**USEFUL LINKS**

* Using ES6 Promises instead of callbacks for mongoose queries - <http://erikaybar.name/using-es6-promises-with-mongoosejs-queries/>
* Quora, difference between callback and a promise - <https://www.quora.com/Whats-the-difference-between-a-promise-and-a-callback-in-Javascript>
* software engineering, is there really a fundamental difference between callbacks and promises? - <https://softwareengineering.stackexchange.com/questions/302455/is-there-really-a-fundamental-difference-between-callbacks-and-promises>
* Promises (about) - <https://promisesaplus.com/#point-2>
* Switching out callbacks with promises in mongoose - <https://eddywashere.com/blog/switching-out-callbacks-with-promises-in-mongoose/>
* Avoiding callback hell while using mongoose - <http://www.summa.com/blog/avoiding-callback-hell-while-using-mongoose>
* Using Promises with mongoose ejs - <http://blog.revathskumar.com/2015/07/using-promises-with-mongoosejs.html>
* **stackoverflow, using promises in mongoose routes and creating re-usable methods with queries/promises in them** - <https://stackoverflow.com/questions/38860898/using-promises-in-mongoose-routes>

**ABOUT**

* Callbacks and Promises are two ways to handle asynchronous programming (see bullet below for asynchronous), though both work, promises are generally considered to be better, due to avoiding ‘callback hell’. This concept and the differences between the two is pretty complex and complicated, so this word doc was made to help explain and understand everything.
* Asynchronous programming is when your code stops running synchronously, meaning your code stops running top to bottom. Synchronous is when your code runs from top to bottom, executing each line of code as you go. Asynchronous is when that stops for some reason, or when you have delayed code. An example of this is the http routes you hit in the factories of your full mean project. Ex: “factory.login = function(data, callback){ $http.post('/login', data).then(…..)”, in this example, you send a post to ‘/login’ and the code waits to get it back. When it does, the code after “.then” gets executed. But this is asynchronous code, it stops running normally and waits for the response. Though the code in this example is a callback, either way, if I had a console.log outside the .then() code, it would get run before the code inside of the .then(), hence the nature of asychronouse code
* What is a promise? A promise is a representation of a value that isn’t necessarily known at its creation time. When you use a promise, the function returns a promise rather than an asynchronous call accepting a callback. The code that needs the promise waits until the promise is fulfilled before executing the next step, in Javascript, this is shown as a .then() code.

**IMPORTANT NOTES AND THINGS TO KEEP IN MIND**

* All promises, and .exec() methods are asynchronous, which as I stated above, means they get executed or finish getting executed out of order. They finish after any code written after them, the .exec() in particular returns a “promise”, which is literally read as undefined, it’s just a piece of code that node/mongoose reads as having a value once the .exec() is finished. So, if I wrote “var users = User.find({}).exec()”, and then in the next line wrote “console.log(users)”, it would log “undefined” because it is still a promise and doesn’t have a value. To work with the actual value, you need to always chain a .then() after it, even if it is nested inside another .then(). Because a .then() waits until whatever it is chained off of actually finishes. So if I put “var users = User.find({}).exec().then(function(users){ console.log(users) })”, it would log the correct value, all of the users in the User model.
* **SAVE()**: .save() like a .exec() returns a promise, but you should always return a .save() if it’s within a .then() method. Because, if you don’t return a .save(), and you write more code inside the .then() method, if there are any issues with the save, it won’t be caught by the .catch() method for some reason, and give you "Unhandled Promise Rejection". For example, see the code below, which is shortened and simplified:

Message.findOne({\_id: req.params.id}).exec()

.then(function(message){

comment.\_message = message.\_id

comment.save()

})

.catch(function(err){

if(err){

console.log("Error: ", err);

res.redirect('/')

}

})

* **STILL SAVE()**: The code below gives you the "Unhandled Promise Rejection", and basically doesn’t even active the .catch() method if the .save() fails. Still not sure why, most likely because it returns a promise like the .exec(), but if you change the code, return the .save() and end the .then() there, then the catch works properly, as shown below

Message.findOne({\_id: req.params.id}).exec()

.then(function(message){

comment.\_message = message.\_id

return comment.save()

})

.catch(function(err){

if(err){

console.log("Error: ", err);

res.redirect('/')

}

})

**WHY PROMISES OVER CALLBACKS**

* Callback hell is when you have nested callbacks, it often gets complicated, hard to read, and very wide before high, meaning it looks like the code in red below:

Department.find({name: 'Development'}, function(error, department){

Manager.find({departmentId: department.\_id}, function(error, manager){

Employee.find({manager: manager.name},function(error, employees){

res.render('employees', {

employees: employees

});

});

});

});

});

* The above code also runs into the issue of, if there is a block or error anywhere in that block, the entire thing gets blocked. Promises not only make your code easier to red, but instead of having an error handler (“if (err)”) for each level, we can have one error handler for multiple blocks. The blue code below is the same as the code above but with promises instead of callbacks:

Department.getDepartment("Development")

.then(function(department){

var Manager = mongoose.model('Manager');

return Manager.findManager(department);

})

.then(function(manager){

var Employee = mongoose.model('Employee');

return Employee.getEmployeesForManager(manager);

})

.then(function(employee){

res.send('/employees', {

employee: employee

});

})

.catch(error) {

console.log(error);

})

.done();

});

* The difference between the pyramid like callback one and the promise block above can already be seen, imagine code where there are even more nested callbacks/promises. Also, to provide an example of not only a mongoose/mongoDb case, but one where the callback needs an error handler for each level but the promise only needs one, see the callback part in red below:

User.findById('123', function(err, user) {

if (err) {

return console.log('error:', err);

}

user.name = 'Robert Paulson';

user.save(function(err) {

if (err) {

return console.log('error:', err);

}

console.log('updated user: ' + user.name);

});

});

* Now see the promise version with only one error handler in blue below:

var promise = User.findById('123').exec();

promise.then(function(user) {

user.name = 'Robert Paulson';

return user.save();

})

.then(function(user) {

console.log('updated user: ' + user.name);

})

.catch(function(err){

console.log('error:', err);

});

* In that example, the .catch serves as the error handler for both .then()s

**BASICS AND FORMAT OF PROMISES WITH MONGOOSE**

* **EXEC:** .exec() is a method that executes the query and returns a promise. You can plug that in a variable, ex: “var promise = User.find({}).exec()”, chain a .then after it, either on the same line or a new one, or return just that result. Queries are executed by either a callback or this method, meaning you can execute it with the above example in quotes, or with “User.find({}, function(err, user){...})”, you could also just put the callback function in the exec(callback here), in which case, it would still be a callback and not a promise. Always remember that this method is asynchronous, so if you plugged a it into a variable and tried to console log it in the next line, it would show up as “undefined” because the value is still a promise and the exec hasn’t finished yet. If you want to do anything with a .exec() return value, you chain a .then() after it, or if it’s already within a .then(), you could return it and end the .then() there.
* **THEN:** technically, queries aren’t full-fledged promises, but they still have a .then() function for yield and async/wait. Basically, a .then() method waits until it’s given what it was “promised”, in other words, after I execute a query with “User.find({}).exec()”, if I have a “.then(function(result){…})” on the next line, the .then() waits until the first query is actually executed and returns a result, and like it’s named, it then does what is inside of it. when writing a .then(), usually you put a function, ex: “.then(function (user){..}), it doesn’t matter what you put as the function parameter, I put “user” in this example, but it represents or is actually the result of the .exec() or .then() method ahead of it. IMPORTANT: unlike .exec(), .then() doesn’t return anything by default, so you need to return something at the end of it, or the next thing, whether it be .then, .catch, or something else won’t have anything to work with.
* **CATCH:** this is used to catch errors, basically the “if (err)” part in callback functions. There is little documentation on it, though from the examples I’ve seen, it can be used for multiple .exec or .then methods. format is typically used after a “.then()”, and is “.catch(function(err){….do something….})”
* Basically, you exec a query with the model by using “.exec()”, example with a User model: “User.find({}).exec()” , you then chain off of it with a .then() method, which you can keep chaining with a .then()s. Make sure you use return at the end of each .then(). At the end, you can use a .catch() to catch any errors though there are other ways you could do it. ex:

User.findOne({….}).exec()

.then(function(user){

do something…..

return [user, something\_else]

})

.then(function(result\_from\_first\_.then){

do something….

return something

})

.catch(function(err){

do something with error…

})

* That’s the basic format, you could return whatever you want, probably the result from all the queries, the link listed above: using promises with mongoose: <http://blog.revathskumar.com/2015/07/using-promises-with-mongoosejs.html>, is a good example

**MY OWN EXAMPLES OF PROMISE CODE/QUERIES**

* See the next section for promises examples found online. I will provide the original callback version in red, then the promise version in blue, with all comments in green. Also NOTE: This is from the message\_board project in the express folder, so now a full mean app.
* **SCHEMAS/MODELS WORKED WITH FOR THE BELOW EXAMPLES:**

var MessageSchema = new mongoose.Schema({

message: {type: String, required: true, minlength: 10},

name: {type: String, required: true, minlength:4, maxlength: 30},

comments: [{type: Schema.Types.ObjectId, ref: 'Comment'}]

}, {timestamps: true});

var CommentSchema = new mongoose.Schema({

comment: {type: String, required: true, minlength: 10, maxlength: 150},

name: {type: String, required: true, minlength: 4, maxlength: 30},

\_message: {type: Schema.Types.ObjectId, ref: 'Message'}

}, {timestamps: true});

var Message = mongoose.model('Message', MessageSchema);

var Comment = mongoose.model('Comment', CommentSchema)

* **EXAMPLE ONE - FIND:** This is a simple example of just finding all of the messages, and populating it with the comments (not important for this example), I then render a page and pass the queries results (results in this case) to the view. I use an .exec() method only because of the .populate() method, but I still pass my callback to the .exec()

Message.find({}).populate('comments').exec(function(err, results){

if(err){

console.log(err)

}

res.render("index", {messages: results});

})

* Next, see the promise version below:

Message.find({}).populate('comments').exec()

.then(function(messages){

res.render("index", {messages: messages});

})

.catch(function(err){

if (err){ console.log("error: ", err);}

})

* As simple of a promise as you can get, I execute the query with .exec(), follow it with a .then(), which gets the results of the exec (“messages” in this case) and passes it to the view, with a .catch() to deal with any errors, though probably unnecessary for a find({}).
* **EXAMPLE TWO - CREATE MESSAGE:** The below example is a callback of creating a new message, which renders the view with errors if anything went wrong, or redirects to ‘/’ if it all was successful. See below:

var message = new Message(req.body)

message.save(function(error){

if(error){

Message.find({}).populate('comments').exec(function(err, results){

if(err){console.log(err)}

res.render("index", {messages: results, err: error}); //this would have to changed in full mean, as it loads the inital page with all the right info, but we're still in the "post" route of "/message", which you shouldn't stay in.

})

} else{

res.redirect('/')

}

})

* Now the promise version below, I start with a .save() instead of a .exec(), I return the exec inside of the first then so that the next then method would have access to it. The .then() method doesn’t return anything by default, so you have to do it yourself. Notice, in the catch(), I run a exec and then a nested .then() within the catch. This is because I wouldn’t be able to send the results from the exec() method to the view, unless I rendered the view inside of a .then(), which waits for the exec() to finish before being run.

var message = new Message(req.body)

message.save()

.then(function(){

return Message.find({}).populate('comments').exec()

// The return line above is a simple way of executing a query inside of a .then() and returning it. If I wanted to return anything else, or also return the data that this .then() started with (nothing in this case), I would create a nested .then() and chain it off of the .exec(), since it's within the scope of the first .then() it would have access to the data it started with. Always remember, that queries and .exec() is asynchronous, so if I didn't chain a .then() (which waits for the .exec() to finish) after it, then anything I put after the .exec() wouldn't actually have access to it, but a "promise" instead, which would be undefined until the .exec() finishes.

})

.then(function(messages){

res.redirect('/')

})

.catch(function(err){

if(err){

var results = Message.find({}).populate('comments').exec()

.then(function(results){ //notice I use a .then() within a .catch(), this is so I have access to the .exec() query. If the res.render wasn't in a .then(), then the results variable would be equal to a "promise", which is undefined until the .exec() finishes. But the .exec() is asynchronous, meaning it breaks the normal workflow and code written after it actually gets executed before it.

console.log("error at save:", err);

res.render("index", {messages: results, err: err}); //this line would have to changed, as it loads the inital page with all the right info, but we're still in the "post" route of "/message", which you shouldn't stay in.

})

}

})

* **EXAMPLE THREE - CREATING A COMMENT:** Since Message and Comment are in a many to one relationship, I need to first find the message, then save the comment, then if that worked, add that comment to the Message’s “comments” column, which is where it keeps an array of foreign keys to keep track of what comments are related to it. See the callback below, also “result” is the single message that was found with findOne({})

Message.findOne({\_id: req.params.id}, function(err, result){

var comment = new Comment(req.body);

comment.\_message = result.\_id;

comment.save(function(err){

if(err){

console.log("There was an error creating the comment");

res.redirect('/')

}

result.comments.push(comment);

result.save(function(error){

if(error){

console.log('There was an error saving the message with the new comment')

}

res.redirect('/')

})

})

})

* Now for the promise version, this one is important. Notice how I always return a .save() if it’s within a .then() method and end the method there. As I stated above in the “things to remember/keep in mind” section, if you don’t do this, and add more code to the .then() after the save method is used, if there was a problem saving it, the catch method won’t see it and you will get a "Unhandled Promise Rejection" note in the terminal, since the catch method didn’t active. If you use a save within a then() method, always return it and end there, continue in another then(). Also, notice how I use a then after the second exec method, nested within a first then (marked by stars). In order to return that exec query results and the data from the initial then() that they are both within, I chained a nested .then() after the exec, since it will have access to the data from the exec and the first then(), I then return both results in an array format. Even though I returned the exec, the .then() chained off of it still gets run, almost as if I returned a function but ran it at the same time. So the order it would go in is, run the exec, run the nested then, return the “return [message, comment]” from the nested then.

var comment = new Comment(req.body)

Message.findOne({\_id: req.params.id}).exec()

.then(function(message){

comment.\_message = message.\_id

return comment.save() //You should always return a .save() and end the .then() there, or you will wind up with "Unhandled Promise Rejection" errors and your .catch() won't work properly, if your validations or some other reason caused the .save()

})

.then(function(comment){

return Message.findOne({\_id: req.params.id}).exec()

.then(function(message){ //\*\*\*\*\*\*\*a .then() nested within a .then()

return [message, comment]

})

})

.then(function(data){

var message = data[0]

var comment = data[1]

message.comments.push(comment)

return message.save()

})

.then(function(){

res.redirect('/')

})

.catch(function(err){

if(err){

console.log("\*\*\*\*\*\*\*\*\*\*\*\*");

console.log("Error: ", err);

res.redirect('/')

}

})

* d

**USING PROMISES IN MONGOOSE/ SWITCHING OUT YOUR CALLBACKS WITH PROMISES**

* **OTHER EXAMPLES AND SOURCE MATERIAL:** also listed above: stackoverflow, using promises in mongoose routes - <https://stackoverflow.com/questions/38860898/using-promises-in-mongoose-routes>, switching out callbacks with promises in mongoose - <https://eddywashere.com/blog/switching-out-callbacks-with-promises-in-mongoose/>, using promises with mongoose ejs - <http://blog.revathskumar.com/2015/07/using-promises-with-mongoosejs.html>, stackoverflow, best practice of using promises with mongoose - <https://stackoverflow.com/questions/38042964/best-practice-of-using-promise-with-mongoose>
* **IMPORTANT NOTE:** In the examples below, the callback code will be in red, the promise code will be in blue, and comments in green
* **EXAMPLE ONE**: In this example, which I take from the switching out callbacks with promises in mongoose link above, I first find a user, update the name, and save it.

// error first callback style

User.findById('123', function(err, user) {

if (err) {

return console.log('error:', err);

}

user.name = 'Robert Paulson';

user.save(function(err) {

// yet another err object to deal with

if (err) {

return console.log('error:', err);

}

console.log('updated user: ' + user.name);

// do something with updated user

});

});

* In the above example, I have two error handlers (two if’s), and the entire block of code is contained within the parentheses opened by “findById”, which makes it hard to tell by looking what ends where. And this is with only one level of nesting, the code below is the same thing but with promises. It also uses model queries that return a promise via the .exec() function:

var promise = User.findById('123').exec();

promise.then(function(user) {

user.name = 'Robert Paulson';

return user.save(); // returns a promise

})

.then(function(user) {

console.log('updated user: ' + user.name);

// do something with updated user

})

.catch(function(err){

// just need one of these

console.log('error:', err);

});

NOTE: the first line “var promise =” doesn’t have to be plugged into a variable, it could also be “User.findById(‘123’).exec()” and then, on the next line, by starting with “.then()”, you chain off of the .exec(), also “.exec()” by default returns a promise. Putting it in a variable, then using the “.then()” off of that variable isn’t necessary, in most examples I see, they don’t use a variable.

* Notice how there is just one error handler for both promises, the .catch(), promises are often more readable, especially when you have even more nested queries. Also notice, in the first promise, you return something, always return something at the end of a .then()
* **EXAMPLE TWO:** this code is from using promises with mongoose - <http://blog.revathskumar.com/2015/07/using-promises-with-mongoosejs.html>. In this example, I fetch a User, then a Project with the user\_id, and an Issue with that project, so I work with 3 models. Also, this isn’t full mean, due to rendering the page directly at the bottom, but the code is still relatable. See the callback version below:

var User = require('./models/user');

var Project = require('./models/project');

var Issue = require('./models/issue'); //these are just calling the models from other files

exports.index = function (req, res) {

var username = req.params.username;

var project = req.params.project;

User.findOne({username: username}, function(err, user){

if(err) { //first error handler

console.log(err);

return

}

Project.findOne({name: project, user: user.\_id}, function(err, project){

if(err) { //second error handler

console.log(err);

return

}

Issues.find({project\_id: project.\_id}, function(err, issues){

if(err) { //third error handler

console.log(err);

return

}

res.render('./views/issues/index', {user: user, project: poject, issues: issues});

//This renders the view directly, we would do this differently in full mean

})

});

});

}

* In the example above, you can start to see how nested queries can get messy, but there isn’t a lot done inside the actual queries themselves. Also, notice how we always have access to the result of each query after said query, so we don’t have to keep track of them with the callback method, since each is inside the scope of the initial query, and each query resides in the scope of the one before. Now, see the promise version below:

var User = require('./models/user');

var Project = require('./models/project');

var Issue = require('./models/issue');

exports.index = function (req, res) {

var username = req.params.username;

var project = req.params.project; //these two lines aren’t necessary, just cleans up the code a bit

User.findOne({username: username}).exec()

.then(function(user){ // “user” is what the first query returned or gave us

return Project.findOne({name: project, user\_id: user.\_id}).exec() //we could actually plug this into another variable so we wouldn’t need the .then() statement below

.then(function(project){ //this is actually a second .then still in the scope of the first one, so it stil has access to “user”

return [user, project]; //now we’re passing the results from the first and second query to the next .then()

});

})

.then(function(result){ // “result” here is equal to the “return[user, project]” above

var project = result[1]; //this is equal to the result from the Project.findOne query above

return Issues.find({project\_id: project.\_id}).exec()

.then(function(issues) {

result.push(issues); // now result would look like: “[user, project, issues]”

return result; //we return result as it looks in the comment above

})

})

.then(function(result){ //this .then just takes the result from our 3 queries and plugs them into variables, would could skip the .then altogether by putting the res.render below in the previous .then() or even trying to put the results from the last then(0 into a variable, though I’m not sure how that could be done.

var user = result[0];

var project = result[1];

var issues = result[2];

res.render('./views/issues/index', {user: user, project: project, issues: issues});

})

.then(undefined, function(err){ // in theory, this can be replaced with a .catch statement

//Handle error

})

}

* The above code could be changed slightly, such as changing the last .then into a .catch, we could also incorporate the .populate method. This code isn’t perfect, but it serves as a good example. also, notice how I have to keep track of the different query results in this one, most likely because each .then is within its own scope, see the comments I put to track the variables.
* **EXAMPLE THREE**: This code is taken from the blog, avoiding callback hell while using mongoose - <http://www.summa.com/blog/avoiding-callback-hell-while-using-mongoose>. In this example, we have a student and a course and we want to enroll the student into the course. But before enrolling the student, we need to make sure that there are enough seats available in the course. See the callback version below:

var Student = require('./student.model');

var Course = rqurie('./course.model');

//Let's assume we are using Express framework for nodeJs

function enrollStudent(req, res, next) {

//First we need to make sure that student exists and load the user.

Student.findById(req.body.studentId, function(err, student){

if(err) return next(err);

//Now we need to load the course

Course.findById(req.body.courseId, function(err, course){

if(err) return next(err);

//Next we need to check if there are available seats in the course

if(course.isSeatAvailable()){

//Enroll student into the course and save the course

course.enrolledStudents.push(student.id);

course.save(function(err){

if(err) return next(err);

return res.json({message : 'Enrollment successful'});

});

} else {

//Call error handler

return next({message : 'No seats available'});

}

});

});

}

* You can see the indentation getting worse, and the effect is lessened in a Word doc. We also have the usual multiple error handlers. the more nested things get, the more unreadable callbacks become. Now see the promise version below:

function enrollStudent(req, res, next) {

var student;

//Load the user

Student.findById(req.body.studentId).exec() //notice how we don’t have to return this or put it in a variable, the “.then()” automatically chains off of it.

//Capture student and load the course

.then(function(studentFromDb){ // “studentFromDb” is the result of the first findById query.

student = studentFromDb

return Course.findById(req.body.courseId).exec(); //we don’t return studentFromDb, so if we didn’t plug it into the student variable, we’d lose it

})

//Check if there are available seats in the course

.then(function(course){ //this is equal to the course we found in the last query

if(course.isSeatAvailable()){

//Enroll student into the course

course.enrolledStudents.push(student.id);

return course; // if it worked, we return the course so the next .then() has access to it.

} else {

//throw an error

throw new Error('No seats available');

}

})

//Save the course

.then(function(course){ //the same “course” that the last .then() used.

return course.save(); // .save returns a promise just like .exec() does, but if we didn’t put the return in front of it, we could have kept going in this .then(), he most likely went to another .then() so if there was an error, the .catch would get it.

})

//Send the response back

.then(function(course){

return res.json({message : 'Enrollment successful'})

});

//Catch all errors and call the error handler;

.then(null, next);

} //this could be replaced by a .catch()

* In the example above, pay careful attention to what gets returned from each .then(), and how it affects the next .then() or rather what it gives it. Using promises makes the code easier to read and keeps it from indenting too much.

END