

Part II — NodeJs

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Lent 2017-2018

These notes are not endorsed by the lecturers, and I have modified them (often significantly) after lectures. They are nowhere near accurate representations of what was actually lectured, and in particular, all errors are almost surely mine.

Contents

1	Introduction to Node	3
1.1	Modules	3
1.2	Events	3
1.3	Asynchronous code and callbacks	3
1.4	fs	3
1.5	Web Server	5
2	Node packages	8
2.1	npm	8
2.2	Express	8
2.3	Express middleware	12
2.4	Request Response Cycle	14
2.5	Cookies and Session	14
3	Promises	17
4	Assignment 1 - dropbox with cache	23
4.1	Introduction	23
4.2	Questions and solutions	23
5	Jasmine	24
5.1	Introduction	24
5.2	Expectation and Matcher	24
5.3	Setup and Teardown	24
5.4	Jasmine Spies	24
5.5	Async and Clock	24
5.6	Supertest	24
6	API and Handlebars	25
6.1	Introduction	25
6.2	Restful APIs	25
6.3	API Methods	25
6.4	HTML Template	27
6.5	Handlebars	27
6.6	Basic Authentication	30
6.7	Postman	32
7	Assignment 2 - notes taking file	33
8	SQL	34
8.1	Introduction	34
8.2	Node & PostgreSQL	36
8.3	SQL joins	38
8.4	Transaction	40
9	Knex	45
9.1	Knex migrations CLI	51

10 Database Theory	59
10.1 Introduction	59
10.2 Associations	59
10.3 Database Design	61
11 Assignment 3 - notes taking knex	62
12 Redis	63
12.1 Introduction	63
12.2 Redis and node	63
13 Websockets	64
13.1 Introduction	64
13.2 Socket.io	64
14 User Authentication	68
14.1 Introduction	68
14.2 Passport.js	68
14.3 Bcrypt	68
14.4 Social Login	68
14.5 Redis Session	68
15 System Admin	69
15.1 Introduction	69
15.2 Digital Ocean	69
15.3 apt-get	69
15.4 Bash	69
15.5 NodeJs Setup	69
15.6 Process Manager and Nginx	69
15.7 Git Deployment	69
16 Assignment 4 - chatroom single file	70
17 Extension topics	71
17.1 Data Structure	71
17.2 HTTP Header	71
17.3 Algorithm	71
17.4 Dependency Injection	71
17.5 Operating System	71
17.6 Hamming	71
17.7 Software Licensing	71

1 Introduction to Node

1.1 Modules

Using Modules

Let's start by creating two files `app.js`, `greet.js`. Write the following:

```
// greet.js
console.log('Hello there');

// app.js
require('./greet');
```

in your terminal run `node app.js`

1.2 Events

1.3 Asynchronous code and callbacks

1.4 fs

1.4.1 read files

To handle files we can use the node module `fs` which stands for file system. Let's look at some code and then try to understand what is going on. Let's create two files, `app.js` and `greet.txt`.

```
// greet.txt
Hello there.

// app.js
var fs = require('fs');

var greeting = fs.readFileSync(__dirname + '/greet.txt');
console.log(greeting);
```

`__dirname` stands for current directory the node file is running in.

Run the code, what does your console log? If you did everything correctly you will see a log of `Buffer 48 65 6c 6c 6f 20 74 68 65 72 65 2e 0a`. That is the buffer with it's binary encoded data. To make it readable we have to decode it in a suitable format. A list of all formats can be found in the documentation for buffer, for our use case we are interested in `utf8`.

```
// app.js
var fs = require('fs');

var greeting = fs.readFileSync(__dirname + '/greet.txt', 'utf8');
console.log(greeting);
```

As you can see now we get everything in human readable format. However our code could still be improved. We are currently using `fs.readFileSync()`. As the name suggests method is synchronous, which we generally should avoid if possible. Imagine you are trying to read a very large file, the code wouldn't continue until

finished reading the file, which would result in a poor user experience. Therefore let's refactor the code to make it asynchronous.

```
// app.js
var fs = require('fs');

var greeting = fs.readFile(__dirname + '/greet.txt', 'utf8',
  function(err, data) {
    console.log(data)
  });
```

1.4.2 write files

We don't just want to read files, but also write to files. Let's look at some code to figure out how we could do that. First we create three files text.txt, textcopy.txt, app.js. Fill the text.txt file with a large amount of lorem ipsum. Generate around 70000 bytes of text.

```
var fs = require('fs');

var readable = fs.createReadStream(__dirname + '/text.txt');

readable.on('data', function(chunk){
  console.log(chunk.length);
});
```

`createReadStream` emits an event called `data`, which we can listen for. The stream fills the buffer with data and emits the event once the buffer is full or all data is read. It then passes on the chunk of data from the buffer and begins to refill the buffer. So we are listening for buffers.

If you run the above code you will notice that your console actually displays two buffers. The reason for that is that default buffer size is around 64000 bytes, however our document is 70000 bytes, so it couldn't be all placed in the buffer at one time.

Imagine you have a lot of traffic, than 64000 bytes buffer can be very memory intensive and slow down everything. We can therefore reduce the size of the buffer, using `highWaterMark` to let's say 32kb. Also let's make it human readable by changing the encoding.

```
var fs = require('fs');

var readable = fs.createReadStream(__dirname + '/text.txt', {
  encoding: 'utf8', highWaterMark: 32*1024 });

readable.on('data', function(chunk){
  console.log(chunk.length);
});
```

Let's actually start writing to a new file.

```
var fs = require('fs');

var readable = fs.createReadStream(__dirname + '/text.txt', {
  encoding: 'utf8', highWaterMark: 32*1024 });

var writeable = fs.createWriteStream(__dirname + '/textcopy.txt');
```

```
readable.on('data', function(chunk){
  writeable.write(chunk);
});
```

Run the code above and check out `textcopy.txt`.

1.4.3 pipes

Connecting two streams by writing from one stream to another. In node you can pipe from a readable stream to a writeable stream. The `createReadStream` object includes a pipe method. So we can refactor above's code a bit.

```
var fs = require('fs');

var readable = fs.createReadStream(__dirname + '/text.txt', {
  encoding: 'utf8', highWaterMark: 32*1024 });

var writeable = fs.createWriteStream(__dirname + '/textcopy.txt');

readable.pipe(writeable);
```

If you run this code you'll notice it achieves exactly the same as the previous code, it is just a lot easier and cleaner to write.

Quick note regarding the video below, doing a server will be covered in the next section, so feel free to skip the end.

1.5 Web Server

1.5.1 API

We have already come across APIs before, let's quickly remind ourselves what APIs are. APIs can be imagined as access to a set of tools that help us write software. These tools are other software. In terms of the web APIs are just URLs that send and accept data, through http.

An API consists out of endpoints, the different URLs of the API.

Keeping that in mind let's put some code down to create our own API:

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

http.createServer(function(req, res){

  // respond to the request

  res.writeHead(200, { 'Content-Type': 'text/plain' });
  res.end('Hello world');

}).listen(8080, '127.0.0.1');
```

1.5.2 Serving files

Sending some plain text isn't really that handy if we want to display complex websites to the user. So let's serve some HTML. Create two files `index.html` and `app.js`

```
<!DOCTYPE html>
<html>
  <head>
    <title>Hello World</title>
  </head>
  <body>
    <h1>Hello World</h1>
  </body>
</html>
```

```
var http = require('http');
var fs = require('fs');

http.createServer(function(req, res){
  res.writeHead(200, { 'Content-Type': 'text/html' });
  fs.createReadStream(__dirname + '/index.html').pipe(res);
}).listen(8080, '127.0.0.1');
```

Serve the page via node and check it out in the browser. If you want you can make changes to the HTML file and refresh the browser window, you should see those changes implemented, without having to restart node. That is because node only runs the JavaScript file and pipes your HTML file anew every time the page is loaded.

1.5.3 sending data

The most common way to transmit data from a server to another server or frontend is through the JSON format. Since JSON is very similar to a JS object, sending JSON through node is an extremely easy process.

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

http.createServer(function(req, res){
  res.writeHead(200, { 'Content-Type': 'application/json' });
  var obj = {
    name: 'John',
    surname: 'Doe'
  }
  res.end(JSON.stringify(obj));
}).listen(8080, '127.0.0.1');
```

`JSON.stringify()` transforms the JS object into JSON. Now your JS on the front end will know how to deal with the object.

1.5.4 routing

So far we only accepted requests on one route. However that doesn't really help us serve more than one file. Let's go back to our html example and change the html, below the heading include an image.

```

```

```
var http = require('http');
var fs = require('fs');

http.createServer(function(req, res){
```

```
fs.createReadStream(__dirname + '/index.html').pipe(res);
}).listen(8080, '127.0.0.1');
```

run the code and try to find the image on the website. It won't appear, the problem is that every request to node will return the html page. When the browser tries to load the image, it will make a request for the image to the node server, but node will just return the same html page.

In order to change that, we need to actually look at the request the node server is receiving.

```
var http = require('http');
var fs = require('fs');

http.createServer(function(req, res){
  if(req.url === '/') {
    fs.createReadStream(__dirname + '/index.html').pipe(res);
  } else if(req.url === '/assets/image.png') {
    fs.createReadStream(__dirname + '/assets/image.png').pipe(
      res);
  } else {
    res.writeHead(404);
    res.end();
  }
}).listen(8080, '127.0.0.1');
```

The request object includes a `url` property which contains the path the request was made to. So we can use that path and determine which document to return. If we receive the image path we return the image, and so on.

It could also happen that a request was made to a path we haven't defined yet, in that case we need to return something otherwise node won't know what to do and stop working. So we just return a header containing 404.

2 Node packages

2.1 npm

We already came across npm before, however we never really talked about how to use it. npm hosts the world wide largest collection of open source code. The code there is available in form of packages. A package is simply a collection of code that you can use. To maintain (install, update, delete) those packages we use a package manager, in our case npm. While you might say installing some code is easy, updating it is pretty hard, especially if the code depends on other packages, because then you need to keep track of all the packages to update. That is where npm comes in as a really useful helper.

npm comes installed with node. You can find packages on the official npm [website](#).

2.1.1 npm init

2.1.2 package.json

2.1.3 installing global packages

2.1.4 dev dependencies

2.1.5 GitHub and .gitignore

2.2 Express

Express is a npm package that allows us to set up servers on node in a more straightforward manner.

Let's get started, create a new folder and `npm init` a new module in that folder. Add a 'app.js' file and let's install express.

```
npm install express --save
```

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

Express the module returns a function constructor, so in order to make use of it we need to call `express()` and save that constructor in a variable, called `app` by convention.

Let's add a listen function to our app

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

app.listen(8080);
```

That's it, we have a running server.

Let's start listening for requests

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

app.get('/', function(req, res) {
  res.send('hello');
});
```

```
app.post('/login', function(req, res) {  
  console.log(req.path);  
  res.send('post received');  
});  
  
app.listen(8080);
```

2.2.1 Routing

When our app grows it will have many different routes, we don't want to manually define the route for every single page. Luckily Express makes that a painless process.

```
app.get('/users/:id', function(req, res){  
  console.log('the user id is ' + req.params.id);  
});
```

Express tells us the parameters (in this case id) that the dynamic url contains. This we can dynamically load content without having to define every route manually.

2.2.2 Serving static files

Middleware is code that sits between two layers of software. So in the case of Express those two layers would be request and response. Express makes it very easy to plugin some middleware between the two and therefore make it extensible. That allows us to handle certain requests and automate things. We could even chain several pieces of middleware together.

Imagine you have a website with many static files that you want to serve, like CSS files, HTML files or image files. We don't want to make a route for every file, so instead we use middleware that handles those kind of requests. We usually put those kind of files in a folder called **public**.

To serve them just use

```
app.use(express.static('public'));
```

2.2.3 Creating middleware

It is very straightforward to create your own middleware. Let's look at some code

```
app.use('/', function(req, res, next){  
  console.log('Request Url: ' + req.url);  
  next();  
});  
  
app.get('/', function(req, res){  
  res.send('hello');  
});
```

As you see in the example above the middleware has a third parameter called **next()**. It tells express to run the next middleware. In the example above express would run **app.get()** next, as it is the next middleware. **app.get()** is a middleware because it sits between the request and response.

2.2.4 Form Submission

There are multiple ways to post data from client to server. The most fundamental way is form submission. You can look at the example below.

Submitting normal data

In `index.html`

```
<html>
  <head>
    <link href="https://maxcdn.bootstrapcdn.com/bootstrap
      /3.3.7/css/bootstrap.min.css"
      rel="stylesheet"
      integrity="sha384-
        BVYiISIFeK1dGmJRAkyCuHAHRg320mUcww7on3RYdg4Va
        +PmSTsz/K68vbdEjh4u"
      crossorigin="anonymous">
  </head>
  <body>
    <form action="/login" method="POST">
      <div class="form-group">
        <label> Email:
          <input type='text' name="email" class="form-
            control" placeholder="Please input Email
            Here" />
        </label>
      </div>
      <div class="form-group">
        <label>
          Password:
          <input type='password' name="password" class="
            form-control" />
        </label>
      </div>
      <input type='submit' value="Submit" class="btn btn-
        primary" />
    </form>
    <script
      src="https://code.jquery.com/jquery-3.2.1.min.js"
      integrity="sha256-
        hwg4gsxgFZh0sEEamd0YGBf13FyQuiTwlAQgxVSNgt4="
      crossorigin="anonymous"></script>
    <script src="https://maxcdn.bootstrapcdn.com/bootstrap
      /3.3.7/js/bootstrap.min.js"
      integrity="sha384-
        Tc5IQib027qvyjSMfHj0MaLkfuWVxZxUPnCJA7l2mCWNIpG9mGCD8wGNiCPD7Txa
        "
      crossorigin="anonymous"></script>
  </body>
</html>
```

Then in your `app.js`

```
const express = require('express');
const bodyParser = require('body-parser');

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

app.use(bodyParser.urlencoded({ extended: false }));

app.get('/', (req, res) => {
```

```

    res.sendFile(path.join(__dirname, 'index.html'));
  });

  app.post('/login', (req, res) => {
    console.log(req.body);
    res.send("Login infomation received.");
  });

```

Uploading files

Let's add a extra file input **profile** to our login form.

```

<html>
  <head>
    <link href="https://maxcdn.bootstrapcdn.com/bootstrap
      /3.3.7/css/bootstrap.min.css"
      rel="stylesheet"
      integrity="sha384-
        BVYiiSIFeK1dGmJRAkycuHAHRg320mUcww7on3RYdg4Va
        +PmSTsz/K68vbdEjh4u"
      crossorigin="anonymous">
  </head>
  <body>
    <form action="/login" method="POST" enctype="multipart/form
      -data">
      <div class="form-group">
        <label> Email:
          <input type='text' name="email" class="form-
            control" placeholder="Please input Email
              Here"/>
        </label>
      </div>
      <div class="form-group">
        <label>
          Password:
          <input type='password' name="password" class="
            form-control"/>
        </label>
      </div>
      <div class="form-group">
        <label>
          Profile:
          <input type='file' name="profile" class="form-
            control"/>
        </label>
      </div>
      <input type='submit' value="Submit" class="btn btn-
        primary"/>
    </form>
    <script
      src="https://code.jquery.com/jquery-3.2.1.min.js"
      integrity="sha256-
        hwg4gsxgFZh0sEEamd0YGBf13FyQuiTwlAQgxVSNgt4="
      crossorigin="anonymous"></script>
    <script src="https://maxcdn.bootstrapcdn.com/bootstrap
      /3.3.7/js/bootstrap.min.js"
      integrity="sha384-
        Tc5IQib027qvyjSMfHj0MaLkfuWVxZxUPnCJA712mCWNIpG9mGCD8wGNicPD7Txa
        "
      crossorigin="anonymous"></script>
  </body>
</html>

```

Please note that the **input** has to be of the type **file**. On the server side, you have to install the package **express-fileupload** using npm.

```
npm install --save express-fileupload
```

And the new **app.js** is as follow,

```
const express = require('express');
const bodyParser = require('body-parser');
const fileUpload = require('express-fileupload');

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

app.use(bodyParser.urlencoded({ extended: false }));
app.use(fileUpload());

app.get('/', (req, res) => {
  res.sendFile(path.join(__dirname, 'index.html'));
});

app.post('/login', (req, res) => {
  console.log(req.body);
  console.log(req.files);
  res.send("Login Information Received.");
});

app.listen(8080)
```

Please make sure you import the **express-fileupload** and **setup-express** to use it as a middleware by the following line.

```
app.use(fileupload());
```

Then the file content is accessible through **req.file**. In this case, the file is accessible through **req.file.profile**

Example. Serve the flowershop website via express.

2.3 Express middleware

So far we have learned how to set up our own API and receive all sorts of requests. However, there is one small problem. If we receive a POST request we cannot read the body of that request. If you **console.log(req.body)** you'll see a **undefined**.

The reason for that is that the creators of Express try to keep the code as lightweight as possible. That means that all code that is not required to run the most basic functions is excluded from the express package itself. Any additional code has to be added manually through separate npm modules.

If you think about it, we don't need the code to read the body of a POST request, if we only want to set up an API that handles GET requests. In the case we need it, we can always add it to Express later, which makes Express so powerful and at the same time lightweight.

2.3.1 Body parser

To be able to read the body of a POST request we need a module called **body-parser**.

Let's npm install it

```
npm install --save body-parser
```

To use it we make use of `app.use`

```
var express = require('express')
var bodyParser = require('body-parser')

var app = express()

// parse application/x-www-form-urlencoded
app.use(bodyParser.urlencoded({ extended: false }))

// parse application/json
app.use(bodyParser.json())
```

The difference between `urlencoded` and `json` is the format in which we receive the body. Either you receive the post request encoded within the URL (more about that below) or it is passed along the request body in a `JSON` format. `body-parser` allows you to read both requests.

So now we can read the request body.

```
app.post('/test', (req, res) => {
  console.log(req.body);
  res.send('post successful');
});
```

here are a lot of other useful npm modules which we can use as middleware. You can find a complete list [here](#)

2.3.2 Url query string

A URL consist of several parts:

- `http://` defines the protocol, you will usually come across this version or the secured `https`
- `www.website.com` the domain of the website. The domain again consist of a few parts, the `www` is considered the subdomain. Whereas `website.com` is called the domain name. `.com` itself is called a domain. With domains we differentiate between Top Level Domains (`.com`, `.net`),
- `/path/to/somewhere` after the domain we find the path, which leads to a specific file or API route
- `play?vidID=8372395` sometimes we also have parameters in the domain, they contain a `?`. These are used to pass along information, like the this example which video to play.

Let's take a better look at the parameters which form something called a query strings. They always start with a `?` which is used to differentiate them from the path, since the server needs to know where does the path end and the query string begin.

We can stuff all sorts of information in these query strings, for example imagine we have a database of workers and want to retrieve all males above

height 175cm. A query string could look like this

Example.

Example. Make an app that has a POST route. If we call the POST route with an array of numbers it should return the sum of all the numbers in the array. Test it out with Postman. Receive the array via the body.

```
var arr = [1,2,3,4] // -> sending that to the API returns 10
```

2.4 Request Response Cycle

Every http action consists of two parts, a **request** and a **response**. Every time somebody makes a request to our server we should respond with an appropriate answer. Imagine somebody greets you, it would be extremely rude if you wouldn't greet back, you wouldn't follow common social etiquette. The same can be said for servers, if you receive a request it is extremely rude to the users browser sending the request, if you don't answer back.

Therefore express is structured around the two fundamental components, request and response, or **req** and **res** as we call them in our code.

2.4.1 Request

2.4.2 Response

2.4.3 Visualisation

2.5 Cookies and Session

You already learned Cookies Before With Express we have two options to deal with cookies. We can either store a large part with the user or keep most of the information on our servers. The difference is using cookies or cookie sessions. Lets look at each one separately.

Note that **passport.js** also makes use of cookies and handles these for us if we use it. Using cookies usually isn't required if we use passport. However passport isn't always the solution, so we need to be able to set cookies ourselves.

2.5.1 cookie parser

If we want to make use of cookies we need a module called cookie-parser It allows us to read cookies on the request with **req.cookies** as well as set cookies using **res.cookie**

```
var express = require('express');
var cookieParser = require('cookie-parser');

var app = express();
app.use(cookieParser());

app.get('/', (req, res) => {
  console.log(req.cookies);
});
```

```
res.cookie('name', 'tobi', { expires: new Date(Date.now() + 1000
    * 60 * 60 * 24 * 14), httpOnly: true });
})
```

In the above example we set the cookie for that person calling our root route. We give the cookie a property name and a value of tobi (should be unique name that allows identification). Then we set the cookie options, like the expiration date, when the cookie will expire.

From now on we can uniquely identify this user, as long as the user doesn't delete the cookie.

There are a lot more properties for res.cookie check them out in the official [documentation](#).

2.5.2 cookie session

The other way to identify a user is using session. Sessions are information stored about the user on the server side, usually in a redis db, but could also be a postgres.

To use sessions we can use a package called cookie-session. Cookie Session stores an identifier (which we define) in a cookie on the client side. However since the user could manually manipulate the cookie to gain access to other peoples accounts, cookie session also stores a hash of that identifier with the identifier itself.

The hash works just like the hashing of user passwords. The identifier is hashed with a secret key to result in an impossible to guess combination. With every request from the user cookie sessions will look at the identifier and hash it together with the secret. If the resulting hash matches the one stored in the cookie, we can be certain that the cookie hasn't been tempered with.

```
var express = require('express');
var cookieSession = require('cookie-session');

var app = express();
app.use(cookieSession({
  name: 'session',
  secret: 'a hard to guess secret' ,

  // Cookie Options
  maxAge: 24 * 60 * 60 * 1000 // 24 hours
}))

app.get('/', (req, res) => {
  console.log(req.session);

  if(!req.session.id) {
    req.session.id = 'unique identifier'
  }

  findUser(req.session.id) // return information about the user
})
```

In the above example we add unique id to the user's session if it doesn't exist. We then call a function to retrieve information about the user based on the unique ID so we can respond dynamically with content based on the user. Please note we can store more information in the session than simply an ID, it's pretty much up to us what we store there. However we should try to keep it to

a minimum if possible, as to don't make the user store too much information in his browser. On top of that is the maximum cookie size 4093 bytes.

3 Promises

3.0.1 Promises

So far we have mainly relied on callbacks for our asynchronous code, which has long been the standard. However you will have noticed that error handling can quickly become very messy as we chain several callbacks together. Luckily with the new ES6 standard a new feature called Promise got introduced.

You can imagine a Promise like the word suggest. You give it some JavaScript code and it promises to return you something. Either everything went well or an error occurred, either way you will get an answer from the Promise once it knows what happened.

A Promise consist of three states:

- unresolved→waiting for something to finish
- resolved→something finished and all went well
- rejected→something finished and an error occurred

By default a Promise is the unresolved state and waiting for something to occur. That something can be any kind of JavaScript function, for example a Get request.

Let's declare a promise to see what is happening

```
var promise = new Promise((resolve, reject) => {
  resolve();
});
console.log(promise);
```

Try running the above code in your browser console. Afterwards replace the `resolve()` with `reject()`. What do you see?

You will notice that first of all you get back an object, which indicates whether the Promise was resolved or rejected. If you look at `promise.__proto__` you will see the object has two methods, `catch` and `then`.

You will further notice that you get an error message if you run the code with `reject()`. That error message basically tells you, you haven't handled the error. So let's solve that by make use of the two methods.

```
var promise = new Promise((resolve, reject) => {
  resolve();
});

promise.then(() => {
  console.log('Promise resolved.');
```

```
});

promise.catch(() => {
  console.log('An error occurred');
```

```
});

Run the above code, then replace the resolve() with reject(). Notice how then() only runs if the the promise was resolved and catch() only runs when it was rejected.
```

The real power of promises comes to light when we start chaining different `.then()` together. Let's refactor to the code to some ES6 standard and chain everything together.

```
const promise = new Promise((resolve, reject) => {
  resolve();
});

promise
  .then(() => console.log('I ran'))
  .then(() => console.log('I ran afterwards'))
  .then(() => console.log('Then I ran'))
  .catch((err) => console.log('uh oh error', err));
```

If you run the code above you will notice that you can do some pretty powerful chaining with promises, without having to worry about callbacks and error handling. You only need to handle the error once. To demonstrate that let's change our code

```
const promise = new Promise((resolve, reject) => {
  resolve();
});

promise
  .then(() => console.log('I ran'))
  .then(() => { throw new Error('Help I am an error'); })
  .then(() => console.log('I did not run'))
  .catch((err) => console.log('uh oh error', err));
```

Run the code above to test it.

Why did we change the arrow function to one with curly brackets? That is because without the curly brackets the arrow function will automatically return the inner content. However we don't want to return anything, but instead throw an error. Therefore we need to wrap it in curly brackets to disable the return.

(Notice if you run the above code and get an error variable already declared, refresh the page. That error occurs because of the `const` declaration, promise can only be declared once, replace it with `var` if you want or omit);

3.0.2 fetch

Promises are often used for AJAX requests, as these are processes that are asynchronous and a Promise makes life a lot easier handling their responses. Let's demonstrate it using a new ES6 feature `fetch()` which makes simple AJAX requests and returns a Promise.

```
const url = 'https://jsonplaceholder.typicode.com/posts';

fetch(url)
  .then(response => response.json())
  .then(data => console.log(data))
  .catch(err => console.log(err))
```

With `fetch` we have to make two requests, in the first one we receive an object, however without a body, so we have to fetch the body using `response.json()`. Chaining the requests together makes this all a breeze to write. Try manipulating the domain to something like `typicode123.com` to see how the errors are handled. The implementation of `fetch` isn't ideal, especially it's error handling. While it is nice to have a native solution, other solutions like `axios` make a lot better use of Promises for API requests.

3.0.3 Axios

Axios is another package that makes a lot of uses of Promises. Here is an example of using `axios`.

```
// GET method
axios.get("/users")
  .then(res=> console.log(res))
  .catch(err=> console.log(err));

// POST method
axios.post("/users",{ "id":2, "username": "newUserName" })
  .then(res=> console.log(res) )
  .catch(err=> console.log(err) );

// DELETE method
axios.delete("/users",{id:3})
  .then(res=> console.log(res))
  .catch(err=> console.log(err));

// PUT method
axios.put("/users",{ "email": "user@user.com", "password": "1234" })
  .then(res=> console.log(res))
  .catch(err=> console.log(res));
```

3.0.4 Applying Promise to asynchronous code

A lot of code we use in node is asynchronous, Promises can help us clean that up.

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

function readdir(path) {
  return new Promise((resolve, reject) => {
    fs.readdir(path, (err, files) => {
      if (err) {
        reject(err);
      } else {
        resolve(files);
      }
    });
  });
}

module.exports = readdir();
```

Now if you require `readdir()` in another module you can chain `.then()` and `.catch` to it.

3.0.5 Promise.all

If you have several Promises you can rely on `Promise.all` to determine once they finished running. `Promise.all` itself is a promise that resolves when all promises resolved, if one fails it rejects. All you need to pass it is an array of promises.

```
const p1 = new Promise((resolve, reject) => {
  setTimeout(resolve, 1000, 'one');
});
const p2 = new Promise((resolve, reject) => {
  setTimeout(resolve, 2000, 'two');
});
```

```
Promise.all([p1, p2])
  .then(values => console.log(values))
  .catch(err => console.log(err));
```

3.0.6 Async & Await

ES7 supports new keyword called **async** and **await** to further simplify your promise method call.

```
// Async Version
async function callAPIs(){
  try{
    let res1 = await axios.get("http://example.com")
    let res2 = await axios.get('http://example2.com?key1=${res1
      .key2}')
    return res2.key2;
  }catch(err){
    console.log(err);
    throw err;
  }
}

// Promise version
function callAPIs(){
  return new Promise((resolve, reject)=>{
    axios.get("http://example.com")
      .then((res1)=>axios.get('http://example2.com?key1=${
        res1.key2}'))
      .then((res2)=> resolve(res2.key2))
      .catch((err)=>{
        console.log(err);
        reject(err);
      });
  });
}
```

As shown above, the async function is correspondent to a new Promise object.

```
// Async Version
async function callAPIs(){
  return doSomething();
}

//Promise Version
function callAPIs(){
  return new Promise((resolve, reject)=>{
    resolve(doSomething());
  })
}
```

Each catch block is correspondent to the catch method call in the promised version.

```
// Async version
async function callAPIs(){
  try{
    let res1 = await axios.get('http://example.com');
    return res1;
  }catch(err){
    console.log(err);
    throw err;
  }
}
```

```

    }
  }

  // Promised version
  function callAPIs(){
    return new Promise((resolve, reject)=>{
      axios.get("http://example.com")
        .then((res1)=>resolve(res1))
        .catch((err)=> reject(err))
    });
  }
}

```

Remark.

- Each **return** in the async version is correspondent to the **resolve** function call in the promised version.
- Each throw **err** in the async version is correspondent to the **reject** function call in the promised version.

3.0.7 Async version \iff Promise version Correspondence

Here is a quick comparison between the twos,

- **async** function \iff new **Promise** Object
- **await** keyword \iff **then()** method call
- **catch** block \iff **resolve()** method call
- **return** keyword \iff **resolve()** function call
- **throw** error \iff **reject()** function call

3.0.8 Promise.all for Async

You can also use **Promise.all** in async function when you want to wait for multiple promises before proceeding.

```

async function callAPIs(){
  let combinedPromise = Promise.all([axios.get('http://example1.
    com'),
                                     axios.get('http://example2.
    com')]);
  let responses = await combinedPromise;
  return responses;
}

```

Example. Create a module that contains a promised version of **fs.readdir** and **fs.stat**. Similar to the example above.

- Then download this [file structure](#)
- Use the modules to determine whether each path leads to a directory or file. Read the documentation for **fs** properly you'll find all the necessary knowledge in there.

- Output should look like this

```
/files/project_A/ is a directory  
/files/project_A/README.md is a file  
/files/project_A/images/ is a directory  
...
```

4 Assignment 1 - dropbox with cache

4.1 Introduction

4.2 Questions and solutions

5 Jasmine

5.1 Introduction

Basics & Adv.

5.2 Expectation and Matcher

5.3 Setup and Teardown

5.4 Jasmine Spies

5.5 Async and Clock

5.6 Supertest

6 API and Handlebars

6.1 Introduction

6.2 Restful APIs

6.3 API Methods

6.3.1 API Structure

6.3.2 HTTP Methods

Now it's time to introduce the verbs to the equation. The verbs are going to be the four main http methods.

- **GET** Ask the server to retrieve some resources
- **POST** Ask the server to create a new resource
- **PUT** Ask the server to edit/update an existing resource
- **DELETE** Ask the server to remove an existing resource

With these four verbs we can basically do anything with our API. In case of our pizza parlor it would work as follows:

Request endpoint action

GET	/orders	List all the orders
POST	/orders	Add new order
GET	/orders/1	List order with ID 1
GET	/orders/2	List order with ID 2
PUT	/orders/1	Update order with ID 1
DELETE	/orders/1	Delete order with ID 1

6.3.3 Express example

The Restful API can thus be translated to the Express application as follow,

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

// Remember to put necessary plugin here.

app.get('/orders/:id', (req, res) => {
  const id = req.params.id;
  const order = // Logic that read order by id.
  res.json(order);
});

app.get('/orders', (req, res) => {
  const orders = // Logic that reads orders from somewhere.
  res.json(orders);
});

app.post('/orders', (req, res) => {
  const newOrder = req.body.order; // Remember to use body-parser
  // Logic that create a order
  res.json({success: true});
});
```

```
});  
  
app.put('/orders/:id',(req,res)=>{  
  const id = req.params.id;  
  //Logic that updates the order  
  res.json({success:true})  
});  
  
app.delete('/orders/:id',(req,res)=>{  
  const orderIdToBeDeleted = req.params.id;  
  // Logic that deletes the order  
  res.json({success:true})  
});
```

6.3.4 API Response

Every request to our API needs an adequate response. Whereas it is very obvious how to respond to a GET request, what is an adequate response to a POST request?

First of all the software posting wants to know that the POST request was successful, so we need to respond with an adequate header of 200 if the request was properly handled. Further by convention we would respond with some sort of unique identifier of that post request. In the above example of the pizza order, we would respond with the order ID.

For a PUT or DELETE request, a response with a header 200 would be adequate.

6.3.5 Scaling the API

Imagine now our Pizza Parlor is booming and the chief Pizza baker decides to reward good customers for their loyalty. For that we need to keep track of customers and give each customer a unique identifier.

How would we go about that? There are some possible ways. The most obvious one would be to create another resource called /customers. So that we could make GET requests to /customers/customer_id and so on.

However, how do we link a customer to his order? Opinions are split here in the developer community amongst two main solutions and you'll encounter both. Either we extend our customer endpoint customers/5/orders to get the orders of customer 5 and customer/5/orders/3 to get customer 5's third order. Or we keep everything as flat as possible and when making a request to orders pass along the customer ID. Both ways are perfectly legit according to REST principles and it is up to you how you'd like to structure your API.

So a request to order a POST pizza would look like

POST /customers/5/orders

```
{  
  "type": "napoletana",  
  "toppings": "extra cheese"  
}
```

POST/orders

```
{
  "type": "napoletana",
  "toppings": "extra cheese",
  "customer_id": "5"
}
```

6.3.6 REST vs RPC vs GraphQL

There are multiple styles of API structures out there. You probably read about it somewhere in internet.

- **REST** is the one we have been discussing in this article.
- **RPC** is the short form of Remote Procedural Call which differs with REST in the format and the semantics of the url.
- **GraphQL** is the newcomer which use a single endpoint with a newly introduced query language GraphQL

Rest vs RPC

Here are two contrasting examples of Rest-style API & RPC-style API

```
//REST
GET /friends
POST /friends
PUT /friends
DELETE /friends

//RPC
GET /friends
POST /addFriends
POST /updateFriends
POST /deleteFriends
```

In REST, the action is represented by the HTTP method while in RPC, the action is represented by the url route. Because the HTTP verb is well-defined, the developers can understand your API easier.

Rest vs GraphQL

GraphQL is the new contender of REST. It features a flexible query language and type system to make writing complex API call easier and more efficient. You can read more about it [here](#)

6.4 HTML Template

6.5 Handlebars

6.5.1 Server side vs Client side rendering

Rendering is the process of picking a template and populating it with the data we needed to create the **HTML** file. Here are the main difference between server-side rendering and client-side rendering:

- **Server Side Rendering:**

- The rendering process is happened on the server side making use of the templates and data.
- It facilitates **form submission** and **page refresh**
- Examples: **Handlebars**
- **Client Side Rendering:**
 - The rendering process is happened on the client side using javascript and HTML templates.
 - It facilitates **AJAX Call** and **DOM manipulations**
 - Example: **JQuery with HTML Template, React** and **Anugular**

We are going to employ a MIXED approach for this problem:

- We are going to use **Server side rendering** to render the layout of your pages.
- We are going to use **AJAX** and **Client side rendering** to populate your page with the necessary data.

6.5.2 Handlebars

Handlebars is an extremely lightweight template engine. Handlebars is used by some of the biggest websites on the Internet. It is extremely simple to use, we run with `res.render` and it returns us HTML pages ready to send to the users. Express is build with support for template engines, making it extremely straightforward to plug in Handlebars.

Create a new npm project with `npm init`. Further install `npm install express`. To install handlebars we can use the `express-handlebars` module.

```
npm install express-handlebars
```

6.5.3 Basic folder structure

To use Handlebars we need to save our files in certain structure. Create a `views` folder and two subfolders `layouts` and `partials`.

```
app.js // main file
views
  - layouts
  - partials
```

6.5.4 Main Handlebars

The main page structure is saved in a file called **main.handlebars**. It contains the HTML code that that sets the page structure. Its actual content can be dynamically replaced, and will be rendered where the `{{body}}` element is. Add it to the **layouts** folder

```

<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>...</title>
  </head>
  <body>

    {{{body}}}

  </body>
</html>

```

Let's add a simple app.js file

```

const express = require('express');
const app = express();
const hb = require('express-handlebars');

app.engine('handlebars', hb({ defaultLayout: 'main' }));
app.set('view engine', 'handlebars');

app.get('/people', function(req, res){
  res.render('person');
});

app.listen(8080);

```

Notice in the file above how we set handlebars as the `app.engine` which is used to register a template engine with express. We set the default layout to `main`, which is the `main.handlebars` file we created earlier. Afterwards we set the `view engine` to handlebars.

In the get request below we don't use `res.send` but instead use `res.render([view])`. The view defines which file from the view folder to render. So in this case, you need a file called `person.handlebars` within the folder `views`.

Let's take a look at layouts, partials and helpers.

6.5.5 Layouts

If you remember the `views` folder we created had the following structure:

```

views
- layouts
  - main.handlebars
- partials

```

We put the `main.handlebars` file in the `layouts` folder. You might have wondered why there is a special folder just for `main.handlebars`. The reason is that we can have several templates in there. Depending on the page section we might want to have a different structure, so we can put that there.

Let's add a second layout, we will call it `otherPage.handlebars`:

```

<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>...</title>

```

```

    </head>
    <body>
      <h1>I am a different template </h1>

      {{{body}}}

    </body>
  </html>

```

When we call `res.render()` we can manually update the default layout in the object we are passing to the function. Look at the object below, we give it a property called `layout` where we define the new layout page to use for that route.

```

app.get('/something', (req, res) => {
  res.render('view', {layout: "otherPage"})
})

```

6.5.6 Partial

The other folder you probably noticed is the `partials` folder. Partial is an element that keeps on reappearing throughout the app. For example a header or a footer. Since we can have several layouts but might want to share a header across layouts it makes no sense to hardcode the header into a layout.

We instead want to have a dynamic and sharable header as well. Let's add one.

In the `partials` folder add a file called `header.handlebars`:

```

<h1>I am a header </h1>

```

In our `otherPage.handlebars` file we add the header with `{{> header }}`:

```

<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8">
    <title>...</title>
  </head>
  <body>

    {{> header }}

    <h1>I am a different template </h1>

    {{{body}}}

  </body>
</html>

```

Render it and you should see the header appear.

6.6 Basic Authentication

The simplest way to authenticate is using password and username, something we call Basic Authentication (Basic Auth). It is pretty simple and pretty old school. However while 'old school = gold school' holds true for Hip Hop, it doesn't necessarily hold true for technology. Let's try to understand why.

We simply pass username and password in the header, in a part called Authorization. So every call we make to an API includes a header with the password and username. Anybody with those two can access the API. However what usually happens is that many people work on an application, including outsiders. Using basic auth gives everybody access to the user credentials and anybody with malicious intends can misuse them and create a mess with your account. You can compare it to giving out the master key to all hotel rooms instead of giving guests only a key to their room. That's why companies came up with a different solution.

6.6.1 Adding Basic Auth to Express

You can easily add basic authentication to express using the package `express-basic-auth`. The following code adds a Basic Authentication for your express application.

```
var app = require('express')()
var basicAuth = require('express-basic-auth')

app.use(basicAuth({
  users: { 'admin': 'supersecret' },
  challenge: true,
  realm: 'My Application'
}))
```

The username is this admin and the password is supersecret. The only problem of this authentication is that you cannot keep the login status if you close your browser. And you cannot logout without closing your browser.

6.6.2 Authenticating different users

You can also use the `authorizer` in this package to authenticate different users.

```
app.use(basicAuth({
  authorizer: myAuthorizer,
  challenge: true,
  realm: 'My Application'
}));

const USERS = [
  {
    "username": "gordon",
    "password": "abc"
  }
]

function myAuthorizer(username, password) {
  return USERS.some((user) => {
    return user.username == username && user.password ==
      password
  })
}
```

Because by default the `express-basic-auth` does not challenge the user. We have to add the attribute for `challenge` to be true. `realm` defines the area of effectiveness for this authentication which Express and the browser handle it for us automatically.

6.7 Postman

6.7.1 What is Postman?

Postman is a popular tool for testing HTTP request/response, espeically RESTful APIs.

6.7.2 Where can I get Postman

[Download it here](#)

7 Assignment 2 - notes taking file

8 SQL

8.1 Introduction

A relational database (RDB) is a collective set of multiple data sets organized by tables, records and columns. RDBs establish a well-defined relationship between database tables. Tables communicate and share information, which facilitates data searchability, organization and reporting. You can imagine them being very similar to an excel spreadsheet, with rows and columns. Whereas a database is more like an excel workbook, which consists out of several spreadsheets.

RDBs use Structured Query Language (SQL) which allows us to program on these databases and query them for data. While there are many SQL databases out there we will be using PostgreSQL.

8.1.1 Setting up

Mac

If you have a Mac the easiest way to install PostgreSQL is via the [PostgresApp](#).

Ubuntu/Windows

If you are using linux (ubuntu) you can run the following code

```
sudo apt-get install postgresql postgresql-contrib
```

You can also consider downloading a graphical interface software like [pgAdmin](#). (linux, windows, mac) . We won't use it for now, but they can help you with debugging at a later stage.

You should start your database server by running the command below.

```
sudo service postgresql start
```

8.1.2 Creating a database

By default `postgresql` creates a user called `postgres`. The `postgres` user has all of the permission on working on the DB. Therefore in order to perform the operation below, you can run the command below.

```
sudo su postgres
```

You are now logged in to the user `postgres` in `ubuntu`. Because of the mechanism of peer authentication. You won't need a password to access the DB using the user `postgres` if you are at the same machine as the postgresql server.

Using the `createdb` command creates a new database. Please note that the following commands are run in **BASH**.

```
createdb fruits
```

Now you can work the database using PostgreSQL. You will notice that your console changes and you are in the database.

```
psql fruits
```

The above command is only a shortform. Here is the full version of a generic command for logging to postgresql server.

```
The above command is only a shortform. Here is the full version of  
a generic command for logging to postgresql server.
```

8.1.3 Setting up user

Please note that the following commands are run in PSQL Shell. In order for you to login to postgresql server easier without switching to the postgres user all the time. We recommend you to create a username same as your username in bash. By peer authentication process, you can then login to postgresql without any problem.

```
CREATE USER <your-user-name> WITH PASSWORD 'password' SUPERUSER;
```

Afterwards double check the user was created

```
\ du
```

8.1.4 Creating tables

Once you created a database you can add tables to it using CREATE TABLE

```
CREATE TABLE citrus (  
    id SERIAL primary key,  
    name VARCHAR(255) not null,  
    color VARCHAR(255),  
    taste VARCHAR(255)  
);
```

As you can see from the code above, we write every PostgreSQL related command in all capital letters. This makes it easier to read once you have a lot of commands.

SERIAL means that the counter id increases with every row. primary key defines that id is the unique key by which each row can be identified.

VARCHAR(255) indicates that the column will be filled with text of a not predefined length. 255 indicates the maximum length the text can have.

not null tells PostgreSQL this value cannot be empty.

To delete a table:

```
DROP TABLE <the_tablename_you_want_to_delete>;
```

After you have finished the operations, you can use the following command to leave postgresql shell.

```
\ q
```

Example.

8.1.5 Adding, updating and deleting data

INSERT is the command we need to add data to our table. We need to specify the table, as well as the columns we are filling with data.

```
INSERT INTO citrus (name, color, taste) VALUES ('lemon', 'yellow', 'sour');
INSERT INTO citrus (name, color, taste) VALUES ('orange', 'orange', 'juicy');
INSERT INTO citrus (name, color, taste) VALUES ('grapefruit', 'orange', 'bitter');
INSERT INTO citrus (name, color, taste) VALUES ('lime', 'green', 'sour');
INSERT INTO citrus (name, color, taste) VALUES ('tangerine', 'yellow', 'sweet');
```

To update we use the UPDATE command

```
UPDATE citrus SET color = 'orange' WHERE color = 'yellow';
```

To delete we use DELETE

```
DELETE FROM citrus WHERE name = 'tangerine';
```

8.1.6 Querying data

To query data we can use the SELECT command.

```
SELECT * FROM citrus;
```

id	name	color	taste
1	lemon	yellow	sour
2	orange	orange	juicy
3	grapefruit	orange	bitter
4	lime	green	sour

Using SELECT * FROM selects everything from the table.

To limit our search to a some specific columns we can extend the SELECT statement.

```
SELECT * FROM citrus WHERE color = 'orange';
```

id	name	color	taste
2	orange	orange	juicy
3	grapefruit	orange	bitter

We can extend the WHERE statement more, with operators or AND, OR clauses

```
SELECT * FROM citrus WHERE color = 'orange' AND id > 2 OR color = 'green';
```

id	name	color	taste
3	grapefruit	orange	bitter
4	lime	green	sour

8.2 Node & PostgreSQL

8.2.1 PostgreSQL

It wouldnt be much fun if we couldnt connect postgres with node, so lets do that. We will use the pg package.

```
npm install --save pg
```

Then hook it up

```
var pg = require('pg');

var config = {
  user: '<your-user-name>',
  database: 'fruits',
  password: 'password',
  host: 'localhost',
  port: 5432,
  max: 10, // max number of clients in the pool
  idleTimeoutMillis: 30000, // how long a client is allowed to
    remain idle before being closed
}

var client = new pg.Client(config);

client.connect();
```

Now we can query our database

```
client.query('SELECT * FROM citrus', function(err, results) {
  if(err) {
    console.log(err);
  }
  console.log(results.rows);
})
```

Example.

8.2.2 SQL injection

You will want to enter a lot of user input into your table, which is input you cannot necessarily trust. If the user inserts any SQL commands via the input, they might run and mess with your table. Just imagine you receive an input `DROP TABLE users;` your whole user database would be gone. It is therefore necessary to protect against SQL injection, by transforming all user input to a string, so it cannot run. Luckily `pg` takes care of that for us, if we use it properly.

Btw if you wonder who tries to do SQL injection, here is an example of the British company registry

```
function getFruit(fruit, color) {
  var client = new pg.Client('postgres://accelerate:
    password@localhost:5432/fruits');

  client.connect();
  var query = 'SELECT * FROM citrus WHERE name = $1 AND color =
    $2;';

  client.query(query, [fruit, color], function(err, results) {
    if(err) {
      console.log(err);
    }

    console.log(results.rows);
  });
}
```

We pass the `client.query` an array as a second argument, and tell pg the index via `$`.

8.3 SQL joins

When there are more than one table in a database, we have to establish relation between them. We are using primary and foreign key to establish relation among different tables.

8.3.1 Primary Key and Foreign Key

Primary key is a unique identifier for each row of data. You have already encounter it in the previous section. It is the `id SERIAL NOT NULL`

Foreign key simply means the primary keys of the other table. They are fundamental to linking two SQL tables together. To join two tables together using foreign key, we normally use the SQL Join. We have other ways like sub-queries to achieve the same thing. But SQL Join is the preferable way of doing this.

8.3.2 Join

Consider you have the following two tables:

```
stock:
id | quantity | price | citrus_id
---+-----+-----+-----
1  |          | 33    | 25       | 1
2  |          | 50    | 15       | 2
3  |          | 10    | 35       | 3
4  |          | 0     | 20       | 4
citrus:
id | name      | color | taste
---+-----+-----+-----
1  | lemon     | yellow | sour
2  | orange    | orange | juicy
3  | grapefruit | orange | bitter
4  | lime      | green  | sour
```

How can you combine information from the two? You need to join the two tables together. As you can see the stock table has a row with `citrus_id` keys, which correspond to the `id` keys in the citrus table. Lets try to find out the price of every fruit.

```
SELECT citrus.name AS citrus_name, stock.price AS stock_price
FROM citrus
JOIN stock
ON citrus.id = stock.citrus_id;

citrus_name | stock_price
-----+-----
lemon       | 25
orange      | 15
grapefruit  | 35
lime        | 20
```

8.3.3 Different type of JOINS

There are four different types of JOINS in SQL and they serve for different purpose. Coding Horror has a nice visual summary of the different JOIN options.

A JOIN clause is as following format:

```
JOIN stock on leftTable.column = rightTable.column
```

All of the following JOINS are going to join row together if `leftTable.column = rightTable.column`. The only difference lies in what happen when either one of them is null.

- INNER JOIN : Join the rows only if both `leftTable.column` and `rightTable.column` are not null
- LEFT OUTER JOIN : Join the rows only if `leftTable.column` is not null. It does not matter whether `rightTable.column` is null or not.
- RIGHT OUTER JOIN: Join the rows only if `rightTable.column` is not null. It does not matter whether `leftTable.column` is null or not.
- FULL OUTER JOIN : Join the rows if `rightTable.column` is not null or `leftTable.column` is not null.

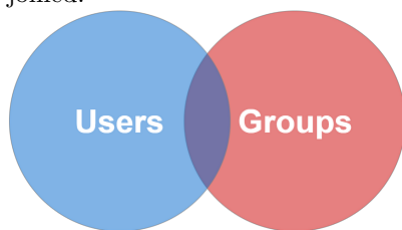
8.3.4 JOINS query examples

Lets say we have a table called users and a table called groups. One group can normally contain multiple users.

- If every user belongs to 1 group only, and every group has at least 1 user.

```
SELECT * FROM users INNER JOIN groups ON users.group_id = groups.id;
```

The intersection part (purple color) is the area of data that are INNER joined.

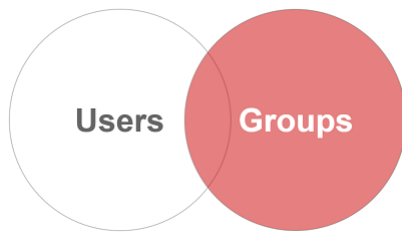


- If some users do not have a group, but every group has at least 1 user.

```
SELECT * FROM users RIGHT OUTER JOIN groups ON users.group_id = groups.id;
```

Here is the query in opposite direction

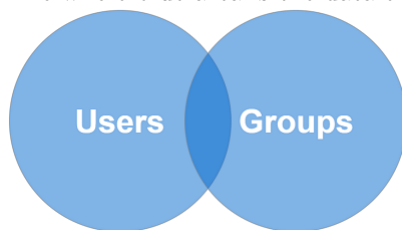
```
SELECT * FROM groups LEFT OUTER JOIN users ON groups.id = users.group_id;
```

- If some users do not have a group, and not every group has users.

```
SELECT * FROM users FULL OUTER JOIN groups ON users.group_id = groups.id;
```

The whole blue area is the data that is FULL OUTER joined.



8.4 Transaction

A Transaction is a unit of work performed which normally includes batch of command that you want to run reliably independent of other transaction.

8.4.1 Database Transaction

Any change on the data of the database can be represented by as a transaction. But normally transactions is used to make sure two things:

- To make sure multiple changes on the data to either succeed completely or fail completely. Therefore no partial changes exists when a transaction is completed or failed.
- To make sure that concurrent access on the data will not corrupt the data in an unexpected way. Hence either the changes on the data is completed successfully. Or the data is failed completely.

The best way to understand this concept is through a hypothetical scenario of doing a bank transfer between two person, Alice and Bob. Lets say Alice has 1000 dollar in her account, she wants to transfer it to Bob. Therefore she logged in to the E-Banking platform to perform the transfer. There are two trivial steps for this transfer which are as follow,

- Withdraw 1000 dollar from Alice Account
- Deposit 1000 dollar to Bob Account

The hypothetical SQL that are going to be run are as follow

```
UPDATE bank_accounts SET amount = amount - 1000 WHERE
    account_holder = 'Alice';
UPDATE bank_accounts SET amount = amount + 1000 WHERE
    account_holder = 'Bob';
```

Lets say Alice types the amount of \$1000 correctly and the amount is deducted successfully by the first SQL. Suddenly, the bank discovers that Bob is involved with money laundering and his account is frozen as the government is investigating him. As a result, the amount should not be deposited to Bobs account, otherwise it is illegal for the bank to do so. Using common sense in how bank transfer works in real life, we can deduce that the correct way of handling this error is the transfer amount should go back to Alices account. And the whole transfer is failed.

We have two ways of solving this problem:

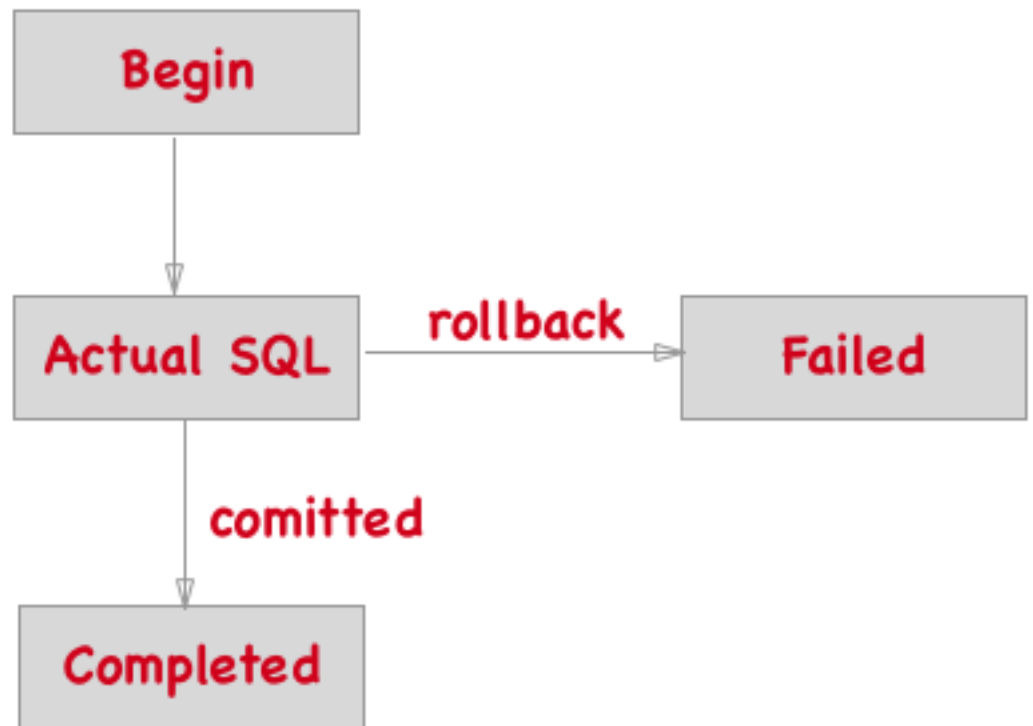
- (i) Un-do what you have already done with another SQL
- (ii) Use Database transaction.

For 1, it simply means that we have to run an additional SQL that un-do what is done already by the previous SQL. But is impractical in real life because we are not going to write a un-do SQL for every SQL we have written.

Therefore database transaction comes to rescue.

8.4.2 Lifecycle of a Transaction

The lifecycle of a transaction could be represented in the following pictures.



- **Begin:** The whole transaction begins when Alice confirm the transfer.
- **Actual SQL:** involves running the SQL to update the amount of Alices account and Bobs account respectively.
- **Commit:** If everything works fine and Bob is not involved in money laundering at all, then the changes are committed and the transfer is successful.
- **Rollback:** Otherwise all the changes are rolled back(go back to the state before any changes) and the transfer is a failure in the case of a frozen account from Bob.

8.4.3 SQL Command: Begin, Commit and Rollback

You can run the control the transaction explicitly in the psql shell. Before running your data-changing SQL. Run **BEGIN** to start the transaction

```
BEGIN;
```

And then run your SQL like usual. If everything works fine, run commit to declare that the transaction is successful.

```
COMMIT;
```

Otherwise, run rollback to declare that the transaction is a failure, all of the changes are going to be rolled back.

```
ROLLBACK;
```

8.4.4 Isolation in transaction

Every transaction is isolated from other transaction . Until you committed your changes in the current transaction , the changes you have made ARE NOT accessible from other transactions. Your instructor can demonstrate this to you.

Going back to the example mentioned in the beginning, if Charlie is accessing Alice account while the transaciton is taking place, Charlie does not know that Alice is doing a transfer until the transaction is committed.

8.4.5 PgClient transaction

You can also use transaction with PgClient easily. Here is an example of using PgClient to manage a transaction manually. But PgClient does not have a special API to manage transactions. Therefore we are going to show you how to write a simple API to make writing transactional code easier.

```
// The connection part are omitted. Just assume that we have a
// variable called client which can access the DB.

function begin(done){
  client.query('BEGIN',function(err){
    if(err){
      // Handle error here
    }
    done();
  });
}

function commit(done){
  client.query('COMMIT',function(err){
    if(err){
      //Handle error here
    }
    done();
  });
}

function rollback(done){
  client.query('ROLLBACK',function(err){
    if(err){
      //Handle error here
    }
    done();
  });
}

begin(function(){
```

```
client.query("UPDATE bank_accounts SET amount = amount -  
1000 WHERE account_holder = 'Alice'",function(err,  
results){  
  if(err){  
    rollback(function(){  
      console.log("Transaction is rolled back!");  
    });  
  }else{  
    commit(function(){  
      console.log("Transaction is committed!");  
    });  
  }  
});  
});
```

8.4.6 ACID Principle

All database transactions should fulfill the ACID principle which are four different properties that are as follow. The definitions below are from Wikipedia which defined the terms accurately.

- Atomicity Atomicity requires that each transaction be all or nothing: if one part of the transaction fails, then the entire transaction fails, and the database state is left unchanged. An atomic system must guarantee atomicity in each and every situation, including power failures, errors and crashes. To the outside world, a committed transaction appears (by its effects on the database) to be indivisible (atomic), and an aborted transaction does not happen.
- Consistency The consistency property ensures that any transaction will bring the database from one valid state to another. Any data written to the database must be valid according to all defined rules, including constraints, cascades, triggers, and any combination thereof. This does not guarantee correctness of the transaction in all ways the application programmer might have wanted (that is the responsibility of application-level code), but merely that any programming errors cannot result in the violation of any defined rules.
- Isolation The isolation property ensures that the concurrent execution of transactions results in a system state that would be obtained if transactions were executed sequentially, i.e., one after the other. Providing isolation is the main goal of concurrency control. Depending on the concurrency control method (i.e., if it uses strict - as opposed to relaxed - serializability), the effects of an incomplete transaction might not even be visible to another transaction.
- Durability The durability property ensures that once a transaction has been committed, it will remain so, even in the event of power loss, crashes, or errors. In a relational database, for instance, once a group of SQL statements execute, the results need to be stored permanently (even if the database crashes immediately thereafter). To defend against power loss, transactions (or their effects) must be recorded in a non-volatile memory.

9 Knex

9.0.1 Knex.JS

So far we have been writing a lot of SQLs and pass them as a string in Javascript. And then the library PgClient would query the database using the SQL we have input. It is working fine for simpler SQL. If we have more complex SQL, it is more error-prone to just write SQL query using string in javascript. And there is also no checking on the structure of the SQL we are writing.

As a result , we are introducing Knex.js which is a SQL query bulder library for Javascript. You can install knex by the following command:

```
npm install knex pg
```

To connect to database using knex

```
const knex = require('knex')({
  client: 'postgresql',
  connection: {
    database: "fruits",
    user: "accelerate",
    password: "password"
  }
});
```

9.0.2 A simple Comparison

Lets say we want to write a SQL like the following ,

```
SELECT * FROM users INNER JOIN groups on users.group_id = users
.id
INNER JOIN bookings on bookings.user_id =
users.id
where users.status = 'active';
```

To write it using string in javascript, we can writing the following,

```
var client = new pg.Client('postgres://accelerate:
password@localhost:5432/bookings');

client.connect();
// We have to write everything in one line because the backtick
preserves the newline characters in the string.
var query = 'SELECT * FROM users INNER JOIN groups on users.
group_id = groups.id INNER JOIN bookings on bookings.
user_id = users.id where users.status = 'active';';

client.query(query, function(err, results) {
  if(err) {
    console.log(err);
  }

  console.log(results.rows);
});
```

As you can see , the SQL becomes a very long string and we lose all the nice syntax highlighting that helps us distinguish keyword and table names/column names.

However, the readability is much nicer if you do it in knex instead,

```

const knex = require('knex')({
  client: 'postgresql',
  connection: {
    database: "bookings",
    user: "accelerate",
    password: "password"
  }
});

let query = knex.select("*").from("users").innerJoin("groups", "
  users.group_id", "groups.id")
  .innerJoin("bookings", "bookings.
    user_id", "users.id")
  .where("user.status", 'active');

console.log(query.toSQL()); // You can print the SQL in this
  way.

query.then((rows)=>{
  // You can access the fetched row here.
}).catch((error)=>{
  console.log(error);
  //Handle the error here.
});

```

As you can see , Knex basically transforms the keyword to a method call in javascript in a fluent interface pattern which allows us to chain the method as we wish just like SQL.

There is a knex Querylab that allows you to test your knex query online. The SQL box would show the SQL generated.

And from the example above, you can see the block

```

var knex = require('knex')({
  client: 'postgresql',
  connection: {
    database: "bookings",
    user: "accelerate",
    password: "password"
  }
});

```

specifies the database client it is going to use. The connection detail of this connection is specified accordingly.

9.0.3 Common methods

Query Builder

It contains the parts of the SQL that are regarded as DQL and DML Knex is flexible that allows you to specify your query in different manners.

Select

To build a select Query , you can write your KnexJS in the following ways.

```

// Using knex() the constructor.
knex("table").column(["column1", "column2", "column3"])

// Using select() method

```

```
knex.select('column1','column2','column3').from('table')

// Using the column() method
knex.column('column1','column2','column3').select().from('table')
```

All Javascript query from above gives you the same SQL which is SELECT column1,column2,column3 FROM table; The knex Select query is very flexible which allows you to write the method in different orders.

Where method

We would of course also want to query the database with where method. Again , the where methods in knex also allow the developers to specify the method call in multiple ways.

```
knex.select("column1","column2","column3").from("table")
  .where("column1","ABC")
  .orWhere("column2",>,"DEF")
  .andWhere("column3","like","%AC%");
```

would give you the following SQL.

```
select "column1", "column2", "column3" from "table"
where "column1" = 'abc'
or "column2" > 'DEF'
and "column3" like '%AC%'
```

The methods that are useful are where and orWhere methods. You can also use subquery in the following way:

```
knex.select("column1","column2","column3").from("table")
  .where("column1","ABC")
  .whereIn("table_2_id",function(){
    this.select("id").from("table2")
  });
```

would give you the following SQL

```
select "column1", "column2", "column3" from "table"
where "column1" = 'ABC'
and "table_2_id" in (
  select "id" from "table2"
)
```

Join/On method

To perform a SQL join in Knex is also very simple.

```
knex.select("column1","column2","column3").from("table")
  .innerJoin("table2","table_2_id","table2.id")
  .where("column1", "ABC")
```

The above javascript method call gives you the following SQL:

```
select "column1", "column2", "column3" from "table"
inner join "table2" on "table_2_id" = "table2"."id" where "
column1" = 'ABC'
```

You can also use an extra function to declare complex joining condition.

```
knex.select("column1","column2","column3").from("table")
  .innerJoin("table2",function(){
    this.on('table.table_2_id','=','table2.id').onNotNull('
      table2.id')
  }).where("column1","ABC")
```

The above javascript method call gives you the following SQL:


```
select "column1", "column2", "column3" from "table"
  inner join "table2"
    on "table"."table_2_id" = "table2"."id"
  and "table2"."id" is not null
 where "column1" = 'ABC'
```

GroupBy/OrderBy/Distinct Method

The SQL clauses group by , order by and distinct are also usable in Knex library.

```
// Using order by
knex.select("column1","column2","column3").from("table").
  orderBy("column1");

// Using group by
knex.count("column1").column("column2").from("table").groupBy("
  column2")

// Using distinct
knex.distinct("column1").from("table");
```

The above query would give the following SQLs respectively.

```
-- using order by
select "column1","column2","column3" from "table" order by "
  column1"

-- using group by
select count("column1"), "column2" from "table" group by "
  column2"

-- using distinct
select distinct "column1" from "table"
```

Insert

To create a insert statement, you can use the following method call.

```
// Using knex() the constructor.
knex("table").insert({column1:"value1",column2:"value2",column3
: "value3"})

// Using insert() method to start the method call
knex.insert({column1:"value1",column2:"value2",column3:"value3"
}).into("table")
```

Both javascript method calls would yield the same sql.

```
insert into "table" ("column1","column2","column3") value ("value1
","value2","value3");
```

You can also insert two rows at the same time by passing in an array instead.

```
knex.insert([
  {column1:"value1",column2:"value2",column3:"value3"},
  {column1:"value4",column2:"value5",column3:"value6"}
]).into("table").returning("id"); // Returning id returns the
  id of the inserted row.
```

Batch Insert

Sometimes we want to insert a large amount of rows at the same time, it is not appropriate to have all of the content in one sql because it is going to affect performance. In that case, we can insert those rows using the batchInsert method of knex.

```

var rows = [{column1:"value1",column2:"value2",column3:"value3"
}, {column1:"value4",column2:"value5",column3:"value6"}];
// The rows could be a lot more.
var batchSize = 30;
knex.batchInsert("table",rows,batchSize)
    .returning('id')
    .then((ids)=>{
        // Handle the returning ids here.
    })
    .catch((error)=>{
        // handle the error here.
    });

```

The batchInsert also automatically wraps a batch of rows using a transaction. In the above case, a transaction is committed for every 30 rows inserted.

Update

The update method call of knex is also intuitive in its design.

```

knex("table").update({column1:"value1",column2:"value2"}).where("column3","value3")

```

The above javascript method call gives you the following sql.

```

update "table" set "column1" = 'value1', "column2" = 'value2'
where "column3" = 'value3'

```

Delete

The same applies to the delete method call .

```

knex("table").where("column1","value1").delete();

```

The corresponding sql is as follow,

```

delete from "table" where "column1" = 'value1';

```

Transaction

Transaction is a very important part in SQL. Knex has a fairly complete support on transaction. Using the example from knexjs official website :

```

var Promise = require('bluebird');

// Using trx as a query builder:
knex.transaction(function(trx) {

    var books = [
        {title: 'Canterbury Tales'},
        {title: 'Moby Dick'},
        {title: 'Hamlet'}
    ];

    return trx
        .insert({name: 'Old Books'}, 'id')
        .into('catalogues')
        .then(function(ids) {
            return Promise.map(books, function(book) {
                book.catalogue_id = ids[0];

                // Some validation could take place here.

                return trx.insert(book).into('books');
            });
        });
});

```

```

    })
    .then(function(inserts) {
        console.log(inserts.length + ' new books saved.');
```

All of the sql run are within a single transaction. In case any one of them has a problem , the whole transaction is rolled back. Knex determines whether the transaction is committed back or rolled back by promise return. If the promise returned is rejected, the whole transaction is rollbacked. On the other hand , if the promise resolved without problem, the transaction is committed.

transacting The following block can also be written in the other way using transacting

```

return trx
    .insert({name: 'Old Books'}, 'id')
    .into('catalogues')
    .then(function(ids) {
        return Promise.map(books, function(book) {
            book.catalogue_id = ids[0];

            // Some validation could take place here.

            return trx.insert(book).into('books');
        });
    });

return knex
    .insert({name: 'Old Books'}, 'id')
    .into('catalogues')
    .transacting(trx)
    .then(function(ids) {
        return Promise.map(books, function(book) {
            book.catalogue_id = ids[0];

            // Some validation could take place here.

            return knex.insert(book).into('books').transacting('trx');
        });
    });
```

9.0.4 SQL Query builder vs Plain SQL

The advantage of using sql query builder is that it saves your time on syntax checking on the keyword of sql. And in general the syntax highlighting of the javascripts method is better than the SQL query wrapped in the Javascript string.

9.0.5 SQL Query builder vs ORM

Object relational mapping is another very common approach of simplifying sql-writing. We are not going to cover ORM at this moment because it is

important for you to get used to the powerful feature of SQL like group by , having and subquery. If you are interested in learning more about ORM, we would recommend you to use Bookshelf.js which is an ORM based on knex.js

9.0.6 Conclusion

We talked about a lot of different method calls in Knex JS. You should get a rough idea how knex method is translated to SQL in general. We are going to cover more on the structure of a knex.js.

9.1 Knex migrations CLI

9.1.1 Install Migration CLI

First of all, we have to also install knex cli globally to allow us to use knex to generate a knex repository.

```
sudo npm install knex -g
```

Then we have to create the project folder, lets say your application is called myApp.

```
# Make folder myApp
mkdir myApp
cd myApp
# Init NPM repository
npm init
# Install knex to the NPM repository
npm install knex
# Run knex CLI to init the repo
knex init
```

The knex migration tool generates a file called knexfile.js which stores the config of your knex project. Here is the content of the knexfile.js.

```
module.exports = {
  development: {
    client: 'postgresql',
    connection: {
      database: 'my_db',
      user: 'username',
      password: 'password'
    },
    pool: {
      min: 2,
      max: 10
    },
    migrations: {
      tableName: 'knex_migrations'
    }
  },

  staging: {
    client: 'postgresql',
    connection: {
      database: 'my_db',
      user: 'username',
      password: 'password'
    },
    pool: {
      min: 2,
```

```

    max: 10
  },
  migrations: {
    tableName: 'knex_migrations'
  }
},

production: {
  client: 'postgresql',
  connection: {
    database: 'my_db',
    user: 'username',
    password: 'password'
  },
  pool: {
    min: 2,
    max: 10
  },
  migrations: {
    tableName: 'knex_migrations'
  }
}
};

```

You can see from the above example that we have three different environments. A environment in knex holds the DB settings for your application in different environment. There are three environments generated by default

- development : It is the default environment for development. Therefore you have to input your development database information in this environment.
- staging : It is also called the beta or testing environment. It is normally the environment for your development team to do testing. You have to input the database information of the testing environment.
- production: It is the environment for your application in production. The database information should also accordingly be the production database information.

By default , knex-cli uses the development environment. You can change the environment you are using with the flag `-env`. For example, in a production environment, you have to run the following as a prefix for all other knex commands.

```
knex --env production
```

9.1.2 Configuration

We can then focus to look at one configuration to understand what configurations are there within each environment:

```

development: {
  client: 'postgresql',
  connection: {
    database: 'my_db',
    user: 'username',
    password: 'password'
  },
  pool: {
    min: 2,

```

```

    max: 10
  },
  migrations: {
    tableName: 'knex_migrations'
  }
}

```

- client : The target database you are connecting to. Knex supports PostgreSQL, Sqlite , Mysql, MariaDB, Oracle and MSSQL which already includes all of the main SQL vendor in the market.
- connection : The connection details of the current connection
 - database : The database name
 - user : The username
 - password : The password
- pool : The database pool configurations for your environment. We normally maintain a certain number of connections for our application instead of initiating a new connection for every request. It saves resource and enhances performance. You can read more about Connection pooling.
 - min : The minimum number of connections that knex would maintain no matter what the loading is.
 - max : The maximum number of connections that knex would maintain in case of high loading.

Dotenv

It is possible to put our username, password, database name directly in this case. But it is not preferable because we don't want the username/password to be exposed in this case. Therefore, we are going to use a package called dotenv. To install the dotenv package:

```
npm install dotenv
```

And then in your knexfile.js

```

require('dotenv').config();

module.exports = {
  development: {
    client: 'postgresql',
    connection: {
      database: process.env.DB_NAME,
      user: process.env.DB_USERNAME,
      password: process.env.DB_PASSWORD
    },
  },
  pool: {
    min: 2,
    max: 10
  },
  migrations: {
    tableName: 'knex_migrations'
  }
},

```

```

    staging: {
      ...
    },
    production: {
      ...
    }
  };

```

What we are trying to do is to load the database name, username and password as the environmental variables. The package `dotenv` would load the file `.env` from your folder. In your `.env` file, you have to input the following,

```

DB_NAME=test
DB_USERNAME=postgres
DB_PASSWORD=postgres

```

Please note that there is no space between and after the `=` sign. And then after you have called the method `require('dotenv').config()`, the environmental variables are then accessible at the object `process.env`.

Knex CLI

We can then use `knex-cli` to generate the next migration file. If you run `knex help` in your `knex` repository which is the folder you have run the command `knex init`. You are going to see the following output.

```

Usage: knex [options] [command]

Options:

  -V, --version          output the version number
  --debug                Run with debugging.
  --knexfile [path]     Specify the knexfile path.
  --cwd [path]           Specify the working directory.
  --env [name]           environment, default: process.env.NODE_ENV
                        || development
  -h, --help            output usage information

Commands:

  init [options]                Create a fresh knexfile.
  migrate:make [options] <name> Create a named migration
                                file.
  migrate:latest                Run all migrations that
                                have not yet been run.
  migrate:rollback              Rollback the last set of
                                migrations performed.
  migrate:currentVersion        View the current version
                                for the migration.
  seed:make [options] <name>   Create a named seed file
  seed:run                     Run seed files.

```

You can see there are two types of files we can created using `knex-cli`. The two types of files are the migration files and the seed files respectively.

Migration files

Migrations are changes to the database schema. We can think of migration just like the revision control of a database. By using migration files to store the changes in the database. We can easily migrate older version of the database to the latest version.

To create a new migration file , we can run the following:

```
knex migrate:make new-change-on-database
```

The command above generates a new migration file with the name `Timestamp_new-change-on-database.js`. Here is one possible example:

```
Using environment: development
Created Migration: /home/gordon/Codes/knexjs-test/migrations
/20171227145233_new-change-on-database.js
```

Note that the timestamp is the unix timestamp for the generation time. So the migrations file are automatically ordered by the respective generation time. Please do not modify the timestamp by yourself. It is supposed to be read by the migration tools only.

Within the file , the content is as follow,

```
exports.up = function(knex, Promise) {
};

exports.down = function(knex, Promise) {
};
```

The `exports.up` is exporting the function for the forward direction of the migration. So the up function is going to be run when you are telling knex-cli to migrate to the latest version of the database.

The `exports.down` is exporting the function for the backward direction of the migration. The down function is going to be run when you are telling knex-cli to rollback to the previous version.

The rule of thumb is that whatever is doing in the up function has to be completely undone by the down function. Otherwise inconsistencies could possibly occurs.

The two parameters passed to the function is the knex connection object initialized using `knexfile.js` and the Promise is the Promise library object that allows you to use common Promise method like `Promise.all()`.

Because knex check for the status of your schema-altering promise to check if the process is successful or not. You always have to return your knex method-calling promise in both the up and down functions.

Schema Builder In order to allow the developer to write the migration file properly, Knex actually comes with a schema builder which helps building DDL. DDL are the part of SQL that is responsible for defining the structure of the data.

Crate Table

Here is one example of writing Schema Building to create table,

```
exports.up = function(knex, Promise){
  return knex.schema.createTable('users', (table) => {
    table.increments();
    table.string("name");
    table.string("email");
    table.timestamps(false, true);
  });
}

exports.down = function(knex, Promise){
  return knex.schema.dropTable('users');
}
```

In the up function , we create a new table using the method call `knex.schema.createTable()`. And then within the function body , we go on to specify the columns details:

- `table.increments()` specifies the table has an id column that auto-increments
- `table.string("name")` specifies the table has an varchar column with the name name.
- `table.string("email")` specifies the table has an varchar column with the name email.
- `table.timestamps(false, true)` specifies the table would have a `created_at` , `updated_at` columns which is updated automatically during creation.

In the down function , we basically just drop the table to undo everything we have done within the up function.

Adding Column

We can also use migration file to add a new foreign key column. Here is an example,

```
exports.up = function(knex, Promise) {
  return knex.schema.table('users', (table) => {
    table.integer('group_id').unsigned();
    table.foreign('group_id').references('groups.id');
  });
};

exports.down = function(knex, Promise) {
  return knex.schema.table('users', (table) => {
    table.dropForeign('group_id');
    table.dropColumn('group_id');
  });
};
```

We can use `knex.schema.table()` to access the table of the database. And then we use the methods of the table object again to add/drop column. The method `table.integer('group_id')` adds an integer column called `group_id` to the table `users`. The method `table.foreign('group_id')` adds a foreign constraint on the column `group_id`.

Running Migration

After you have finished writing your migration files, you should check in all these files in git in order to track them as part of your source code. Now you can regard your database structure also version-controlled.

Migration to latest version

It is actually easy to run database migration. You can run the following command:

```
knex migrate:latest
```

Knex will migrate your database to the latest possible version by running all the up function. Note that THERE IS NO COMMAND IN KNEX THAT ALLOWS DEVELOPER TO MIGRATE ONLY ONE MIGRATION.

Rollback migrations

To rollback last set of migrations , you can run the following command:

```
knex migrate:rollback
```

Knex will migrate your database to the latest possible version by running all the up function. Note that THERE IS NO COMMAND IN KNEX THAT ALLOWS Knex will rollback your previous set of database migration by running the down function in your migrations files. That is the reason why is crucial to write also the down function correctly.

Current Version

You can also check what is the current version of migration.

```
knex migrate:currentVersion
```

9.1.3 Development Environment Migration Flow

The normal flow of database migration which is applicable for development environment.

Creating Migration

1. Generate a new migration file by running the command

```
knex migrate:make <name-of-the-migration>
```

2. Write the corresponding up and down function in the migration file. The following content is an example.

```
exports.up = function(knex, Promise){
  return knex.schema.createTable('users', (table) => {
    table.increments();
    table.string("name");
    table.string("email");
    table.timestamps(false, true);
  });
}

exports.down = function(knex, Promise){
  return knex.schema.dropTable('users');
}
```

3. Run Migration

```
knex migrate:currentVersion
knex migrate:latest
```

4. Git Add , Git Commit and Git push to the collaborating repository

```
git add .
git commit -m "Commit message"
git push origin master
```

Running Migration

The following is applicable for both development and production environment:

5. The other collaborators run git pull origin master to get the latest changes. And then run the command to migrate to the latest version.

```
knex migrate:latest
```

Seeding

Other than migrations, you can also generate seeding files for your project. Seeding are initial data that your application need in order to run your correctly. To generate a seeders file, you can run :

```
knex seed:make initial-user
```

initial-user is the name of this seeding. You should have different name for different seeders. The file initial-user.js should be generated within the folder seeds. The content should be as follow,

```
exports.seed = function(knex, Promise) {
  // Deletes ALL existing entries
  return knex('table_name').del()
    .then(function () {
      // Inserts seed entries
      return knex('table_name').insert([
        {colName: 'rowValue1'},
        {colName: 'rowValue2'},
        {colName: 'rowValue3'}
      ]);
    });
};
```

It is just like the migration function , the only difference is that you are going to create initial data for this application. Once you finish writing this , you can run the seeders file with the following command.

```
knex seed:run
```

It is going to run all of your seeders file.

10 Database Theory

10.1 Introduction

10.2 Associations

Database design should be the first step in your database-driven application development. It is often said that we should always design our code around the data because once the database design is designed well, normally the code to manipulate the data will be trivial.

10.2.1 Different Types of Associations

There are mainly three types of association. To illustrate the differences, we can look at the tables of a hypothetical school.

- One-to-One :
- Many-to One and One-to-Many :
- Many-to-Many :

One-to-One

A one-to-one association can be defined by putting one table's foreign key into another one. Here is the migration example for the head teacher and class example in above. Migration for classes:

```
exports.up = function(knex, Promise){
  return knex.schema.createTable('classes', (table) => {
    table.increments();
    table.string("name");
    table.string("classroom");
    table.string("period");
    table.timestamps(false, true);
  });
}

exports.down = function(knex, Promise){
  return knex.schema.dropTable("classes")
}
```

Migration for teachers:

```
exports.up = function(knex, Promise){
  return knex.schema.createTable('teachers', (table) => {
    table.increments();
    table.string("name");
    // The unique is necessary to guarantee it is a one-to-one relation.
    table.integer('class_id').unsigned().unique();
    table.foreign('class_id').references('classes.id');
    table.timestamps(false, true);
  });
}

exports.down = function(knex, Promise){
  return knex.schema.dropTable("teachers")
}
```

Because the column `class_id` is marked as unique. Now each `class_id` can only appear once in the whole table. Thus one teacher (one row in teachers) can only correspond to one class (one row in classes).

Many-to-One and One-to-Many

I am going to reuse the table classes again in the previous example. And now we have to create migration for the table students.

```
exports.up = function(knex, Promise){
  return knex.schema.createTable('students', (table) => {
    table.increments();
    table.string("name");
    //No unique is necessary because it is a one-to-many relation.
    table.integer('class_id').unsigned();
    table.foreign('class_id').references('classes.id');
    table.timestamps(false, true);
  });
}

exports.down = function(knex, Promise){
  return knex.schema.dropTable("students")
}
```

For one-to-many/many-to-one relations, the only difference in the table is that on the MANY side, you don't need to constraint the `class_id` to be a unique value. Now the table students has multiple rows of data contains the same `class_id`. Thus many students are joined to one class.

Many-to-Many

Each Students can take multiple subjects at the same time while each subject can be taken by multiple students at the same time. Thus the entity relation between the students and subjects is many-to-many relation. A many-to-many relation would need a join table as the join table to connect both the students and the subjects table. We can call this table `students_subjects`.

Lets create the migration for the table subjects and `students_subjects` to show you that is actually possible to create multiple tables in one migration.

```
exports.up = function(knex, Promise){
  return knex.schema.createTable("subjects", (subjects) => {
    subjects.increments();
    subjects.string("name");
    subjects.timestamps(false, true);
  }).then(() => {
    return knex.schema.createTable("students_subjects", (
      studentsSubjects) => {
        studentsSubjects.increments();
        studentsSubjects.integer("student_id").unsigned();
        studentsSubjects.foreign("student_id").references("
          students.id");
        studentsSubjects.integer("subject_id").unsigned();
        studentsSubjects.foreign("subject_id").references("
          subjects.id");
      });
  });
}
```

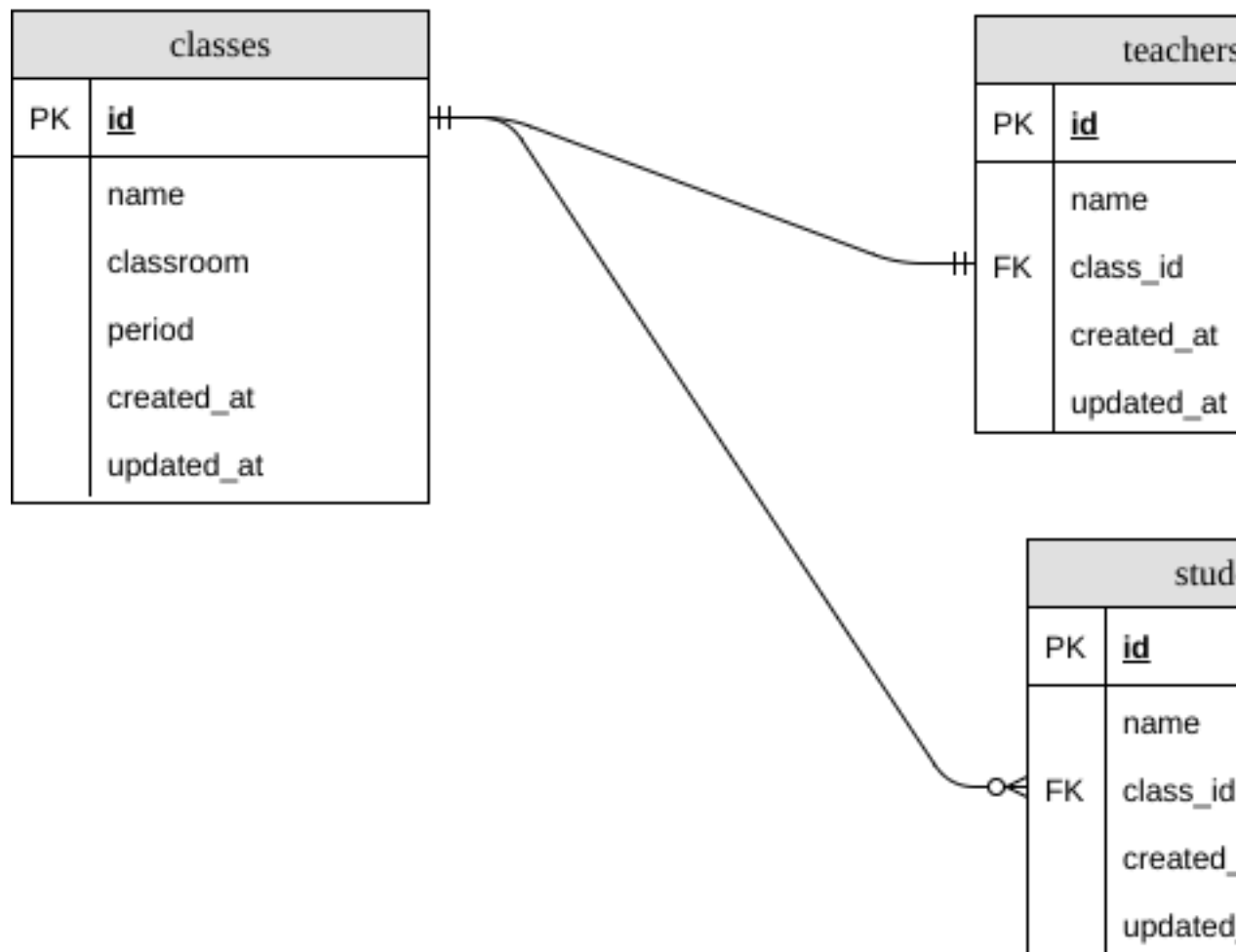
```

}

exports.down = function(knex, Promise){
  return knex.schema.dropTable('students_subjects')
    .then(()=>knex.schema.dropTable('subjects'));
}

```

Basically, the Entity relation diagram(ERD) from the examples above is as follow:



You should also draw your own ERD to visualize your entity relation. You can check out a tools called LucidChart

10.3 Database Design

10.3.1 Principles of designing your database

11 Assignment 3 - notes taking knex

12 Redis

12.1 Introduction

12.1.1 Installing redis

12.1.2 Troubleshooting

12.2 Redis and node

13 Websockets

13.1 Introduction

13.2 Socket.io

```
//server.js
const express = require('express');
const app = express();
const http = require('http').Server(app);
const io = require('socket.io')(http);

app.get('/', (req, res) => {
  res.sendFile(__dirname + '/index.html');
});

io.on('connection', (socket) => {
  console.log('a user connected to the socket');
});

http.listen(3030);
```

As you can see above we set up a very simple server using express. The server only serves one file, the index.html file. interestingly we listen using the http module internal to node. That is because socket.io makes use of this module. We then require socket.io and pass it the http module.

To listen out for events using socket.io we use the .on method and specify the event we are listening for, in our case the connection event.

Let's add the index.html file so the code actually works.

```
<html>
<head>
  <style>
    * { margin: 0; padding: 0; box-sizing: border-box; }
    body { font: 13px Helvetica, Arial; }
    form { background: #000; padding: 3px; position: fixed;
      bottom: 0; width: 100%; }
    form input { border: 0; padding: 10px; width: 90%; margin-right: .5%; }
    form button { width: 9%; background: rgb(130, 224, 255);
      border: none; padding: 10px; }
    #messages { list-style-type: none; margin: 0; padding: 0; }
    #messages li { padding: 5px 10px; }
    #messages li:nth-child(odd) { background: #eee; }
  </style>
</head>
<body>
  <ul id="messages"></ul>
  <form action="">
    <input id="m" autocomplete="off" /><button>Send</button>
  </form>

  <script src="https://cdnjs.cloudflare.com/ajax/libs/socket.io
    /2.0.3/socket.io.slim.js"></script>
  <script src="https://code.jquery.com/jquery-1.11.1.js"></script>
  <script>
    var socket = io();
  </script>
```

```
</body>
</html>
```

Let's add another event listener to our server file. This time we will listen on the socket (the parameter passed in the callback) directly. The code should look like this:

```
io.on('connection', (socket) => {
  console.log('a user connected to the socket');
  socket.on('disconnect', () => console.log('a user left us'));
});
```

13.2.1 emitting events

In order to actually listen to events we also need to be able to emit them. Besides a few events like `connection` few events are predefined in `socket.io`

In our case we want to create a simple chat, that means the user will add messages, which would be an ideal event to listen for. So let's edit the client side logic.

```
<script>
  \$(function () {
    var socket = io();
    \$('#form').submit(function(){
      socket.emit('chat message', \$('#m').val());
      \$('#m').val('');
      return false;
    });
  });
</script>
```

Every time the user adds a new message, `socket.io` will fire off an event which we can listen out for. So let's add the relevant code on the server.

```
io.on('connection', function(socket){
  socket.on('chat message', function(msg){
    console.log('message: ' + msg);
  });
});
```

13.2.2 Broadcasting

Now it is time to send something back from the server. Since we want to inform all the participants of the new message. We can broadcast the message back to all listeners. Let's update our server code.

```
io.on('connection', function(socket){
  socket.on('chat message', function(msg){
    io.emit('chat message', msg);
  });
});
```

As you can see above all we do is listen for a message and then rebroadcast this message to all listening sockets. We do that by emitting an event which the clients listen for.

Now we need to listen out on the client for the server broadcast and render the message to the user. Let's update the html file.

```
<script>
  \$(function () {
    var socket = io();
    \$('#form').submit(function(){
      socket.emit('chat message', \$('#m').val());
      \$('#m').val('');
      return false;
    });
    socket.on('chat message', function(msg){
      \$('#messages').append(\$('#<li>').text(msg));
    });
  });
</script>
```

13.2.3 Using SocketIO with express

In order to use SocketIO with express , you have to use the package http to retrieve the server instance from express. Here is the official example from SocketIO:

```
var app = require('express')();
var server = require('http').Server(app);
var io = require('socket.io')(server);

// Call listen method ON SERVER!! Not app
server.listen(80);

app.get('/', function (req, res) {
  res.sendFile(__dirname + '/index.html');
});

io.on('connection', function (socket) {
  socket.emit('news', { hello: 'world' });
  socket.on('my other event', function (data) {
    console.log(data);
  });
});
```

13.2.4 Namespaces

By default, SocketIO is using the namespace /. You can actually switch to other namespace to use it with another endpoint(Not URL!!). You can actually making use of the namespace by the method of on the server-side. On the server side,

```
const namespace1 = io.of('/namespace1');
namespace1.on('connection', (socket) => {
  console.log('Socket with id ${socket.id} connected!');
});
namespace1.emit('hello', "World!");
```

On the client side,you can access this namespace1 by providing the name of the namespace.

```
let socket = io('/namespace1')
```

13.2.5 Rooms

Namespaces are good if you want to completely separate the clients. But if you want to concept of subscribing, which one client can listen to multiple channels at the time. Then you have to use **Rooms** instead. Here is one simple **subscribe** event that can hook the respective socket to the room.

```
//Server Side
io.on('subscribe',(room)=>{
  socket.join(room);
});

//Client side
socket.emit('subscribe','my-room');
```

To simply send messages to a specific room, you can use the method **to**.

```
io.to('my-room').emit('subscription-reply',"Thanks for subscribing
my-room!");
```

14 User Authentication

14.1 Introduction

14.2 Passport.js

14.2.1 Users Data

14.3 Bcrypt

14.4 Social Login

14.5 Redis Session

15 System Admin

15.1 Introduction

15.2 Digital Ocean

15.3 apt-get

15.4 Bash

15.5 NodeJs Setup

15.6 Process Manager and Nginx

15.7 Git Deployment

16 Assignment 4 - chatroom single file

17 Extension topics

17.1 Data Structure

17.1.1 List, Map and Set

17.1.2 Stack and Queue

17.2 HTTP Header

17.3 Algorithm

17.3.1 Sorting

17.3.2 Searching

17.4 Dependency Injection

17.5 Operating System

17.6 Hamming

17.6.1 Introduction

17.7 Software Licensing

17.7.1 Introduction