IN4MATX 133: User Interface Software

Lecture:
AJAX, Fetch, & Promises

Advanced JavaScript Quiz and Demo

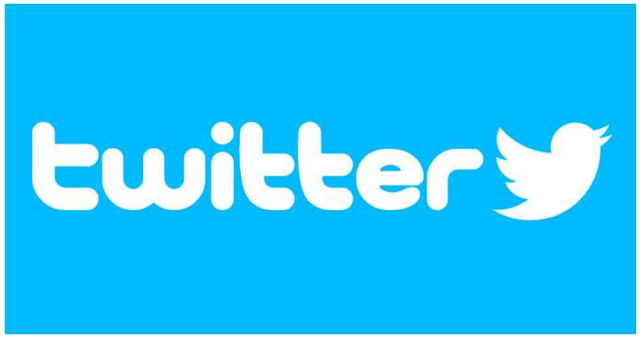
Goals for this Lecture

By the end of this lecture, 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
- Use async/await 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

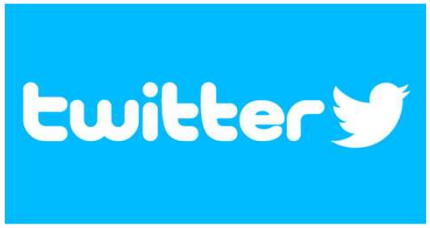
Application Programming Interface

- 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) {
//...
}
```

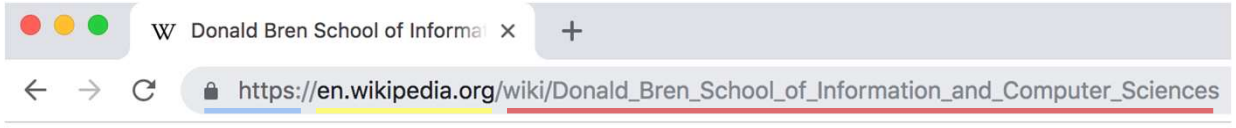
An interface

Web APIs



https://www.programmableweb.com/

Using the internet

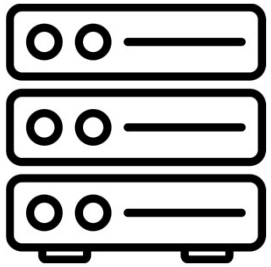


Protocol (how to handle info) Host (who has info) Resource (what info you want)

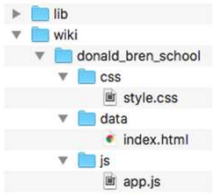
"Hey Wikipedia, I'd like to see the page for the school of ICS!"

Request

Response



Web server



Your browser

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

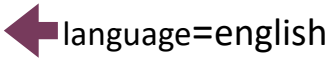
- Base URI:
  - How every API request for that API starts
  - `https://api.twitter.com/`
- Endpoint
  - Specific resources which can be accessed via that api
  - `1.1/search/tweets.json`
  - `1.1/status/filter.json`

Endpoints often contain an API version number

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

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`



"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

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>
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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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```
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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();
```
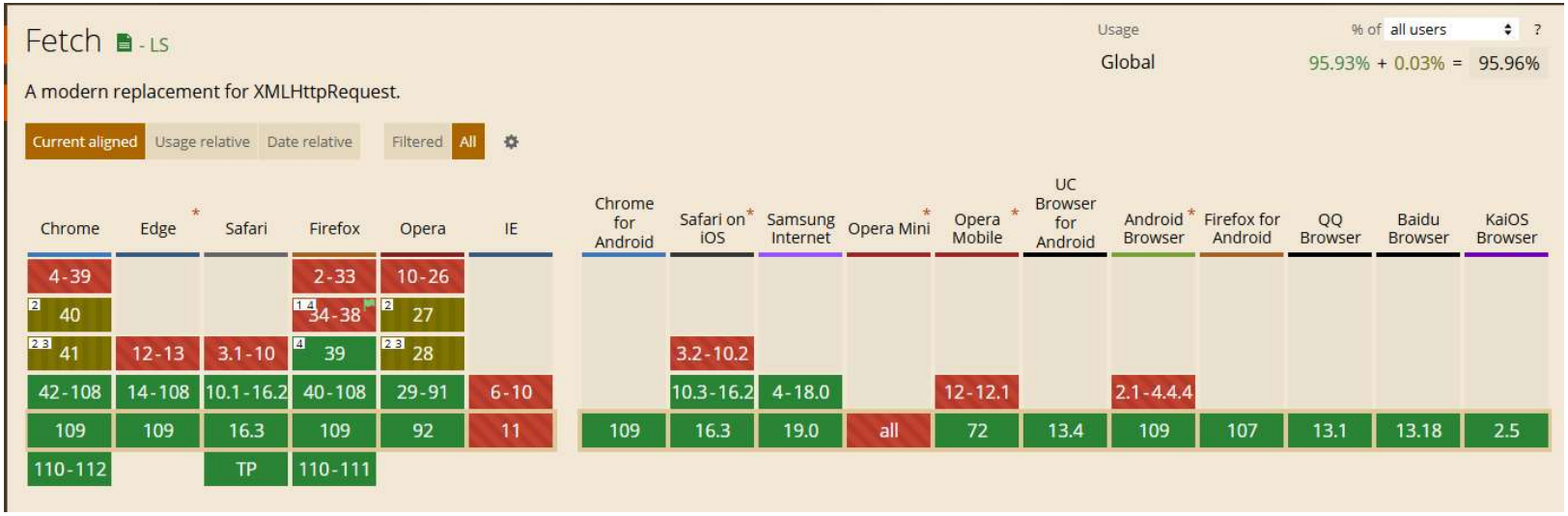

Fetch

- A new-ish, modern method for submitting XMLHttpRequests
- Included in most browsers (but not IE)



https://caniuse.com/fetch

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

https://css-tricks.com/using-fetch/

Using fetch

- For a `GET` request

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

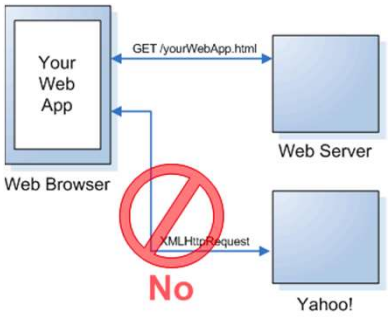
- For a `POST` request

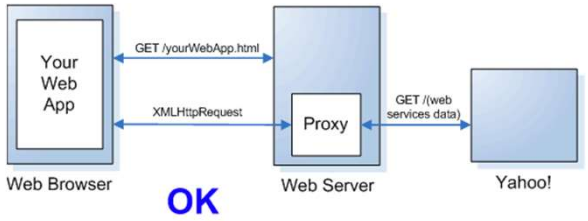
```
fetch('some-url', {
  method:'POST',
  headers: {'Content-Type': 'application/json'},
  body: JSON.stringify(data-to-send)
});
```

https://css-tricks.com/using-fetch/

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





https://en.wikipedia.org/wiki/Same-origin_policy

Same-origin policy

- Two browser tabs: A bank app open in one, an evil app in the other
  - Both run JavaScript scripts written by their source
- 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 information
  - Different tabs, but both running with the same JavaScript engine

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

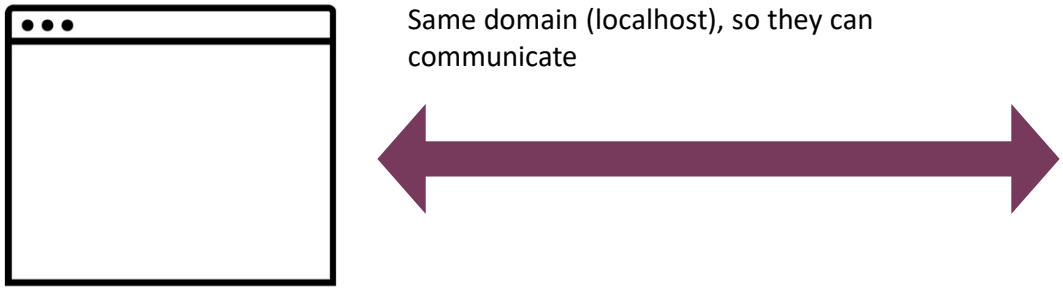
Same-origin policy

- So instead, the bank app can only talk to the bank server, and the evil app can only talk to the evil server
- 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 this in your browser, but probably shouldn't

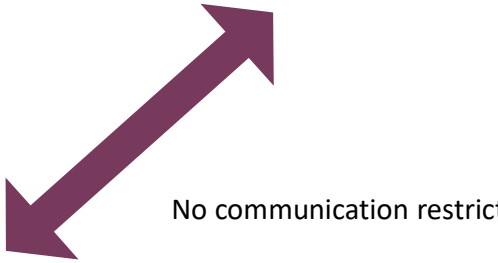
https://security.stackexchange.com/questions/8264/why-is-the-same-origin-policy-so-important

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

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

Does **NOT** return the data

(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
- A promise will exist in one of three states:
  - Pending – initial state
  - Fulfilled – operation successfully completed
  - Rejected – operation failed

```
//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);
}

//when fulfilled, execute the callback function
//(which will be passed the fetched data)
var promise = fetch(url);
promise.then(successCallback, rejectCallback);

//more common to use anonymous variables/callbacks:
fetch(url).then(function(response) {
    console.log(response);
});
```

Callback will be passed the request response

Optional parameter

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();
var promiseB = promiseA.then(makeString);
var promiseC = promiseB.then(makeUpper);
promiseC.then(function(data) {
    console.log(data);
};
```

When completed, promiseA => json data

promiseB => comma-separated string

promiseC => uppercase string

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
    });
```

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!
  })
```

Promise Demo

But wait, there’s more!

Async/Await

- Alternative mechanism to Promise/then
- Streamlines the Promise/then approach:
  - Improved readability and maintainability
  - More straightforward error handling (cleaner use of try/catch)
  - Debugging is simplified due to linear code execution
  - Linear execution is easier to reason about
- Usage largely depends on type of asynchronous requests that your application makes, development ecosystem, and organizational preferences

Async/Await

- Using async/await, the fetch and data processing occurs in an asynchronous function that will **await** the results.
- Applying a try/catch block handles any potential errors that may occur during the fetch operation.

```
async function getData(){
    try {
      const response = await fetch(uri);
      const data = await response.json();

    } catch (error){
    //do something with error
}

getData();
```

Async/Await Demo

Goals for this Lecture

By the end of this lecture, 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
- Use async/await to make an asynchronous request