Controller/server communication

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Controller's role in Model, View, Controller

- Controller's job to fetch model for the view
  - May have other server communication needs as well (e.g. authentication services)

- Browser is already talking to a web server, ask it for the model

- Early approach: have the browser do a HTTP request for the model
  - First people at Microsoft liked XML so the DOM extension got called: XMLHttpRequest

- Allowed JavaScript to do a HTTP request without inserting DOM elements

- Widely used and called **AJAX - Asynchronous JavaScript and XML**

- Since it is using an HTTP request it can carry XML or anything else
  - More often used with JSON
**Sending a Request**

```javascript
xhr = new XMLHttpRequest();
xhr.onreadystatechange = xhrHandler;
xhr.open("GET", url);
xhr.send();
```

Any HTTP method (GET, POST, etc.) possible.

Responses/errors come in as events

**Event handling**

```javascript
function xhrHandler(event) {
    // this === xhr
    if (this.readyState != 4) { // DONE
        return;
    }
    if (this.status != 200) { // OK
        return; // Handle error ...
    }
    ...  
    let text = this.responseText;
    ...
```
XMLHttpRequest event processing

- Event handler gets called at various stages in the processing of the request

  0  UNSENT       open() has not been called yet.
  1  OPENED      send() has been called.
  2  HEADERS_RECEIVED send() has been called, and headers and status are available.
  3  LOADING     Downloading; responseText holds partial data.
  4  DONE        The operation is complete.

- Response available as:
  - raw text - responseText
  - XML document - responseXML

- Can set request headers and read response headers
Traditional AJAX uses patterns

- Response is HTML
  
  ```javascript
  elem.innerHTML = xhr.responseText;
  ```

- Response is JavaScript
  
  ```javascript
  eval(xhr.responseText);
  ```

Neither of the above are the modern JavaScript framework way:

- Response is model data (JSON frequently uses here)
  
  ```javascript
  JSON.parse(xhr.responseText);
  ```
Fetching models with XMLHttpRequest

- Controller needs to communicate in the request what model is needed
- Can encode model selection information in request in:

URL path: 
```
xhr.open("GET","userModel/78237489/fullname");
```

Query params: 
```
xhr.open("GET","userModel?id=78237489&type=fullname");
```

Request body: 
```
xhr.open("POST", url);
xhr.setRequestHeader("Content-type",
        "application/x-www-form-urlencoded");
xhr.send("id=78237489&type=fullname");
```
REST APIs

- **REST** - **re**presentational **st**ate **tr**ansfer

- Guidelines for web app to server communications

- 2000 PhD dissertation that was highly impactful
  - Trend at the time was complex Remote Procedure Calls (RPCs) system
  - Became a must have thing: Do you have a REST API?

- Some good ideas, some not so good
  - Doesn't work for everything
Some RESTful API attributes

- **Server should export resources to clients using unique names (URIs)**
  - Example: `http://www.example.com/photo/` is a collection
  - Example: `http://www.example.com/photo/78237489` is a resource

- **Keep servers "stateless"**
  - Support easy load balancing across web servers
  - Allow caching of resources

- **Server supports a set of HTTP methods mapping to Create, Read, Update, Delete (CRUD) on resource specified in the URL**
  - GET method - Read resource (list on collection)
  - PUT method - Update resource
  - POST method - Create resource
  - DELETE method - Delete resource
REST API design

- Define the **resources** of the service and give them unique names (URIs)
  - Example: Photos, Users, Comments, ...
- Have clients use a CRUD operations using HTTP methods
- Extend when needed (e.g. transaction across multiple resources)
React accessing RESTful APIs

- React has no opinion. Prefer something higher level than XMLHttpRequest
  - Example: `DoHTTPRequest(HTTP_METHOD, body, doneCallback)`

- Popular: Axios - Promise based HTTP client for the browser and node.js
  - Wrapper around XMLHttpRequest

- REST Read (GET of URL): `result = axios.get(URL);`

- REST Create (POST to URL): `result = axios.post(URL, object);`
  - JSON encoding of object into body of POST request

- Similar patterns for REST Update (PUT) and REST Delete (DELETE)
Axios handling of HTTP responses

```javascript
result = axios.get(URL); // Note: no callback specified! It's a Promise

result.then((response) => {
    // response.status - HTTP response status (e.g. 200)
    // response.statusText - HTTP response status text (e.g. OK)
    // response.data - Response body object (JSON parsed)
})
  .catch((err) => {
    // err.response.{status, data, headers} - Non-2xxx status
    // if !err.response - No reply, can look at err.request
  });
```
Minor Digression - Promises
Callbacks have haters - out of order execution

fs.readFile(fileName, function (error, fileData) {
    console.log("Got error", error, "Data", fileData);
});
console.log("Finished reading file");

What order to the console.log statements appear?
callbacks have haters - pyramid of doom

fs.readFile(fileName, function(error, fileData) {
  doSomethingOnData(fileData, function(tempData1) {
    doSomethingMoreOnData(tempData1, function(tempData2) {
      finalizeData(tempData2, function(result) {
        // Called Pyramid of Doom
        doneCallback(result);
      });
    });
  });
});

- An alternative to pyramid: Have each callback be an individual function
  - Sequential execution flow jumps from function to function - not ideal
Same code without pyramid: Control jumps around

```javascript
fs.readFile(fileName, readDone);

function readDone(error, fileData) {
  doSomethingOnData(fileData, doSomeDone);
}

function doSomeDone (someData) {
  doSomethingMoreOnData(someData, doSomeMoreDone);
}

function doSomeMoreDone (someMoreData) {
  finalizeData(someMoreData, doneCallback);
}
```
Idea behind promises

- Rather than specifying a done callback
  
  ```javascript
doSomething(args, doneCallback);
  ```

- Return a promise that will be filled in when done
  
  ```javascript
  var donePromise = doSomething(args);
  ```
  
  `donePromise` will be filled in when operation completes

- Doesn't need to wait until you need the promise to be filled in

- Still using callbacks under the covers
then() - Waiting on a promise

- Get the value of a promise (waiting if need be) with `then`.

```javascript
donePromise.then(function (value) {
    // value is the promised result when successful
}, function (error) {
    // Error case
});
```
Example of Promise usage

- axios.get() returns a promise

```javascript
axios.get(url).then(function(response) {
    var ok = (response.status === 200);
    doneCallback(ok ? response.data : undefined);
}, function(response) {
    doneCallback(undefined);
});
```
Promises

```javascript
var myFile = myReadFile(fileName);
var tempData1 = myFile.then(function (fileData) {
    return doSomethingOnData(fileData);
});
var finalData = tempData1.then(function (tempData2) {
    return finalizeData(tempData2);
});
return finalData;
```

- Note no **Pyramid of Doom**
- Every variable is a promise
  - A standard usage: Every variable - If *thenable* call `then()` on it otherwise just use the variable as is.
Chaining promises

return myReadFile(fileName)
    .then(function (fileData) { return doSomethingOnData(fileData); })
    .then(function (data) { return finalizeData(data); })
    .catch(errorHandlingFunc);

- Add in ES6 JavaScript arrow functions:

return myReadFile(fileName)
    .then((fileData) => doSomethingOnData(fileData))
    .then((data) => finalizeData(data))
    .catch(errorHandlingFunc);
Going all in on promises

```javascript
function doIt(fileName) {
    let file = ReadFile(fileName);
    let data = doSomethingOnData(file);
    let moreData = doSomethingMoreOnData(data);
    return finalizeData(moreData);
}

- All reads of variables become "then" calls:

  myVar becomes myVar.then( fn => ...)
```
Promises vs Callbacks

- Easy to go from Promise to Callback: Just call `.then(callbackFunc)`
  - `axios.get(url).then(callback)`

- Going from Callback to Promise requires creating a Promise
  ```javascript
  var newPromise = new Promise(function (fulfill, reject) {
    // calls fulfill(value) to have promise return value
    // calls reject(err) to have promise signal error
  });
  ```
Converting callbacks to Promises

function myReadFile(filename) {
    return new Promise(function (fulfill, reject) {
        fs.readFile(filename, function (err, res) {
            if (err)
                reject(err);
            else
                fulfill(res);
        });
    });
}
Language support: async and await keywords

- async function - Declare a function to return a Promise
  
  ```javascript
  async function returnOne() { // returns a Promise
    return 1;
  }
  ```

- await - Resolve the promise and returns its value
  
  ```javascript
  let one = await returnOne();
  console.log(one);              // Prints 1
  ```

- await only valid inside of async function functions
async and await makes it easier to use promises

```javascript
async function doIt(fileName) {
    let file = await ReadFile(fileName);
    let data = await doSomethingOnData(file);
    let moreData = await doSomethingMoreOnData(data);
    return finalizeData(moreData);
}
```

- file, data, moreData can be regular variables, not forced to be promises
- doIt() does return a promise
async and await still breaks into functions

```javascript
function doIt(fileName) {
    let file, data moreData;
    file = ReadFile(fileName, f1);
    return newPromise();
    f1() => { data = doSomethingOnData(file, f2); }
    f2() => { moreData = doSomethingMoreOnData(data, f3); }
    f3() => { finalizeData(moreData, (e) => resolvePromise(e); }
}
```
End Digression
Other Transports: HTML5 WebSockets

- Rather than running over HTTP, HTML5 brings sockets to the browser
  - TCP connection from JavaScript to backend Web Server - Bidirectional pipes

- Event-based interface like XMLHttpRequest:
  ```javascript
  var socket = new WebSocket("ws://www.example.com/socketserver");
  socket.onopen = function (event) {
    socket.send(JSON.stringify(request));
  };

  socket.onmessage = function (event) {
    JSON.parse(event.data);
  };
  ```
Remote Procedure Call (RPC)

- Traditional distributed computation technology supporting calling of a function on a remote machine.
  - Browser packages function's arguments into a message to the web server.
  - Function is invoked with the arguments on the server.
  - Function's return value is sent back to the browser.

- Allows arbitrary code to be run on server - handles complex, multiple resource operations
  - Reduces number of round trip messages and makes failure handling easier.

- Can result in more complex to use interface compared to REST
  - Need to document the API (i.e. functions and calling sequence)

- RPC can be done over HTTP (e.g. POST) or WebSockets
Trending approach: GraphQL

- Standard protocol for backends from Facebook
  - Like REST, server exports resources that can be fetched by the web app
  - Unlike REST
    - Server exports a "schema" describing the resources and supported queries.
    - Client specifies what properties of the resource it is interested in retrieving.
    - Can fetch from many different resources in the same request (i.e. entire model in one query).

- Update operations specified in the exported schema
  - Allows an RPC-like interface

- Gaining in popularity particularly compared to REST
  - Gives a program accessible backend - Application Programming Interface (API)