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 switching page

- 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
XMLHttpRequest

Sending a Request

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

function xhrHandler() {
    if (this.readyState != 4) { // DONE
        return;
    }
    if (this.status != 200) { // OK
        // Handle error ... return;
    }
    var 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
  
  `elem.innerHTML = xhr.responseText;`

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

Neither of the above are the modern JavaScript framework way:

- Response is model data (JSON frequently uses here)
  
  `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 - representational state transfer
- 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

```javascript
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

```javascript
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
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:

  ```javascript
  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 keyword

- 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
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
- 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)