Lab 1: Introduction to JavaScript, Node.js and API's

1 Purpose of this lab

This lab is split into two parts. In the first part, we introduce JavaScript and Node. JavaScript is the default scripting language used in all standard web browsers (e.g. Chrome, Safari, Firefox, even Internet Explorer) and is therefore the language for implementing the majority of web applications. Node brings the power of JavaScript to the server-side of an application. Consequently, JavaScript can be used on both the client-side and server-side of a web application. In the second part of this lab, we begin to look at how to use Node to implement API's.

This lab looks long, but it's mostly due to the amount of theory you need to be aware of to get started. Subsequent labs will be more practical based and will require less reading.

2 Overview to JavaScript

Taken from: https://developer.mozilla.org/en-US/docs/Web/JavaScript/Guide/Introduction

JavaScript is a cross-platform, object-oriented scripting language. It is a small and lightweight language. Inside a host environment (for example, a web browser), JavaScript can be connected to the objects of its environment to provide programmatic control over them.

JavaScript contains a standard library of objects, such as Array, Date, and Math, and a core set of language elements such as operators, control structures, and statements. Core JavaScript can be extended for a variety of purposes by supplementing it with additional objects; for example:

- Client-side JavaScript extends the core language by supplying objects to control a browser and its Document Object Model (DOM). For example, client-side extensions allow an application to place elements on an HTML form and respond to user events such as mouse clicks, form input, and page navigation.
- Server-side JavaScript extends the core language by supplying objects relevant to running JavaScript on a server. For example, server-side extensions allow an application to communicate with a database, provide continuity of information from one invocation to another of the application, or perform file manipulations on a server. Node is the primary server-side Javascript implementation used today.

Throughout this course we will be using JavaScript for the majority of the exercises. Specifically, we will be using the ES2015 standard. If you are new to JavaScript and/or the ES2015 standard then you should take some time now to familiarise yourself. There is an abundance of information available online.

Below are some useful resources:

- https://developer.mozilla.org/en-US/docs/Web/JavaScript
- https://leanpub.com/understandinges6
- https://developers.google.com/web/fundamentals/getting-started/
- https://leanpub.com/understandinges6

- http://exploringjs.com/
- https://leanpub.com/es6-in-practice
- http://javascript.crockford.com/
- https://github.com/ericdouglas/ES6-Learning#articles--tutorials

3 What is Node.js?

From their website (nodejs.org):

"Node.js® is a JavaScript runtime built on Chrome's V8 JavaScript engine. Node.js uses an event-driven, non-blocking I/O model that makes it lightweight and efficient. Node.js' package ecosystem, npm, is the largest ecosystem of open source libraries in the world."

But what does this mean? Let's break it down:

"Node.js® is a JavaScript runtime built on Chrome's V8 JavaScript engine."

V8 compiles and executes JavaScript source code, handles memory allocation for objects, and garbage collects objects it no longer needs. JavaScript is most commonly used for client-side scripting in a browser, being used to manipulate Document Object Model (DOM) objects for example. The DOM is not, however, typically provided by the JavaScript engine but instead by a browser. So V8, as a pure Javascript engine, does not include any methods for DOM manipulation. V8 does however provide all the data types, operators, objects and functions specified in the ECMA standard. http://node.green/ shows exactly which ES2015 features are supported by each Node version. It shows that version 6.4.0 and above have the best support.

"Node.js uses an event-driven, non-blocking I/O model that makes it lightweight and efficient."

Event driven: "In computer programming, event-driven programming is a programming paradigm in which the flow of the program is determined by events such as user actions (mouse clicks, key presses), sensor outputs, or messages from other programs/threads." - https://en.wikipedia.org/wiki/Event-driven_programming

Non-blocking: Read a short blog post on the difference between blocking and non-blocking code at: https://medium.com/@hengkiardo/blocking-versus-non-blocking-code-d3bde835062f

"Node.js' package ecosystem, npm, is the largest ecosystem of open source libraries in the world."

NPM: "npm , short for Node Package Manager, is two things: first and foremost, it is an online repository for the publishing of open-source Node projects; second, it is a command-line utility for interacting with said repository that aids in package installation, version management, and dependency management." - https://docs.nodejitsu.com/articles/getting-started/npm/what-is-npm/

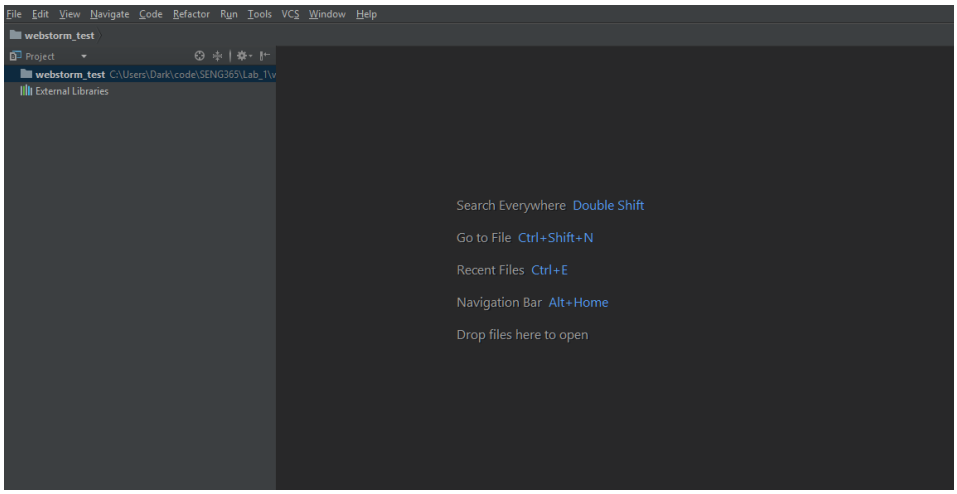
3.1 Before we start: Running scripts in WebStorm

Many of the seasoned JavaScript developers amongst you may already have a preferred workflow for writing web applications. For those of you who do not, then we recommend using the WebStorm IDE. Webstorm is simple to use and already installed in the labs. For any of you wishing to use

Webstorm on your personal machines, then you get a free version using your university email account (you may have to reconfirm that you are a student each year).

Running scripts on Webstorm is easy:

1. Open Webstorm
2. Select **Create New Project**
3. Create an empty project (make sure to rename your project first and provide a project path). The IDE will open your project directory, as shown below:



4. Right click on your project directory and select: **New → JavaScript File**
5. When prompted for a filename, call it **test.js**
6. Your new file will open, copy and paste the below code into it:

```
console.log('Hello!');
```

7. Run your script by **right-clicking** and clicking **Run 'test.js'** or using the shortcut SHIFT + F10. **Alternatively:** you can run your scripts by opening your terminal (View > Tool Windows > Terminal) and entering the command **node test.js**

Read more: https://www.jetbrains.com/help/webstorm/quick-start-guide.html

Note: *You may need to set up Webstorm to validate ES2015 code. To do this go to: File → Settings → Languages & Frameworks → JavaScript and set the JavaScript Language Version to be* ***ECMAScript 6****. (For Mac users, you may need to navigate through a slightly different menu structure.)*

3.2 Getting Started: Download and installation *(if using a personal computer)*

1. Download the latest version of Node from http://nodejs.org
2. Run the downloaded file and navigate through the wizard.
3. Confirm the installation by opening your terminal and typing 'node.' You should be presented with the node prompt ('>').

4. Confirm that node has installed correctly by moving onto Exercise 1.

3.3 Exercise 1: Hello World

1. Create a file named **exercise1.js** on your machine
2. Open the file and insert the following code

```
/* Hello, World! program in node.js */
console.log('Hello, World!');
```

3. Open your terminal, navigate to the directory where your file was created and type: **node exercise1.js**
4. If node was successfully installed, 'Hello, World!' should be outputted to the console.

3.4 Exercise 2: Write a Web Server

In Node, we load modules into other modules using the **require** directive. (cf. 'import' in Python).

1. Create a new file called **exercise2.js**
2. Use the **require** directive to import the **http** module into a variable for later use.

```
const http = require('http');
```

Note: *You may see Webstorm put a yellow underline on the require function and on hover say "Unresolved function or method require()". This means you need to enable Node.js coding assistance. To do this, go to: File → Settings → Languages & Frameworks → Node.js and NPM and tick the "Coding assistance for Node.js" box.*

3. Now use the **http** module's **createServer** function to create a new server. The example code below ignores the content of any request given and instead will just return a 200 (OK) response with the text "Hello World".

```
http.createServer((request, response) => {
   // Send the HTTP header
   // HTTP Status: 200 (OK)
   // Content Type: text/plain
   response.writeHead(200, {'Content-Type': 'text/plain'});

   // Send the response body as "Hello World"
   response.end('Hello World\n');
}).listen(8081);

console.log('Server running at http://127.0.0.1:8081/');
```

The documentation for the **createServer** function can be found at:
https://nodejs.org/api/http.html#http_http_createserver_requestlistener

4. Open your terminal and run: **node exercise2.js**

5. Open your browser and navigate to http://localhost:8081 or http://127.0.0.1:8081

3.5 Exercise 3: Handling URL parameters

Next we want to be able to retrieve URL parameters so that we can use them in our applications. Read https://en.wikipedia.org/wiki/Query_string for an explanation of what URL parameters are and their syntax.

1. Make a copy of your exercise2.js file and call it **exercise3.js**
2. Use the require directive to import the **URL class** from the **url module**. This module allows us to easily parse URLs.

```
const http = require('http');
const URL = require('url').URL;
```

3. Next, edit the contents of your **createServer** function. Now whenever we receive a request, we will parse the URL to retrieve its **searchParams**. We will then return a 200 HTTP response with the parameters we found in the response body. Essentially we are "parroting" the request back to the user.

```
http.createServer((request, response) => {
   const url = new URL(request.url, 'http://localhost');
   const parameters = url.searchParams;

   // Write the response
   response.writeHead(200, {
       'Content-Type': 'text/plain'
   });

   response.end(`Here is your data: ${parameters}`);
}).listen(8081);
```

4. Again, run your server and then go to your browser and navigate to localhost:8081. Add parameters to your URL and they should be shown in your browser (e.g. http://localhost:8081?name=Jake&age=35).

3.6 Exercise 4: Putting it all into practice

In this exercise, we will create a server that contains a shopping list. When a user navigates to the server with the parameter **itemNum** set, the server will respond with the name of the item at the specified index of **itemNum**.

1. Create a new file called **exercise4.js**
2. Import the **http** and **url** modules
3. Create a constant that contains a list of item names that are typical of a shopping basket (e.g. milk, bread, eggs, flour).
4. Create a server, and inside it parse the URL for the parameters.
5. Find out how you can get the value of a specific named parameter (hint: you can select any variable and press **CTRL + Q** to find out its inferred type. You can also **CTRL + Left-Click** to jump to its definition and find out what that type can do).
6. Use this to find the value of **itemNum**, and retrieve this parameter's value, i.e. the name at index **itemNum** in the list.

7. Return a 200 HTTP response that sends back to the browser the **name** of the item in the list at position **itemNum**.
8. Test your server by going to localhost:8081?itemNum=2. It should print out something along the lines of "You selected item 2: eggs".

Now that we have created a simple web application, let's look at creating our first API.

4 Creating an API in Node

4.1 Data formats e.g. JSON

Throughout this course, we will be using **JSON** objects. JSON stands for **JavaScript Object Notation**. JSON is a lightweight data-interchange format that (as the name suggest) has native support in Javascript. W3Schools provide a good introduction to JSON if you are unfamiliar (https://www.w3schools.com/js/js_json_intro.asp).

5 What is ExpressJS?

"Express is a minimal and flexible Node.js web application framework that provides a robust set of features to develop web and mobile applications. It facilitates the rapid development of Node based Web applications." [expressjs.com]

5.1 Exercise 5: Introduction to ExpressJS - Hello World!

Taken from: https://expressjs.com/en/starter/hello-world.html

1. First create a directory named **lab1_ex5**, navigate to this directory in your terminal.
2. Install express using: **npm install express**
3. In the lab1_ex5 directory, create a file named **app.js** and add the following code:

```
const express = require('express');

const app = express();

app.get('/', (req, res) => {
   res.send('Hello World!');
});

app.use((req, res, next) => {
   res.status(404)
       .send('404 Not Found');
});

app.listen(3000, () => {
   console.log('Example app listening on port 3000!');
});
```

4. In your terminal, run **node app.js**
5. Navigate to localhost:3000 to see the output.

The app starts a server and listens on port **3000** for connections. When receiving a HTTP request for the root ('/') resource, the app responds with "Hello World!" For every other path, it will respond with a "404 Not Found" HTTP response.

Note: you can read more about HTTP ports here:
https://en.wikipedia.org/wiki/Port_(computer_networking)

6 RESTful APIs

REpresentational State Transfer (REST) is an architecture that makes use of the HTTP protocol for communicating between different clients and servers on the Web. A REST API provides access to resources that the client can access and modify using the HTTP protocol. Each resource is identified using URI's and unique identifiers. Table 1 below shows how different HTTP methods are used in REST to perform specific actions.

HTTP Method	REST Action	Example URL	Example (A blog)
GET	Retrieve a resource	/articles/1234	Viewing a blog article
POST	Add a new resource	/articles/	Posting a new blog article
PUT	Replace an existing resource	/articles/1234	Correcting a spelling mistake in an already posted blog article, by replacing the whole article
DELETE	Delete a resource	/articles/1234	Delete a blog article
PATCH	Partial update to a resource (diff)	/articles/1234	Correcting a word in an already posted blog article, by replacing one word at a given index

Table 1: An example of how different HTTP methods are used within an application

The difference between PUT and PATCH is sometimes confusing. Both are used for updating data, but PUT will update the whole resource while PATCH updates by identifying only the parts the need to change, similar to a diff operation.

6.1 Exercise 6: Basic routing in Express

In Express, we can use these HTTP methods to perform different actions. In this exercise, we will use Express to make a single web page react differently depending on the HTTP method that is used.

1. Create a new directory named **lab1_ex6**. Inside this directory, use *npm* to install **express** and create an **app.js** file.
2. As with exercise 5, include the express module and **create an express server** using a variable called **app**:

```
const express = require('express');
const app = express();
```

3. Add a function to manage a user sending a GET request to the applications root resource. This GET request should just return the string "HTTP request: GET /"

```
app.get('/', (req, res) => {
   res.send('HTTP request: GET /');
});
```

4. Next, create similar functions for **POST**, **PUT** and **DELETE** requests that simply respond with the appropriate message.
5. Call the **listen** function at the end to start a server on port **3000**.
6. Run the server.
7. To test your simple API, you can use the following tools:
   a. **POSTMAN (recommended)**: https://www.getpostman.com/

      Postman is installed in the labs. You can also download it from getpostman.com/app/download/linux64 and run the Postman binary. Postman will continuously prompt you to create an account but feel free to ignore these. Here is a tutorial on how to use Postman: https://www.getpostman.com/docs/postman/sending_api_requests/requests

   b. **CURL**: https://en.wikipedia.org/wiki/CURL or https://curl.haxx.se/

      This is installed by default on Windows 10, Mac and nearly every Linux distribution, but because it is a command-line tool can be difficult to use for complex requests.

6.2 Exercise 7: Creating an API - Microblogging site

Now that we understand the basic concepts behind Express, we can create our first API. We will create an API for a microblogging site (like Twitter), beginning with the following functionality:

HTTP Method	URL	Action
GET	/users	List all users
GET	/users/:id	List one user
POST	/users	Add a new user
PUT	/users/:id	Update a user
DELETE	/users/:id	Delete a user

1. Create a new directory called **lab1_ex7**. Inside this directory, use *npm* to install **express** and create an **app.js** file.
2. Once again, within app.js include the **express** module and create an express server.
3. Copy and paste the JSON from Appendix A into a file called **users.json** in the same directory.
4. Import the list of JSON users into your application using the require directive. You can confirm that this has worked by printing it out to the console:

```
const data = require('./users.json');
const users = data.users;
console.log(users);
```

5. Now we can start to build our API functionality. Create the list all users function that returns the JSON:

```
app.get('/users', (req, res) => {
   res.status(200).send(users);
});
```

6. Creating the function to list one **specific** user is more difficult as we have to retrieve the correct user from the list. Create the function using the code below:

```
app.get('/users/:id', (req, res) => {
   const id = req.params.id;

   let response = `No user with id ${id}`;
   for (const user of users) {
       if (id === user.id) {
           response = user;
           break;
       }
   }

   res.status(200)
       .send(response);
});
```

7. Now we will write the **POST** request. This time the request will contain a JSON object that contains the data required for the new user. Before doing so, we need to include the **body-parser** module - this will take care of interpreting request bodies as JSON for us. Install it using npm and import it as normal, then tell the app to parse request bodies as JSON:

```
// Import should be at the top of the file
const bodyParser = require('body-parser');
...

// Tell the express app to expect json in the body of the request
app.use(bodyParser.json());
```

8. Now we can write our **POST** function:

```
app.post('/users', (req, res) => {
   const newUser = req.body;

   users.push(newUser);
   res.status(201)  // POST requests should return 201 if they create something
       .send(users);
});
```

9. Using the 'list one user' and 'add a new user' functions as a template, we can create a function for the **PUT** method:

```
app.put('/users/:id', (req, res) => {
   const id = req.params.id;
   const updatedUser = req.body;

   for (const user of users) {
       if (id === user.id) {
```

```
            const index = users.indexOf(user);
            users[index] = updatedUser;
            break;
        }
    }

    res.status(200)
        .send(updatedUser);
});
```

10. Finally, to create our **DELETE** method, we use the JavaScript array **splice** method to remove the user from the list

```
app.delete('/users/:id', (req, res) => {
    const id = req.params.id;

    for (const user of users) {
        if (id === user.id) {
            const index = users.indexOf(user);
            users.splice(index, 1);  // Remove 1 user from the array at this index
        }
    }
    res.send(users);
});
```

11. Make your application listen on port **3000** and test using Postman or CURL. Check that all five endpoints work as expected.

NOTE: The remaining exercises have been left vague intentionally; how you implement the changes is up to you.

6.3 Exercise 8: Adding followers

For this exercise, make a copy of your solution to exercise 7, renaming it to **lab1_ex8**. Then add functionality that allows users to follow other users. The JSON for each user should include a **following** key, the value of which is a list of user IDs that the user follows.

Make sure you add functionality for the following:

1. Add the followers feature to the project, by copying and updating the existing functionality.
2. Add a **follow** function to the API. This function should add a new user ID to a specified users following list.
3. Add an **unfollow** function.
4. Add a **view_following** endpoint. This should show all the users that a specified user is following.

6.4 Exercise 9: Adding microblog posts

Each user should also have a list of microblog posts. Functionality should exist that:

1. Creates a new post for a user

2. Retrieves all of a user's posts
3. Retrieves a single post of a specified user
4. Updates an existing post for a user
5. Deletes a post
6. Retrieves all the posts from all the followers of a specified user
7. **(Extra challenge)** Implement 'Likes' on posts

We have now written our first API using Node. However, a problem with our application is that the data isn't persisted anywhere. Once the server is stopped (or crashes), we will lose all of our users. In the next lab, we will look at persisting our application data to a database.

Appendix A: users.json

The JSON data below was generated using an automatic online data generator (http://www.json-generator.com/). We use this data in the exercises for this lab as an example.

(If you have problems copying and pasting this text, try the users.json file available on Learn)


```
{
   "users": [
       {
              "id": "1001",
              "age": 35,
              "first_name": "Burch",
              "last_name": "George",
              "gender": "male",
              "email": "burchgeorge@geofarm.com"
       },
       {
              "id": "1002",
              "age": 31,
              "first_name": "Rachelle",
              "last_name": "Chang",
              "gender": "female",
              "email": "rachellechang@geofarm.com"
       },
       {
              "id": "1003",
              "age": 38,
              "first_name": "Sheri",
              "last_name": "Bennett",
              "gender": "female",
              "email": "sheribennett@geofarm.com"
       },
       {
              "id": "1004",
              "age": 32,
              "first_name": "Fisher",
              "last_name": "Dillard",
              "gender": "male",
              "email": "fisherdillard@geofarm.com"
       },
       {
              "id": "1005",
              "age": 20,
              "first_name": "Pope",
              "last_name": "Bailey",
              "gender": "male",
              "email": "popebailey@geofarm.com"
       }
   ]
}
```