- C** HTTP GET `https://api.twitter.com/1.1/search/tweets.json?q=ice%20cream`
- D** HTTP POST `https://api.twitter.com/1.1/search/tweets.json?q=ice%20cream`
- E** HTTP POST `https://api.twitter.com/1.1/search/tweets.json?q=ice cream`

## Which request would search the Twitter API for recent mentions of ice cream?

- A** HTTP GET `https://api.twitter.com/1.1/search/tweets.json?q=ice cream`
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- D** HTTP POST `https://api.twitter.com/1.1/search/tweets.json?q=ice%20cream`
- E** HTTP POST `https://api.twitter.com/1.1/search/tweets.json?q=ice cream`

A

0%

B

0%

C

0%

D

0%

E

0%

# Question

Character	From Windows-1252	From UTF-8
space	%20	%20
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- E** HTTP POST `https://api.twitter.com/1.1/search/tweets.json?q=ice cream`

**So how do we make a web request?**



**Asynchronous JavaScript and XML**

# XML

## Extensible Markup Language

- A generalized syntax for semantically defining structured content
- HTML is XML with defined tags

```
<person>  
  <firstName>Alice</firstName>  
  <lastName>Smith</lastName>  
  <favorites>  
    <music>jazz</music>  
    <food>pizza</food>  
  </favorites>  
</person>
```

# Plain text

## Belgian Waffles

"Two of our famous Belgian Waffles with plenty of real maple syrup"  
\$5.95  
650 calories

## Strawberry Belgian Waffles

"Light Belgian waffles covered with strawberries and whipped cream"  
\$7.95  
900 calories

## Berry-Berry Belgian Waffles

"Light Belgian waffles covered with an assortment of fresh berries and whipped cream"  
\$8.95  
900 calories

## French Toast

"Thick slices made from our homemade sourdough bread"  
\$4.50  
600 calories

## Homestyle Breakfast

"Two eggs, bacon or sausage, toast, and our ever-popular hash browns"  
\$6.95  
950 calories

# XML

```
<breakfast_menu>
  <food>
    <name>Belgian Waffles</name>
    <price>$5.95</price>
    <description>
      Two of our famous Belgian Waffles with plenty of real maple syrup
    </description>
    <calories>650</calories>
  </food>
  <food>
    <name>Strawberry Belgian Waffles</name>
    <price>$7.95</price>
    <description>
      Light Belgian waffles covered with strawberries and whipped cream
    </description>
    <calories>900</calories>
  </food>
  <food>
    <name>Berry-Berry Belgian Waffles</name>
    <price>$8.95</price>
    <description>
      Light Belgian waffles covered with an assortment of fresh berries and whipped
cream
    </description>
    <calories>900</calories>
  </food>
  <food>
    <name>French Toast</name>
    <price>$4.50</price>
    <description>
      Thick slices made from our homemade sourdough bread
    </description>
    <calories>600</calories>
  </food>
  <food>
    <name>Homestyle Breakfast</name>
    <price>$6.95</price>
    <description>
      Two eggs, bacon or sausage, toast, and our ever-popular hash browns
    </description>
    <calories>950</calories>
  </food>
</breakfast_menu>
```



# XML

```
<breakfast_menu>
  <food>
    <name>Belgian Waffles</name>
    <price>$5.95</price>
    <description>
      Two of our famous Belgian Waffles with plenty of real maple syrup
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    <calories>650</calories>
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  <food>
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    <price>$7.95</price>
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    </description>
    <calories>900</calories>
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  <food>
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  <food>
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    <price>$6.95</price>
    <description>
      Two eggs, bacon or sausage, toast, and our ever-popular hash browns
    </description>
    <calories>950</calories>
  </food>
</breakfast_menu>
```

# JSON

```
{
  "breakfast_menu": {
    "food": [
      {
        "name": "Belgian Waffles",
        "price": "$5.95",
        "description": "Two of our famous Belgian Waffles with plenty of real maple
syrup",
        "calories": "650"
      },
      {
        "name": "Strawberry Belgian Waffles",
        "price": "$7.95",
        "description": "Light Belgian waffles covered with strawberries and whipped
cream",
        "calories": "900"
      },
      {
        "name": "Berry-Berry Belgian Waffles",
        "price": "$8.95",
        "description": "Light Belgian waffles covered with an assortment of fresh
berries and whipped cream",
        "calories": "900"
      },
      {
        "name": "French Toast",
        "price": "$4.50",
        "description": "Thick slices made from our homemade sourdough bread",
        "calories": "600"
      },
      {
        "name": "Homestyle Breakfast",
        "price": "$6.95",
        "description": "Two eggs, bacon or sausage, toast, and our ever-popular hash
browns",
        "calories": "950"
      }
    ]
  }
}
```



# XML vs. JSON

- XML and JSON represent the same data
- JSON is more concise
  - Less data to move around on the web
- JSON is easier to read
  - Close tags in XML are redundant
- JSON has taken over as the typical format of web requests



**Asynchronous JavaScript and ~~XML~~**  
JSON

# **Sending an *AJAX* request**

# XMLHttpRequest

- AJAX requests are built into a browser-provided object called XMLHttpRequest

```
var xhttp = new XMLHttpRequest();
xhttp.onreadystatechange = function() {
    if (xhttp.readyState == 4 && xhttp.status == 200) {
        // Action to be performed when the document is read;
        var xml = xhttp.responseXML;

        var movie = xml.getElementsByTagName("track");
        //...
    }
};
xhttp.open("GET", "filename", true);
xhttp.send();
```


# XMLHttpRequest

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xhttp.onreadystatechange = function() {  
    if (xhttp.readyState == 4 && xhttp.status == 200) {  
        // Action to be performed when the document is read;  
        var xml = xhttp.responseXML;  
  
        var movie = xml.getElementsByTagName("track");  
        //...  
    }  
};  
xhttp.open("GET", "filename", true);  
xhttp.send();
```

# Fetch

- A new, modern method for submitting XMLHttpRequests
- Included in most browsers (but not IE)
- `fetch('url')`

Fetch  - LS

A modern replacement for XMLHttpRequest.

Current aligned Usage relative Date relative Filtered All 

IE	Edge <sup>*</sup>	Firefox	Chrome	Safari	Opera	iOS Safari <sup>*</sup>	Opera Mini <sup>*</sup>	Android Browser <sup>*</sup>	Opera Mobile <sup>*</sup>
		2-33	4-39		10-26				
		<sup>1 4</sup> 34-38	<sup>2</sup> 40		<sup>2</sup> 27				
	12-13	<sup>4</sup> 39	<sup>2 3</sup> 41	3.1-10	<sup>2 3</sup> 28	3.2-10.2			
6-10	14-86	40-83	42-86	10.1-13.1	29-71	10.3-13.7		2.1-4.4.4	12-12.1
11	87	84	87	14	72	14.3	all	81	59
		85-86	88-90	TP					

# Fetch polyfill

- Polyfills ensure a user's browser has the latest libraries
  - Downloads "fill" versions of added functions, re-written using existing functions
- Fetch polyfill: <https://github.com/github/fetch>
- Or import it from a CDN:

```
<script src="https://cdnjs.cloudflare.com/ajax/libs/fetch/3.0.0/fetch.min.js"></script>
```

# Using fetch

- `fetch ( 'some-url' )` defaults to a GET request
- `fetch` can optionally take a second `options` argument (as a dictionary)
  - `method`: what method to use (e.g., POST, PUT, DELETE)
  - `headers`: specify content type format, etc. (more on headers in the next week)
  - `body`: what you want to send for a POST/PUT request



# Using fetch

- For a GET request

```
fetch( 'some-url' );
```

- For a POST request

```
fetch( 'some-url', {  
  method: 'POST',  
  headers: { 'Content-Type': 'application/json' },  
  body: JSON.stringify(data-to-send)  
} );
```

# A local web server

- Install live-server package globally
  - `npm install -g live-server`
- Running it
  - `cd path/to/project`
  - `live-server .`
- Will open up your webpage at <http://localhost:8080>



**Asynchronous JavaScript and ~~XML~~ JSON**

# Asynchronous requests

- Ajax requests are asynchronous, so they happen simultaneously with the rest of the code
- After the request is sent, the next line of code is executed **without waiting for the request to finish**

```
(1) console.log( 'About to send request' );
```

```
//send request for data to the url
```

```
(2) fetch(url);
```

← Does **NOT** return the data

```
(3) console.log( 'Sent request' );
```

(4) Data is actually received sometime later!

# Asynchronous requests

- It's uncertain how long it'll take the request to complete
- Handling requests asynchronously allows a person to continue interacting with your page
  - The request is not blocking their interface interactions
  - It's a bad experience when a person tries to navigate your webpage, but can't

# Promises

- Because `fetch()` is asynchronous, the method returns a **Promise**
- Promises act as a “placeholder” for the data that will eventually be received from the AJAX request

`//fetch() returns a Promise`

```
var thePromise = fetch(url);
```

# Promises

- We use the `.then()` method to specify a **callback** function to be executed when the promise is *fulfilled* (when the asynchronous request is finished)

//what to do when we get the response

```
function successCallback(response) {  
    console.log(response);  
}
```



Callback will be passed the request response

//when fulfilled, execute the callback function

//(which will be passed the fetched data)

```
var promise = fetch(url);  
promise.then(successCallback, rejectCallback);
```



Optional parameter

//more common to use anonymous variables/callbacks:

```
fetch(url).then(function(response) {  
    console.log(response);  
});
```

# Promise polyfill

- Promises are the modern way of handling asynchronous, but again the standard is not yet available in all browsers (specifically: IE)
- <https://caniuse.com/#feat=promises>
- So we need another polyfill
- <https://cdnjs.com/libraries/es6-promise>  
`<script src="https://cdnjs.cloudflare.com/ajax/libs/es6-promise/4.1.1/es6-promise.min.js"></script>`



# fetch() responses

- The parameter passed to the `.then()` callback is the **response**, not the data we're looking for
- The `fetch()` API provides a method `.json()` that we can use to extract the data from the response
  - But this method is *also* asynchronous and returns a promise!

```
fetch(url).then(function(response) {  
    var newPromise = response.json();  
    // ... what now?  
});
```

↑  
Another promise

↑  
Not the data

# Chaining promises

- The `.then()` method itself returns a Promise containing the value (data) returned by the callback method
- This allows you to **chain** callback functions together, doing one after another (but *after* the Promise is fulfilled)

```
function makeString(data) {  
    return data.join(", "); //a value to put in Promise  
}
```

```
function makeUpper(string) {  
    return string.toUpperCase(); //a value to put in Promise  
}
```

```
var promiseA = getData(); When completed, promiseA => json data  
var promiseB = promiseA.then(makeString); promiseB => comma-separated string  
var promiseC = promiseB.then(makeUpper); promiseC => uppercase string  
promiseC.then(function(data) {  
    console.log(data); Data is an uppercase,  
}); comma-separated string
```

# Chaining promises

- The `.then()` method itself returns a Promise containing the value (data) returned by the callback method
- This allows you to **chain** callback functions together, doing one after another (but *after* the Promise is fulfilled)

```
function makeString(data) {  
    return data.join(", "); //a value to put in Promise  
}
```

```
function makeUpper(string) {  
    return string.toUpperCase(); //a value to put in Promise  
}
```

```
//more common to use anonymous variables and chain functions  
getData()  
    .then(makeString)  
    .then(makeUpper)  
    .then(function(d) { console.log(d); });
```

# Multiple promises (sequential)

- The .then() function will also handle promises *returned by previous callbacks*, allowing for sequential async calls

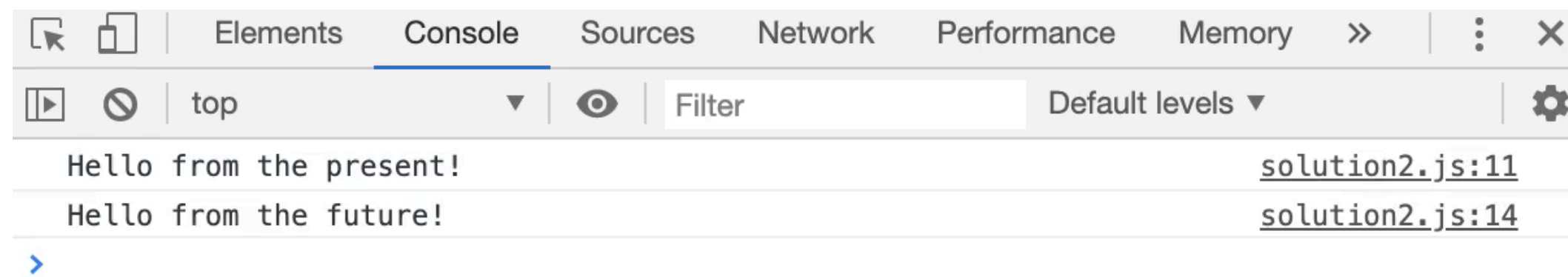
```
getData(fooSrc)
  .then(function(fooData) {
    var modifiedFoo = modify(fooData)
    return modifiedFoo;
  })
  .then(function(modifiedFoo) {
    //do something with modifiedFoo
    var barPromise = getData(barSrc);
    return barPromise;
  })
  .then(function(barData) {
    //do something with barData
  })
```

# Extracting fetch() data

- To actually download JSON data...

```
fetch(url)
  .then(function(response) {
    var dataPromise = response.json();
    return dataPromise;
  })
  .then(function(data) {
    //do something with data
  });
```

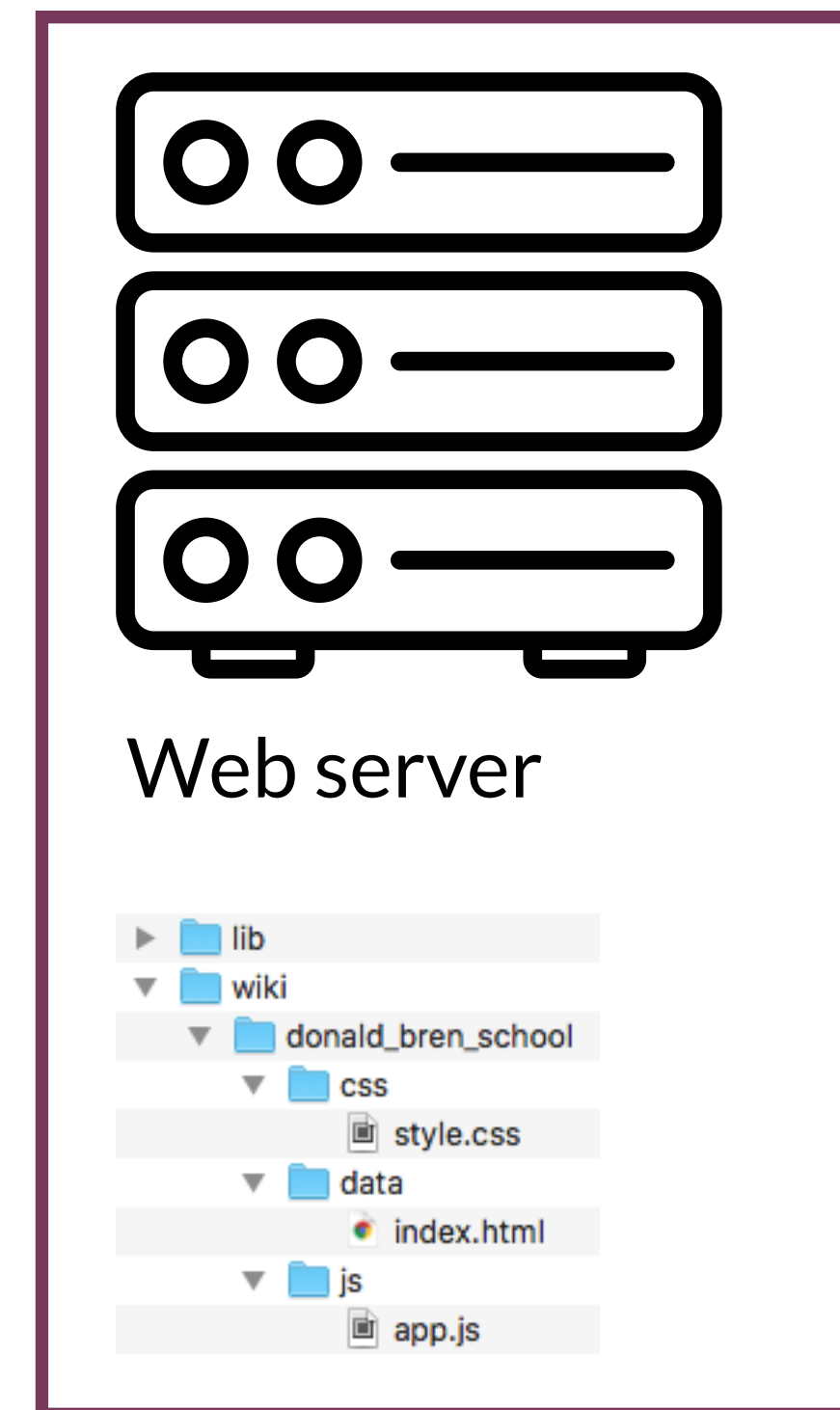
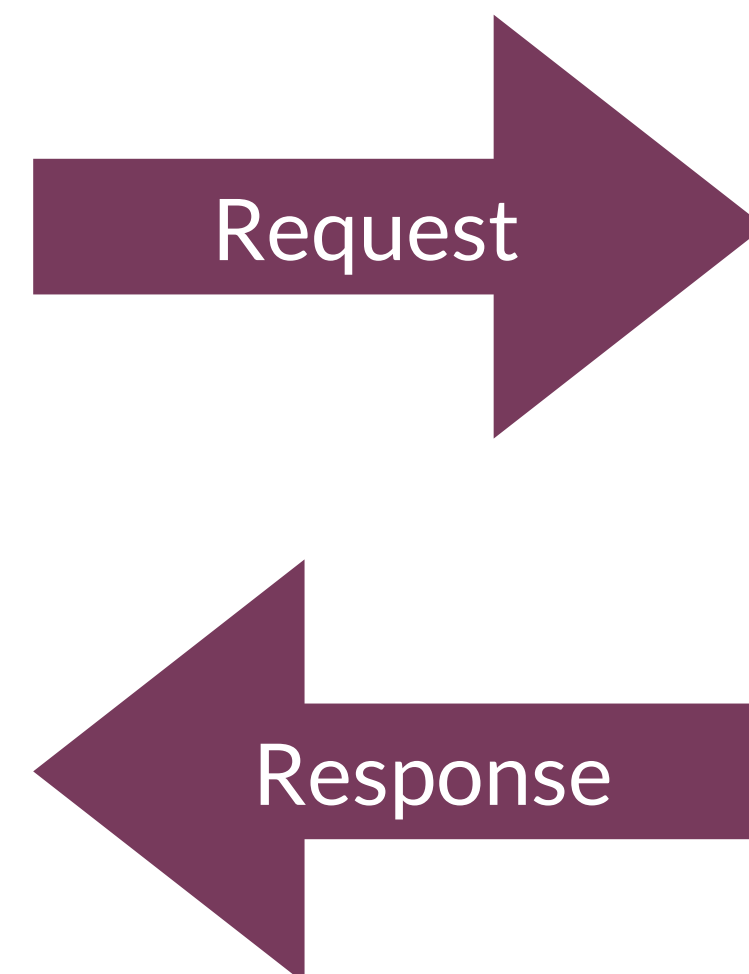
# Promises



# Client-side and server-side JavaScript



Edit what's being rendered  
Trigger or react to events

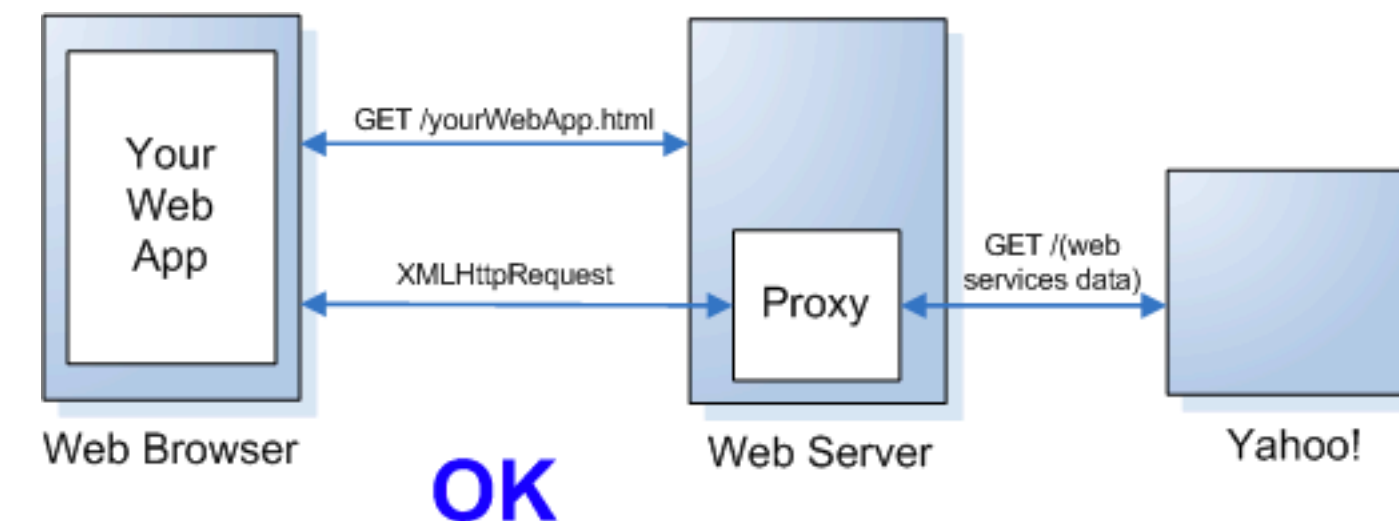


Navigate file system programmatically  
Dynamically generate pages or views  
Transport, store, or interact with data



# Same-origin policy

- Many browsers will not permit AJAX requests to a different server. This helps prevent malicious scripts from accessing data in the DOM
- A non-browser proxy server running locally can communicate with a different server
- The browser can communicate with the proxy server





# Same-origin policy

- Two browser tabs: a bank app is open in one, an evil app in the other
  - Both have JavaScript scripts
  - The bank uses it's script to read, edit, etc. your bank data
- The *origin* is what HTML page opened the JavaScript file
  - So each tab is a separate origin
- *Without* the same-origin policy, the evil app could read, edit, etc. your bank data
  - Different tabs, but both running with the same JavaScript engine



<https://security.stackexchange.com/questions/8264/why-is-the-same-origin-policy-so-important>

# Same-origin policy

- So instead, the bank's JavaScript script can only perform actions in its browser tab (origin), and the evil app's JavaScript script can only perform actions in its browser tab
- Two exceptions:
  - An app can always communicate with other apps in the same domain (e.g., localhost apps can communicate with any other localhost apps\*)
  - A server can designate that it will accept connections from sources with a particular origin (or any origin)
  - You *can* disable the policy in your browser, but probably shouldn't



<https://security.stackexchange.com/questions/8264/why-is-the-same-origin-policy-so-important>

# Client-side

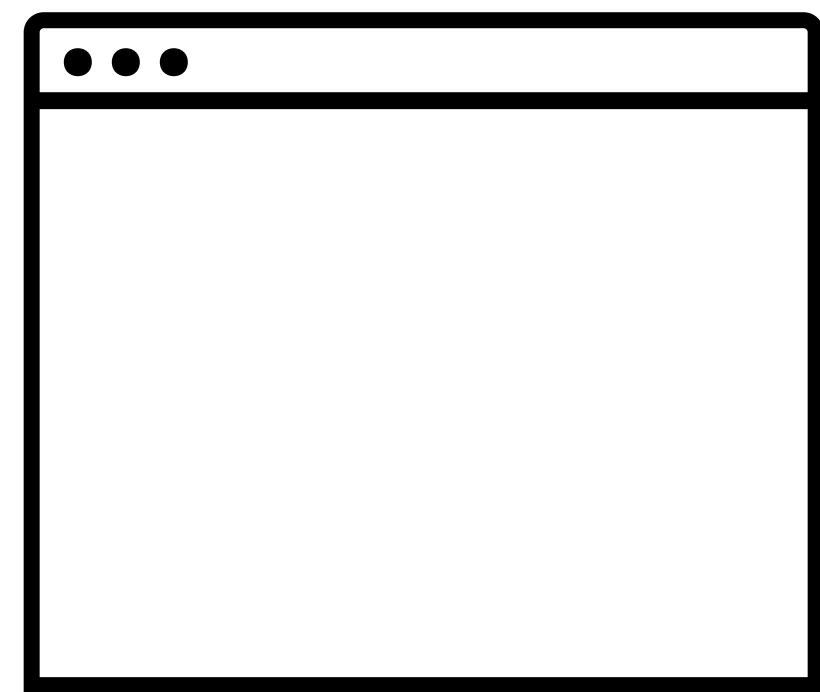
- Runs in the browser
- Changes happen in real-time in the browser
- Cannot make HTTP requests to many APIs
- Examples: AJAX, Angular, React, Vue.js

# 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

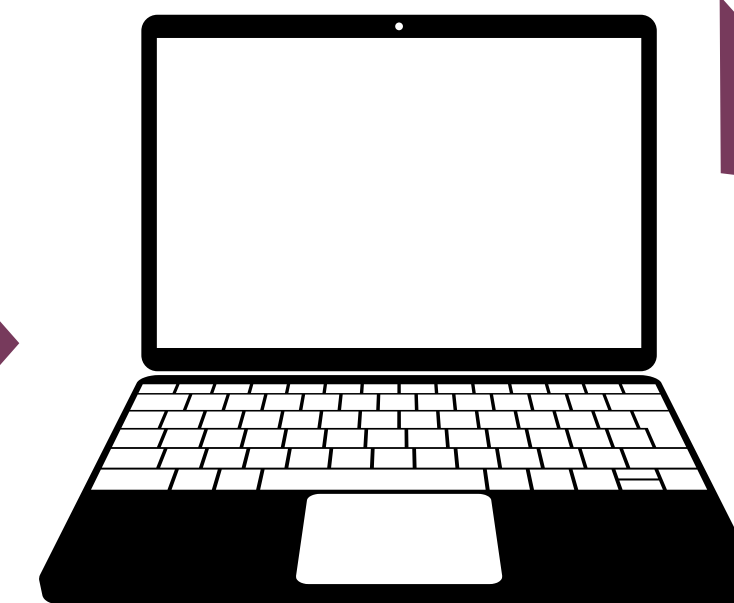
- Localhost: “this computer”



Live server: localhost:8080

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

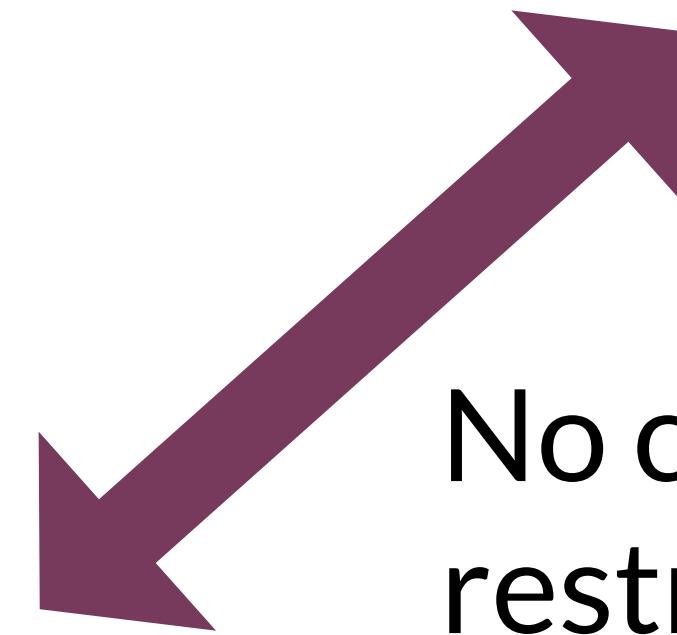
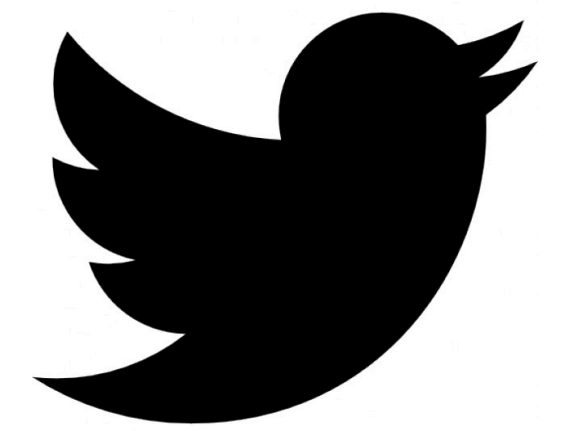
Same domain (localhost),  
so they can communicate\*



Twitter proxy: localhost:7890

Running as a server, so no same-origin policy restrictions.  
Can communicate with Twitter

No communication  
restrictions



# Proxy servers

- Twitter's new API recommends some server-side (Node) libraries to serve as proxies
- More on server-side development next class

## JavaScript (Node.JS) / TypeScript

- **node-twitter-api-v2** strongly typed, full-featured, light, versatile yet powerful Twitter API client for Node.js
- **twitter.js** an object-oriented Node.js and TypeScript library for interacting with Twitter API v2
- **twitter-types** type definitions for the Twitter API
- **twitter-v2** An asynchronous client library for the Twitter APIs
- **tweet-json-to-html** converts Twitter API v2 Tweet JSON objects into HTML format

<https://developer.twitter.com/en/docs/twitter-api>

# Question

## Which can make an HTTP request to the Spotify API?

(Assume the browser uses default settings)

**A** 4

**B** 1, 4

**C** 1, 2, 4

**D** 1, 3, 4

**E** 1, 2, 3, 4

(1) A browser open to spotify.com

(2) A browser with client-side JavaScript at localhost:8888

(3) A browser with server-side JavaScript at localhost:8888

(4) A server running in the Spotify domain



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A

0%

B

0%

C

0%

D

0%

E

0%

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# Getting live tweet data



## 10 Tweets about RunKeeper

- Just completed a 4.87 km run with @Runkeeper. Check it out! <https://t.co/QeB0SmBONJ> #Runkeeper
- Just completed a 1.89 mi run with @Runkeeper. Check it out! <https://t.co/Yo1voS1OoJ> #Runkeeper
- Just completed a 10.61 km run with @Runkeeper. Check it out! <https://t.co/9GnepQIr70> #Runkeeper
- Just posted a 10.34 km run - New PB on this route 😊 <https://t.co/7cGHIhEIIW> #Runkeeper
- Just completed a 3.02 km run with @Runkeeper. Check it out! <https://t.co/VUzLbkFGyW> #Runkeeper
- Just completed a 10.00 km run with @Runkeeper. Check it out! <https://t.co/slGWps1MJ6> #Runkeeper
- Just completed a 21.01 km run with @Runkeeper. Check it out! <https://t.co/1rfZO6pZpU> #Runkeeper
- Just completed a 4.66 km run with @Runkeeper. Check it out! <https://t.co/T4j6NWANNJ> #Runkeeper
- Just completed a 11.40 km walk with @Runkeeper. Check it out! <https://t.co/5BMMcaGDzJ> #Runkeeper
- Just posted a MySports Freestyle in 1:01:28 - TomTom MySports Watch <https://t.co/tv6pKRfYRo> #Runkeeper

# Question

What will (probably) be shown in the console?

```
favorite_pet = "dogs";  
  
var url = 'https://fakeapi.com/send_cats';  
fetch(url).then((response) => {  
  //sends back the string "cats"  
  console.log("I like " + favorite_pet);  
  response.json().then((pet) => {  
    favorite_pet = pet;  
    console.log("I like " + favorite_pet);  
  });  
});  
  
console.log("I like " + favorite_pet);
```

- A** I like dogs  
I like cats  
I like dogs
- B** I like dogs  
I like dogs  
I like dogs
- C** I like cats  
I like dogs  
I like dogs
- D** I like dogs  
I like dogs  
I like cats
- E** I like dogs  
I like cats  
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```

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I like cats  
I like dogs

**C** I like cats  
I like dogs  
I like dogs

**E** I like dogs  
I like cats  
I like cats

**B** I like dogs  
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I like dogs

**D** I like dogs  
I like dogs  
I like cats

A

0%

B

0%

C

0%

D

0%

E

0%

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I like cats  
I like cats

# Catching errors

- We can use the `.catch()` function to specify a callback that will occur if the promise is **rejected** (an error occurs).
  - This method will “catch” errors from all previous `.then()`s

```
getData(fooSrc)
  .then(firstCallback)
  .then(secondCallback)
  .catch(function(error) {
    //called if EITHER previous callback
    //has an error

    //param is object representing the error itself
    console.log(error.message);
  })
  .then(thirdCallback) //will only do this if
                       //no previous errors
```



# Multiple promises (concurrent)

- Because Promises are just commands to do something, we can wait for all of them to be done

```
var foo = fetch(fooUrl);  
var bar = fetch(barUrl);
```

```
//a promise for when all commands ready  
Promise.all(foo, bar)  
  .then(function(fooRes, barRes) {  
    //do something both both responses, e.g.,  
  
    return Promise.all(fooRes.json(), barRes.json());  
  
  })  
  .then(function(fooData, barData){  
    //now have both data sets!  
  })
```

# Today's goals

By the end of today, you should be able to...

- Explain how programs access web resources and common ways they respond
- Implement a fetch request to get a resource from a web API
- Use promises to make an asynchronous request

# IN4MATX 133: User Interface Software

## Lecture 8: AJAX, Fetch, & Promises