IN4MATX 133: User Interface Software

Lecture:
AJAX, Fetch, & Promises

Goals for this Lecture

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

- Differentiate the roles of arrays and associative arrays
- Implement functional programming concepts in JavaScript like forEach, map, and filter
- 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

Socrative Quiz!

Enter your UCI Email when prompted name!!!
e.g.,

xxxxx@uci.edu

https://api.socrative.com/rc/CvereT

A bit more about JavaScript

Accessing properties

Values (or properties) can be referenced with the array[] syntax

```
ages = {alice:40, bob:35, charles:13}

//access ("look up") values
console.log( ages['alice'] ); //=> 40
console.log( ages['bob'] ); //=> 35
console.log( ages['charles'] ); //=> 13

//keys not in the object have undefined values
console.log( ages['fred']); //=> undefined

//assign values
ages['alice'] = 41;
console.log( ages['alice'] ); //=> 41

ages['fred'] = 19; //adds the key and assigns
                   //a value to it
```

Accessing properties

Values can also be referenced with dot notation

```
var person = {
  firstName: 'Alice',
  lastName: 'Smith',
  favorites: {
    food: 'pizza',
    numbers: [12, 42]
  }
};

var name = person.firstName; //get value of 'firstName' key
person.lastName = 'Jones'; //set value of 'lastName' key
console.log(person.firstName+' '+person.lastName); //"Alice Jones"

var topic = 'food'
var favFood = person.favorites.food; //object in the object
              //object           //value

var firstNumber = person.favorites.numbers[0]; //12
person.favorites.numbers.push(7); //push 7 onto the Array
```

Functions

Functions in JavaScript are like static methods in Java

```
//Java
public static String sayHello(String name){
    return "Hello, "+name;
}
public static void main(String[] args){
    String msg = sayHello("IN4MATX 133");
}
```

Parameters have no type

```
//JavaScript
function sayHello(name){
    return "Hello, "+name;
}
```

Parameters are comma-separated

No access modifier or return type

```
var msg = sayHello("IN4MATX 133");
```

Functions

In Javascript, all parameters are optional

```
function sayHello(name)
{
    return "Hello, "+name;
}

//expected; parameter is assigned a value
sayHello("In4MATX 133"); //"Hello, IN4MATX 133"

//parameter not assigned value (left undefined)
sayHello(); //"Hello, undefined"

//extra parameters (values) are not assigned
//to variables, so are ignored
sayHello("IN4MATX","133"); //"Hello, IN4MATX"
```

Now for the confusing part…

Functions are objects

```
//assign array to variable
var myArray = ['a','b','c'];


var other = myArray;

//access value in other
console.log( other[1] ); //print 'b'
```

```
//assign function to variable
function sayHello(name) {
   console.log("Hello, "+name);
}

var other = sayHello;

//prints "Hello, everyone"
other('everyone');
```

Functions are objects

```
//assign array to variable
var myArray = ['a','b','c'];



var other = myArray;

//access value in other
console.log( other[1] ); //print 'b'
```

```
//assign function to variable
var sayHello = function(name) {
   console.log("Hello, "+name);
}

//second variable, same object
var greet = sayHello;

//execute object named `greet`
greet('everyone');
    //prints "Hello, everyone"
```

Functions are objects

```
var obj = {};
var myArray = ['a','b','c'];


//assign array to object
obj.array = myArray;

//access with dot notation
obj.array[0]; //gets 'a'


//assign literal (anonymous value)
obj.otherArray = [1,2,3]
```

```
var obj = {}
function sayHello(name) {
   console.log("Hello, "+name);
}

//assign function to object
var obj.sayHi = sayHello;

//access with dot notation
obj.sayHi('all'); //prints "Hello all"


//assign literal (anonymous value)
obj.otherFunc = function() {
    console.log("Hello world!");
}
```

How “non-static” methods are made

Anonymous variables

```
var array = [1,2,3]; //named variable (not anonymous)
console.log(array); //pass in named var

console.log( [4,5,6] ); //pass in anonymous value
```

Anonymous variables

```
//named function
function sayHello(person){
   console.log("Hello, "+person);
}

//anonymous function (no name!)
function(person) {
   console.log("Hello, "+person);
}

//anonymous function (value) assigned to variable
var sayHello = function(person) {
   console.log("Hello, "+person);
}
```

Anonymous variables

```
//anonymous functions often follow
an “arrow” (abbreviated) syntax
var sayHello = (person) => {
   console.log("Hello, "+person);
}

sayHello('IN4MATX 133');
```

this keyword

- this usually refers to the object that the method was called on
- this is only preserved with abbreviated (arrow) syntax

```
var alice = {
  first: 'Alice',
  last: 'Jones',
  sayHello:()=> {
    console.log("Hello, I'm " + this.first);
  }
};
```

Refers to containing object (alice)

```
alice.sayHello(); //=> "Hello, I'm Alice"
```

Passing functions

Since functions are objects, they can be passed like variables

```
//anonymous function syntax
var doAtOnce = function(funcA, funcB) {
    funcA();
    console.log(' and ');
    funcB();
    console.log(' at the same time! ');
}

var patHead = function(name) {
    console.log("pat your head");
}

var rubBelly = function(name) {
    console.log("rub your belly");
}
```

No parens … (),
just passing variable

```
doAtOnce(patHead, rubBelly);
```

Callback functions

- A function that is passed to *another* function for it to “call back to” and execute

```
function doLater(callback) {
  console.log("I'm waiting a bit...");
  console.log("Okay, time to work!");
  callback();
}
```

Takes in a callback

```
function doHomework() {
  ...
};

doLater(doHomework);
```

Pass in the callback function

Callback function example: `forEach`

- To iterate through each item in a loop, use the `forEach` function and pass it a function to call on each array item

```
//Iterate through an array
var array = ['a','b','c'];
var printItem = function(item) {
   console.log(item);
}

array.forEach(printItem);  ⬅Callback

//more common to use anonymous function
array.forEach(function(item) {
   console.log(item);
});
```

Callback function example: `map`

- `map` applies the function to each element in an array and returns a *new* array of elements returned by the function

```
var array = [1,2,3];
var squared = function(n) {
   return n*n;
};

array.map(squared); //returns [1,4,9]

//more common to do this inline:
array.map(function(n) {
   return n*n;
});
```

Callback function example: `filter`

- `filter` applies the function to each element in an array and returns a *new* array of only the elements for which the function returns true.

```
var array = [3,1,4,2,5];

var isACrowd = array.filter(function(n) {
   return n >= 3;
}); //returns [3,4,5]
```

Callback function example: `reduce`

- `reduce` applies the function to each element in an array to update an “accumulator” value. The callback function should return the “updated” value for the accumulator.

```
var array = [1,2,3,4];

var sum = array.reduce(function(total, current) {
   var newTotal = total + current;
   return newTotal;
}, 0); //returns 1+2+3+4=10
```

Requesting Data on the Web

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

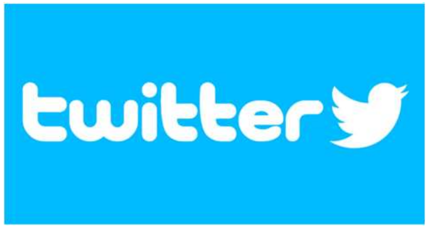
Application Programming Interface

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

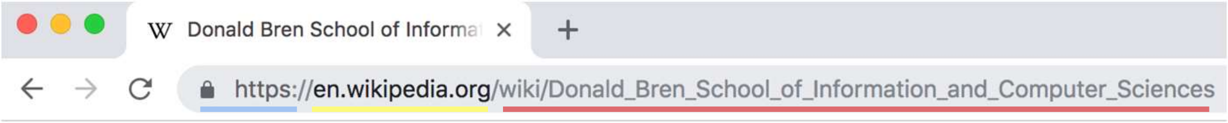
An interface

Web APIs



https://www.programmableweb.com/

Using the internet

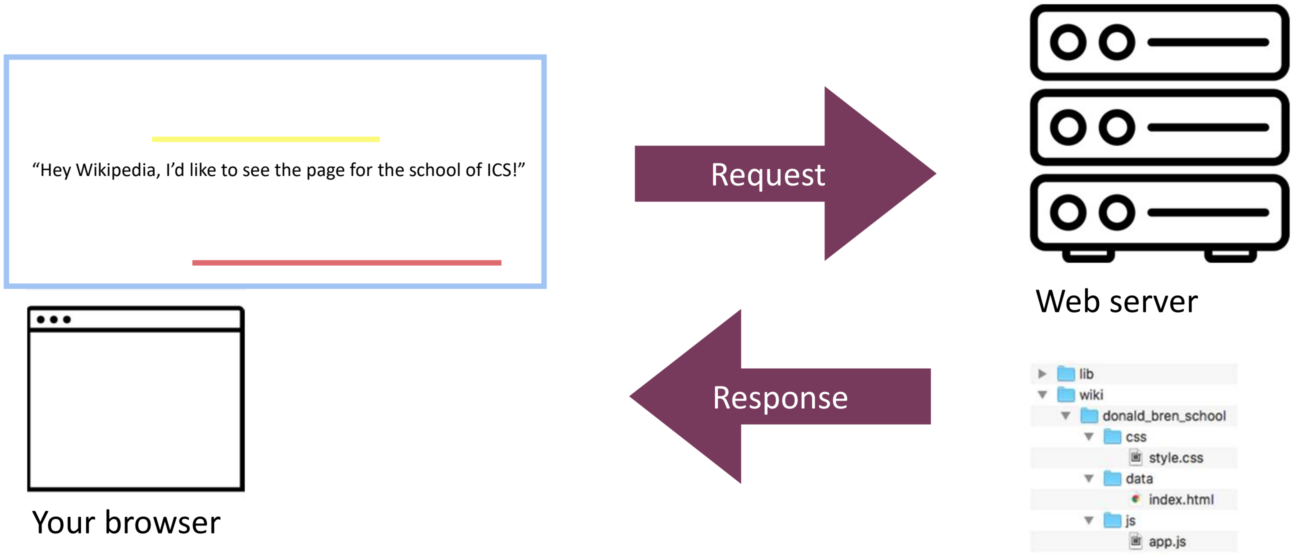


https://en.wikipedia.org/wiki/Donald_Bren_School_of_Information_and_Computer_Sciences

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!”

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`

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)

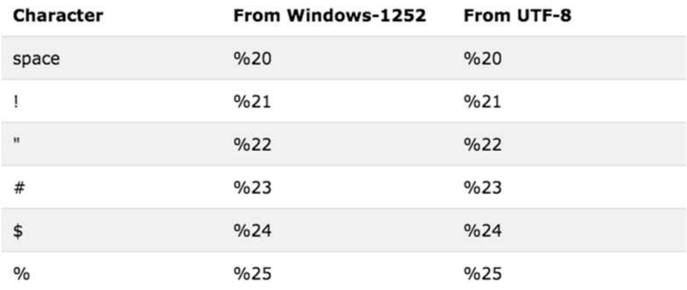
https://www.restapitutorial.com/httpstatuscodes.html

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

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

```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>
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    <description>
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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

```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"
    },
    {
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      "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

AJAX

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

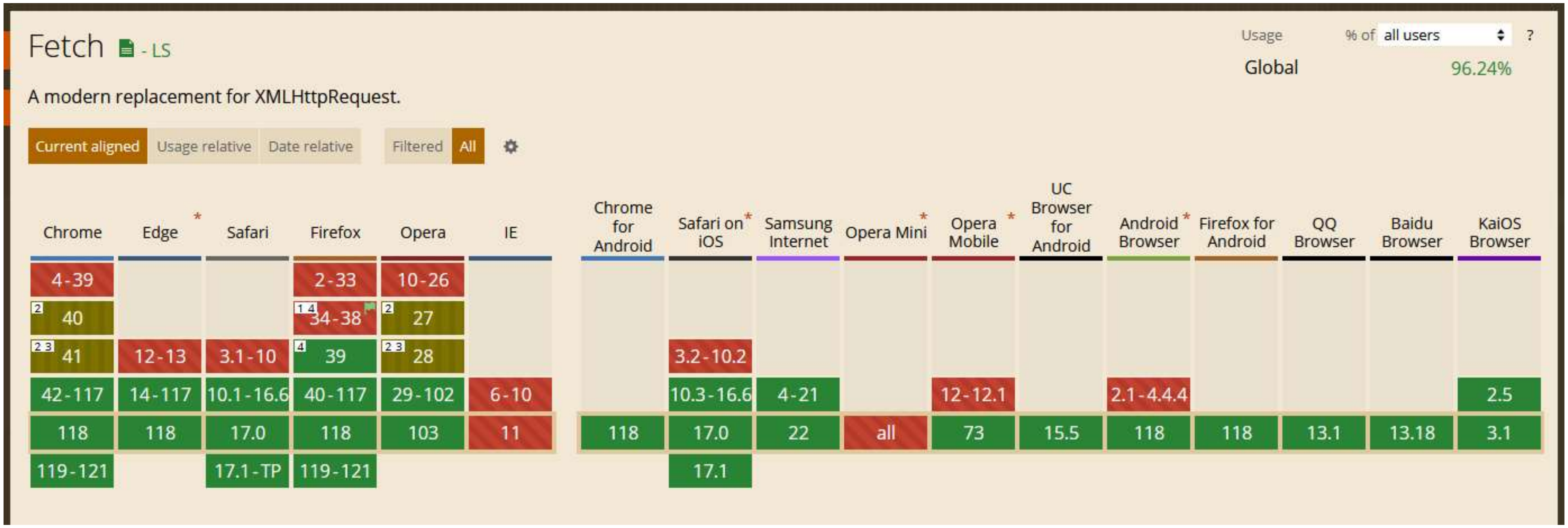
- AJAX requests are built into a browser-provided object called `XMLHTTPRequest`

```
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();
```

Fetch

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



Fetch - LS

Usage | % of all users | ?

Global 96.24%

A modern replacement for XMLHttpRequest.

Chrome	Edge *	Safari	Firefox	Opera	IE	Chrome for Android	Safari on iOS *	Samsung Internet	Opera Mini *	Opera Mobile *	UC Browser for Android	Android Browser *	Firefox for Android	QQ Browser	Baidu Browser	KaiOS Browser
4-39			2-33	10-26												
[2] 40			[1 4] 34-38	[2] 27												
[2 3] 41	12-13	3.1-10	[4] 39	[2 3] 28			3.2-10.2									
42-117	14-117	10.1-16.6	40-117	29-102	6-10		10.3-16.6	4-21		12-12.1		2.1-4.4.4				2.5
118	118	17.0	118	103	11	118	17.0	22	all	73	15.5	118	118	13.1	13.18	3.1
119-121		17.1-TP	119-121				17.1									

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');
```

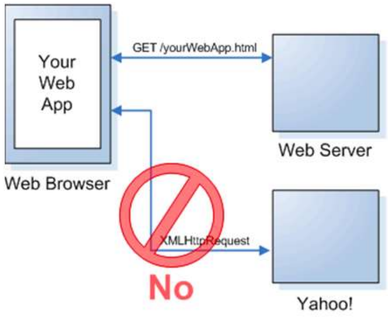
- For a `POST` request

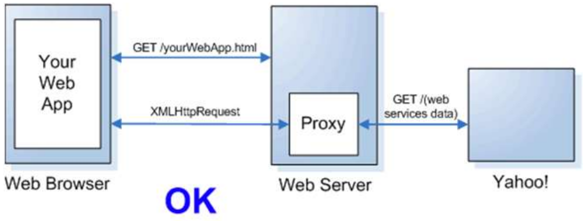
```
fetch('some-url', {
 method:'POST',
 headers: {'Content-Type': 'application/json'},
 body: JSON.stringify(data-to-send)
});
```

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

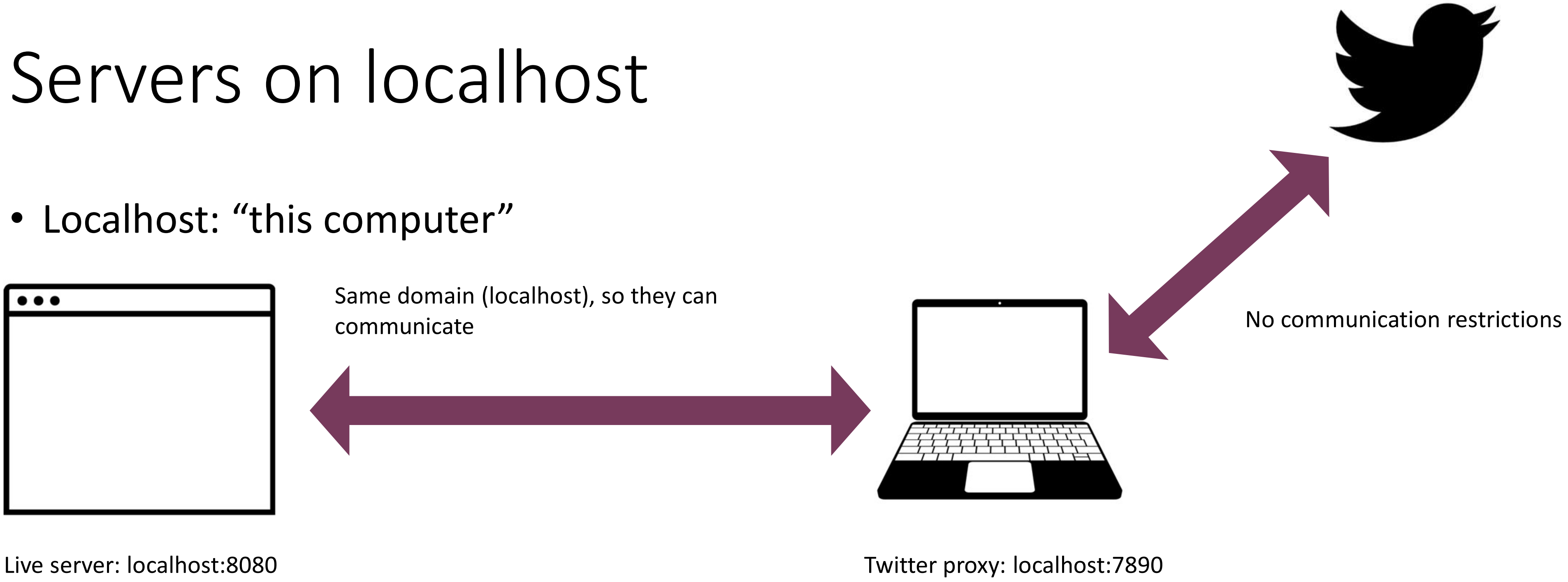
Same-origin policy

- 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);   ⬅ 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);
});
```

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?
});
```

Not the data

Another promise

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!
  })
```

Goals for this Lecture

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

- Differentiate the roles of arrays and associative arrays
- Implement functional programming concepts in JavaScript like forEach, map, and filter
- 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