



# WEB322

Web Programming Tools and Frameworks

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## WEB322 Week 7 Notes

### Data Persistence

“Data Persistence” (the ability to “persist” or “save” new, updated or deleted information) is a vital part of any web application project. For example, this could be registering new users, deleting users, updating profile information or payment data for users, viewing saved files or uploaded images, etc. etc. To truly create an “application” we must be able to work with (and persist) data.

Fortunately, there are many different database systems that we can leverage to accomplish this notion of “data persistence”. These range from powerful “relational” database systems, including: [Microsoft SQL Server](#), [Oracle](#), [MySQL](#), [PostgreSQL](#), and [many others](#) as well as “NoSQL” database systems such as [Amazon’s DynamoDB](#), [Azure DocumentDB](#) and [MongoDB](#).

In WEB322, we will be focusing on [PostgreSQL](#) and [MongoDB](#) - this week, we will look at how we can work with a PostgreSQL database in a node.js environment.

### PostgreSQL (Postgres)

From the PostgreSQL site, [postgresql.org](#):

*“PostgreSQL (also known as “Postgres”) is a powerful, open source object-relational database system. It has more than 15 years of active development and a proven architecture that has earned it a strong reputation for reliability, data integrity, and correctness. It runs on all major operating systems, including Linux, UNIX (AIX, BSD, HP-UX, SGI IRIX, macOS, Solaris, Tru64), and Windows. It is fully [ACID compliant](#), has full support for foreign keys, joins, views, triggers, and stored procedures (in multiple languages). It includes most SQL:2008 data types, including INTEGER, NUMERIC, BOOLEAN, CHAR, VARCHAR, DATE, INTERVAL, and TIMESTAMP. It also supports storage of binary large objects, including pictures, sounds, or video. It has native programming interfaces for C/C++, Java, .Net, Perl, Python, Ruby, Tcl, ODBC, among others, and [exceptional documentation](#).*

This is a great choice for us for multiple reasons; it is open source, highly available, standards compliant and most importantly, works nicely with node.js.

To get started, we need to **add a Postgre database (DB)** to a new (or existing) **Heroku application**. For specific instructions (and to refresh your memory) on creating a new application in Heroku, refer to the [Getting Started with Heroku](#) guide.

Once your app is up and running, [log into Heroku](#) and find your application on the dashboard - it should have an automatically generated name, like “cryptic-garden-34394”. Next, follow the steps to set up your free Postgres database!

1. Click on your application to go to the resources screen

2. At the bottom, you will see an “Add-ons” section with a textbox “Quickly add add-ons from Elements”

Add-ons

Find more add-ons

Quickly add add-ons from Elements

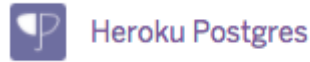
You haven't added any add-ons yet

Add-ons provide tools and services for developing, extending and operating your app

Estimated Monthly Cost

\$0.00

3. Type “Heroku Postgres” into this textbox and click the “Heroku Postgres” item that comes up:



4. This will open a dialog window showing you that “Heroku Postgres” will be added to your application. Be sure you leave the “Plan name” to **Hobby Dev - Free** and click **Provision**
5. This will create an item (link) in your “Add-ons” section with the label: **“Heroku Postgres :: Database”**. Click this link to go to the page for your new Postgres Database instance!
6. Click the “settings” tab, which will reveal a “View Credentials” button on the right side of the page. This will expand a section that lists all of the credentials that you will use when connecting to this database.
7. Write down the following information for: **Host, Database, User, Port, Password**. Note: You can always log back on to Heroku to see these credentials if you forget them.

pgAdmin

Now that we have our brand new Postgres database created in Heroku, why don’t we try to connect to it using the most popular GUI tool for Postgres; [pgAdmin](#). If you’re following along from the lab room, it should already be installed. However, if you’re configuring your home machine, you will need to download pgAdmin:

- <https://www.pgadmin.org/download/>

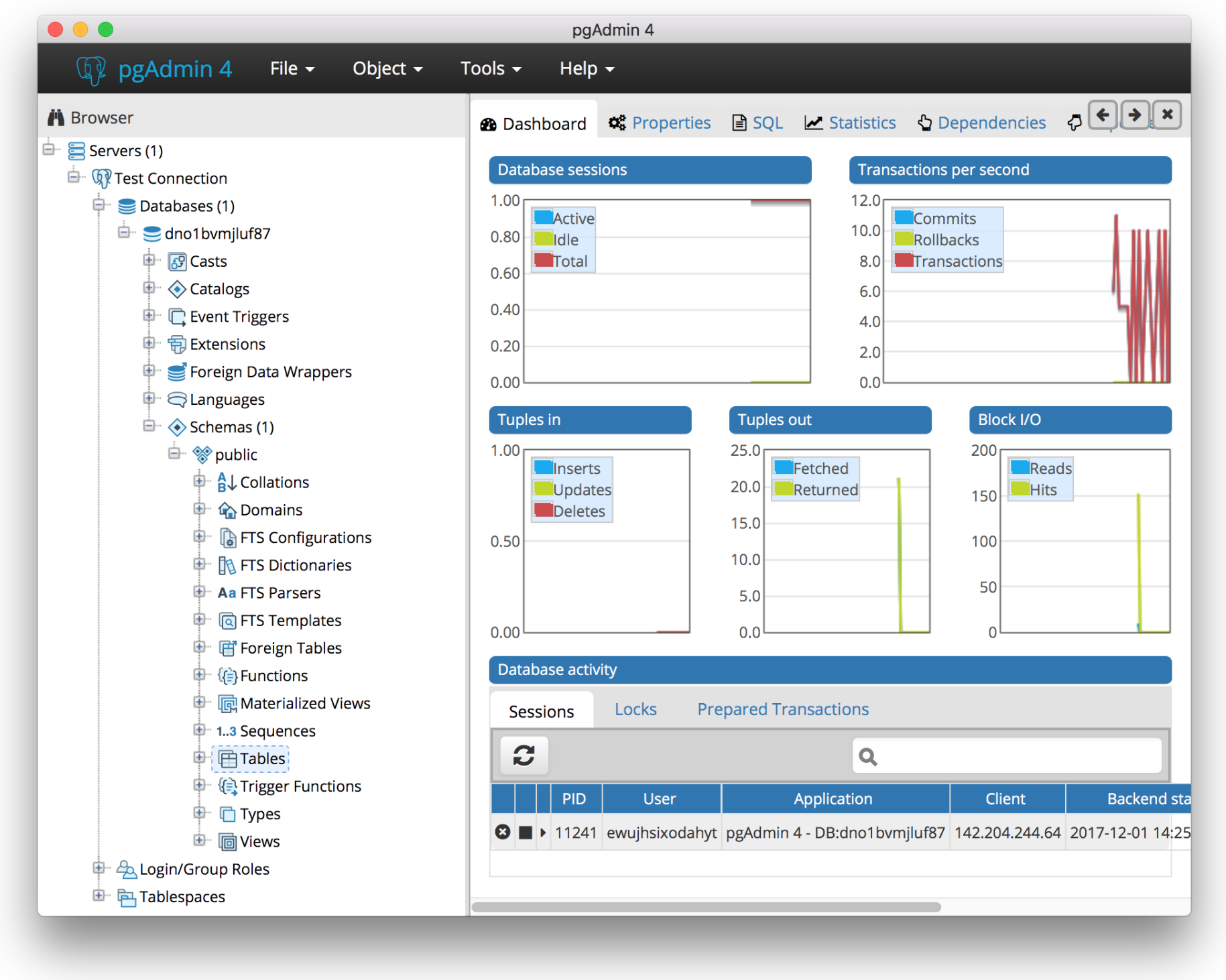
Once it is installed and you have opened the app, we need to configure it to connect to our database:

1. Right Click on the **“Servers”** icon in the left pane (Under “Browser”) and select **Create > Server**
2. This will open the “Create - Server” Dialog window. Proceed to enter the following information about your Postgres Database on Heroku

Field	Value
Name	This can be anything you like, ie “Test Connection”
(Connection Tab) Host	This is the host for your Heroku Postgres DB, ie: <b>[some identifier].compute-1.amazonaws.com</b>
(Connection Tab) Port	This is the port for your Heroku Postgres DB - it should be the same as what’s already there, ie: <b>5432</b>
(Connection Tab) Maintenance database	Enter your randomly generated Heroku Postgres Database name here
(Connection Tab) Username	Enter your randomly generated Heroku Postgres Database user name here
(Connection Tab) Password	Enter your randomly generated Heroku Postgres Database password here
(Advanced Tab) DB restriction	Under the “Advanced” tab in the “DB Restriction” field, enter your Heroku Postgres Database name

Once you have entered all of your information, hit the “Ok” button and click “Servers” in the left pane to expand your server connections. If you entered valid information for the above fields, you should see your Heroku Postgres DB Connection. Expand this item and the following **“Databases (1)”** item, and you should see your database. Expand this

item, as well as the nested **“Schemas (1)”** item, followed by the **“public”** item, and you should be presented with something that looks like this:



**Success!** We will be keeping an eye on our data using this tool so leave it running in the background. Next, why don't we see if we can get our node.js server to connect to the database as well? For us to be able to connect to a relational database, we will need to use an existing module. Fortunately, **sequelize** will do exactly what we want.

Sequelize

Like all modules in node.js, we will have to use **Node Package Manager (npm)** to acquire the module from the online package collection. With your application folder open in Visual Studio Code, open the **integrated terminal** and enter the command

```
npm install sequelize
```

followed by the command:

```
npm install pg pg-hstore
```

This will add both the **sequelize** and the **pg / pg-hstore** modules to our node\_modules folder, as well as add their names & version numbers to our package.json file under "dependencies".

Next, we need to update our **server.js** file to use the new modules so that we can test our connection to the database. If you're working with an existing application, comment out any existing Express app code (routes, listen, etc.) that you have in server.js (for the time being) and add the following code:

```
const Sequelize = require('sequelize');

// set up sequelize to point to our postgres database
```

```
var sequelize = new Sequelize('database', 'user', 'password', {
  host: 'host',
  dialect: 'postgres',
  port: 5432,
  dialectOptions: {
    ssl: { rejectUnauthorized: false }
  }
});

sequelize
  .authenticate()
  .then(function() {
    console.log('Connection has been established successfully.');
```

```
  })
```

```
  .catch(function(err) {
```

```
    console.log('Unable to connect to the database:', err);
```

```
  });
```

Where **database** is your randomly generated Heroku Postgres Database name, **user** is your username, **password** is your password and lastly, **host** will be your Heroku Postgres Database host url. Recall: all of this information is available online via the Heroku dashboard under **Resources > Add-ons - Heroku Postgres :: Database** for your specific app

Once you have updated your app to use the **Sequelize** module, try running it using our usual “**node server.js**” command. If everything was entered correctly, you should see the following message in the console:

```
Executing (default): SELECT 1+1 AS result
Connection has been established successfully.
```

Finally, If you see any other errors at this point, go back and check that you have entered all of your credentials correctly when creating the sequelize object. Recall: You can use Ctrl + c to stop a node.js application from running.

## Models (Tables) Introduction

Now that we have successfully tested the connection to our Postgres database from our node.js application, we must discuss what the **Sequelize** module does and how we will be using it to manage data persistence within our Postgres Database.

Sequelize is technically an [Object-Relational Mapping \(“ORM”\) framework](#). It maps our JavaScript objects (“models”) to tables and rows within our database and will automatically execute relevant SQL commands on the database whenever data using our “models” (JavaScript objects) is updated. This saves us the trouble of manually writing complex SQL statements whenever we wish to update the back-end database to reflect changes made by the user. We can simply update our data and let Sequelize do the rest!

To see this in action, update your server.js file to use the following code:

```
const Sequelize = require('sequelize');

// set up sequelize to point to our postgres database
var sequelize = new Sequelize('database', 'user', 'password', {
  host: 'host',
  dialect: 'postgres',
  port: 5432,
  dialectOptions: {
    ssl: { rejectUnauthorized: false }
  }
});

// Define a "Project" model

var Project = sequelize.define('Project', {
  title: Sequelize.STRING,
  description: Sequelize.TEXT
```

```
});

// synchronize the Database with our models and automatically add the
// table if it does not exist

sequelize.sync().then(function () {

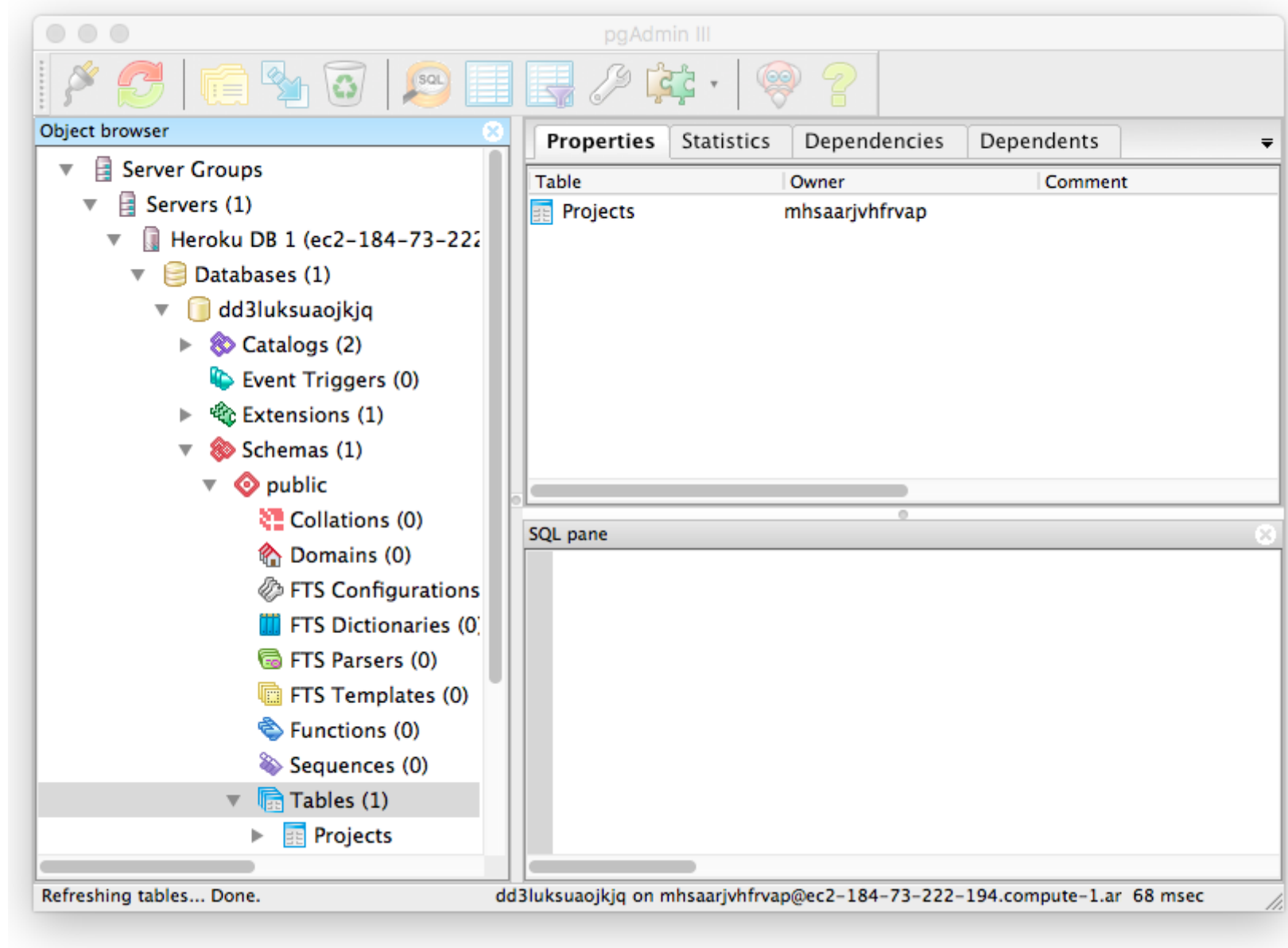
  // create a new "Project" and add it to the database
  Project.create({
    title: 'Project1',
    description: 'First Project'
  }).then(function (project) {
    // you can now access the newly created Project via the variable project
    console.log("success!")
  }).catch(function (error) {
    console.log("something went wrong!");
  });
});
```

Once again, **database** is your randomly generated Heroku Postgres Database name, **user** is your username, **password** is your password and **host** is your Heroku Postgres Database host url.

There is a lot going on in the above code - but before we walk through what everything is doing, try updating the above code with your database credentials and run it once again with **node server.js**. You should see the something very similar to the following output:

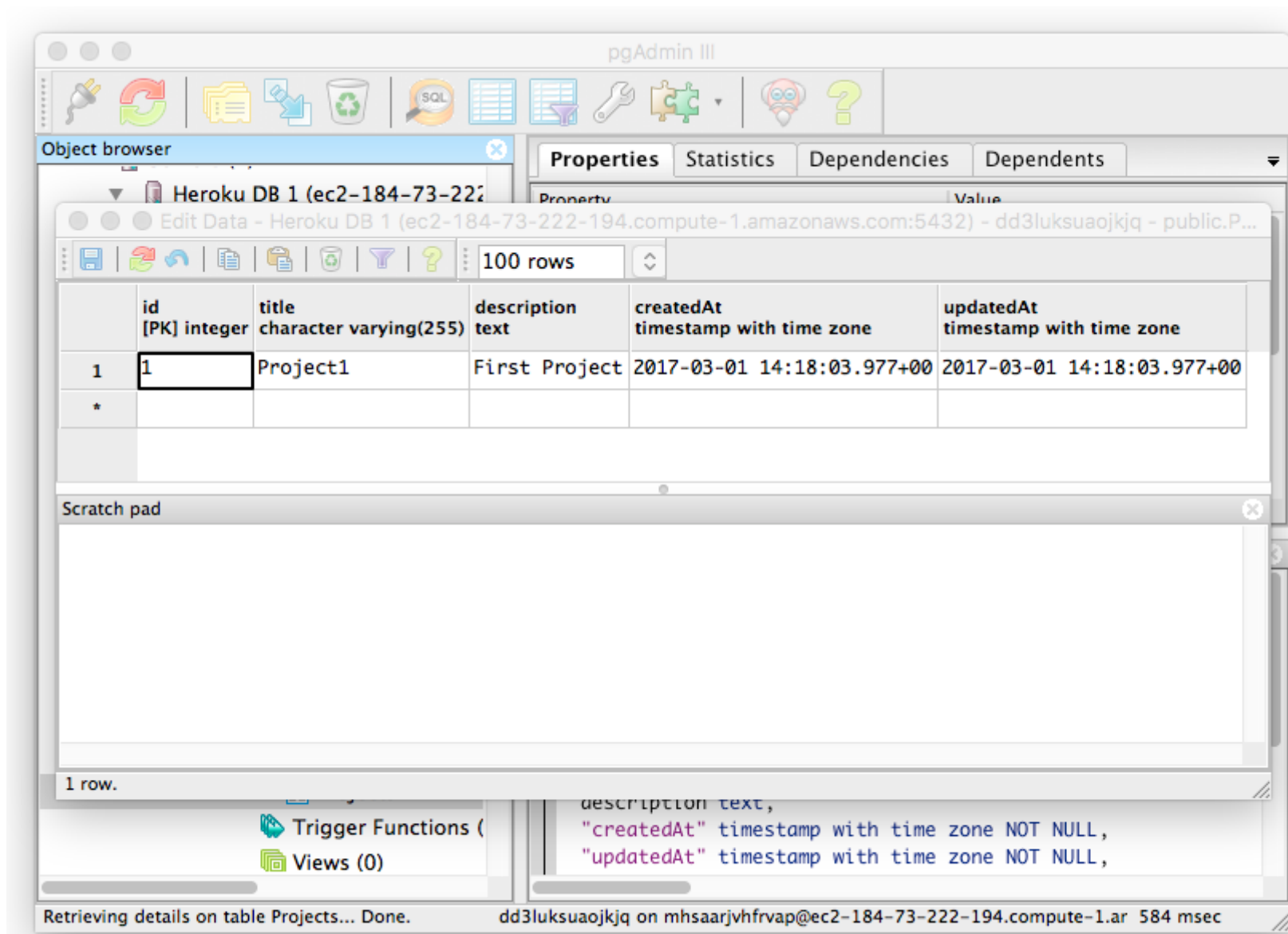
```
Executing (default): INSERT INTO "Projects" ("id","title","description","createdAt","updatedAt")
success!
```

It appears that Sequelize has done some of the heavy lifting for us. To confirm that the create operation was successful and that we have indeed persisted "Project1" in a new "Project" table, go back to your **pgAdmin** application, right-click on "**Tables (0)**" and choose "Refresh". You should now see our new "Projects" table in the list!



To view the contents of the table, **right-click** on the "**Projects**" table and select **View Data > View Top 100 Rows**. This will open a new window with a grid view that you can use to explore the data in the table:





You will notice that there are some columns in the “Project” table that we didn’t define in our “Project” Model; specifically: **id**, **createdAt** and **updatedAt**; recall:

```
// Define a "Project" model

var Project = sequelize.define('Project', {
  title: Sequelize.STRING,
  description: Sequelize.TEXT
});
```

It follows that the **title** and **description** columns are there, but where did the others come from? The addition of the extra columns are actually added by default by the **sequelize** module. Whenever we “define” a new model, we automatically get **id**, **createdAt** and **updatedAt** and when we save data using this model, our data is automatically updated to include correct values for those fields. This is extremely handy, as we didn’t actually create our primary-key for the table! (sequelize went ahead and made “id” our primary key). Also, the **createdAt** and **updatedAt** fields are both widely used. However, if we decide that we want to specify our own auto-incrementing primary key and remove the createdAt and updatedAt fields, we can define our model using the following code instead:

```
// Define a "Project" model

var Project = sequelize.define('Project', {
  project_id: {
    type: Sequelize.INTEGER,
    primaryKey: true, // use "project_id" as a primary key
    autoIncrement: true // automatically increment the value
  },
  title: Sequelize.STRING,
  description: Sequelize.TEXT
},{
  createdAt: false, // disable createdAt
  updatedAt: false // disable updatedAt
});
```

Now that we have defined our **Project** model (either with or without the “createdAt” and “updatedAt” timestamps) we can look at the rest of the code, ie the **sync()** operation and creating **Project1** - recall:

```
// synchronize the Database with our models and automatically add the
// table if it does not exist

sequelize.sync().then(function () {

  // create a new "Project" and add it to the database
  Project.create({
    title: 'Project1',
    description: 'First Project'
  }).then(function (project) {
    // you can now access the newly created Project via the variable project
    console.log("success!")
  }).catch(function (error) {
    console.log("something went wrong!");
  });
});
```

The `sequelize.sync()` operation needs to be completed before we can do anything else. This ensures that all of our models are represented in the database as tables. If we have defined a model in our code that doesn't correspond to a table in the database, `sequelize.sync()` will automatically create it (as we have seen).

**Important Note:** We **do not** have to `sync()` the database before every operation. Only once when the server starts to ensure that the models are correctly represented as tables within the database.

Once our models have been successfully `sync()`'d with the database, we can start working with the data. You will notice that we use the familiar `then()` and `catch()` functions; this is because both `sync()` and `create()` return a **promise** (see "Promises" in the "JavaScript Concept Review" weekly notes) and as we stated above, we must work with the data **after** the `sync()` operation has successfully completed.

If `sync()` resolves successfully, we then wish to create a new record in the "Project" table, so we use `Project.create()` method and pass it some data (**title** and **description**). If the operation completed successfully, we see the message "success!" in the console - otherwise we catch the error and output "something went wrong!"

## Defining Models - in detail

One of the most important things we must do when working with Sequelize is to correctly [set up all of our models](#). Once the models are set up successfully, working with the data is simple. Since each model technically corresponds to a table within our database, what we are really doing is defining tables. Each column of a table within our database stores a specific **type** of data. In our previous example, we define the column **title** as a **STRING** and the column **description** as **TEXT** within a table called **Project**. Sequelize provides definitions for a full [list of types](#), and each column is given a type. The following is a list of the most common types:

- **Sequelize.STRING** - A variable length string. Default length 255
- **Sequelize.TEXT** - An unlimited length text column.
- **Sequelize.INTEGER** - A 32 bit integer.
- **Sequelize.FLOAT** - Floating point number (4-byte precision).
- **Sequelize.DOUBLE** - Floating point number (8-byte precision)
- **Sequelize.DATE** - A datetime column
- **Sequelize.TIME** - A time column
- **Sequelize.BOOLEAN** - A boolean column

So, if we want to define a model (table) that stores blog entries, we could use the following code:

```
// Define a "BlogEntry" model

var BlogEntry = sequelize.define('BlogEntry', {
  title: Sequelize.STRING, // entry title
  author: Sequelize.STRING, // author of the entry
  entry: Sequelize.TEXT, // main text for the entry
  views: Sequelize.INTEGER, // number of views
```

```
    postDate: Sequelize.DATE // Date the entry was posted
  });
```

**NOTE:** It is also possible to introduce **data validation** when we define our models. For a full list of available rules and how they're implemented, see: [Validators](#) in the official documentation.

## Model Relationships / Associations

As we know from our work in earlier semesters, tables (models) can be **related** using foreign key relationships / [associations](#). For example, say we have a table of **Users** and a table of **Tasks**, where each User could have **1 or more** Tasks. To enforce this relationship, we would add an additional column on the Tasks table as a foreign-key to the Users table, since 1 or more Tasks could belong to a specific user. For example, "Task 1", "Task 2" and "Task 3" could all belong to "User 1", whereas "Task 4" and "Task 5" may belong to "User 2".

Using Sequelize models, we can easily define this relationship using the [hasMany\(\)](#) method on our User model (since "User has many Task(s)"), for example:

```
// Define our "User" and "Task" models

var User = sequelize.define('User', {
  fullName: Sequelize.STRING, // the user's full name (ie: "Jason Bourne")
  title: Sequelize.STRING // the user's title within the project (ie, developer)
});

var Task = sequelize.define('Task', {
  title: Sequelize.STRING, // title of the task
  description: Sequelize.TEXT // main text for the task
});

// Associate Tasks with user & automatically create a foreign key
// relationship on "Task" via an automatically generated "UserId" field

User.hasMany(Task);
```

If we wish to create a User and then assign him some tasks, we can "create" the tasks immediately after the user is created, ie:

```
sequelize.sync().then(function () {

  // Create user "Jason Bourne"
  User.create({
    fullName: "Jason Bourne",
    title: "developer"
  }).then(function (user) {

    console.log("user created");

    // Create "Task 1" for the new user
    Task.create({
      title: "Task 1",
      description: "Task 1 description",
      UserId: user.id // set the correct UserId foreign key
    }).then(function(){ console.log("Task 1 created")});

    // Create "Task 2" for the new user
    Task.create({
      title: "Task 2",
      description: "Task 2 description",
      UserId: user.id // set the correct UserId foreign key
    }).then(function(){ console.log("Task 2 created")});

  });
```



```
});
```

Next, try running this code and take a look at your database in pgAdmin. You should see that two new tables, **“Users”** and **“Tasks”** have been created, with **“Jason Bourne”** inside the **“User”** table and **“Task 1”** and **“Task 2”** inside the **“Task”** table. The two new tasks will both have a **UserId** matching **“Jason Bourne”**’s id! We have achieved the one-to-many relationship between this user and his tasks.

**NOTE:** other relationships can be defined using the following functions:

- [belongsTo\(\)](#)
- [hasOne\(\)](#)
- [belongsToMany\(\)](#)

## CRUD - Create Read Update Delete

The four major operations that are typically performed on data are **Create**, **Read**, **Update** and **Delete (CRUD)**. Using these four operations, we can effectively work with the data in our database. Assume we have a simple **Name** model defined:

```
// Define a "Name" model

var Name = sequelize.define('Name', {
  fName: Sequelize.STRING, // first Name
  lName: Sequelize.STRING, // Last Name
});
```

We can use the following code to **Create** new names, **Read** a list of names, **Update** a specific name and lastly **Delete** a name from the **“Name”** table in our database

### Create

To **create** new names in our **Name** table, we can use the following code:

```
sequelize.sync().then(function () {

  Name.create({
    fName: "kyler",
    lName: "odin"
  }).then(function(){ console.log("kyler odin created")});

  Name.create({
    fName: "Grier",
    lName: "Garrick"
  }).then(function(){ console.log("Grier Garrick created")});

  Name.create({
    fName: "kolby",
    lName: "Greyson"
  }).then(function(){ console.log("kolby Greyson created")});

});
```

In the above code we [create](#) three new objects following the fields defined in our **“Name”** model. Since our **“Name”** model is synchronized with the database, this adds three new records - each with their own unique **“id”** value, as well as **“createdAt”** and **“updatedAt”** values for the implicit primary key and timestamp columns. The create function automatically persists the new object to the database and since it also returns a [promise](#), we can execute code after the operation is complete. In this case we simply output the name to the console.

## Read

To **read** entries from our **Name** table, we can use the following code:

```
sequelize.sync().then(function () {

  // return all first names only
  Name.findAll({
    attributes: ['fName']
  }).then(function(data){
    // pull the data (exclusively)
    data = data.map(value => value.dataValues);

    console.log("All first names");
    for(var i =0; i < data.length; i++){
      console.log(data[i].fName);
    }
  });

  // return all first names where id == 2
  Name.findAll({
    attributes: ['fName'],
    where: {
      id: 2
    }
  }).then(function(data){
    // pull the data (exclusively)
    data = data.map(value => value.dataValues);

    console.log("All first names where id == 2");
    for(var i =0; i < data.length; i++){
      console.log(data[i].fName);
    }
  });

});
```

Here, we are once again using a reference to our “Name” model. This time we are using it to fetch data from the “Name” table using the `findAll()` method. This method takes a number of configuration options in it’s object parameter, such as **attributes**, which allows you to limit the columns that are returned (in this case we only want ‘fName’) and a **where** parameter that enables us to specify conditions that the data must meet to be returned. In the above example, **id** must have a value of **2**. See the documentation for [advanced queries](#) for more detailed query information.

Lastly, we can also specify an **order** that the returned data should be in. In the above example, we are not concerned with the order, however in the below “Putting it All Together” example, we wish to order the output by “id” (accomplished by setting the **order**: parameter to `['id']`)

**Note:** You will notice that in our “then” callback function(s), we have line:

```
// pull the data (exclusively)
data = data.map(value => value.dataValues);
```

This is to ensure that our “data” object contains the returned data (only) and nothing else.

## Update

To **update** existing names in our **Name** table, we can use the following code:

```
sequelize.sync().then(function () {
```

```
// update User 2's last name to "James"
// NOTE: this also updates the "updatedAt field"
Name.update({
  Name: "James"
}, {
  where: { id: 2 } // only update user with id == 2
}).then(function () { console.log("successfully updated user 2");});

});
```

In order to “update” a record in the “Name” table, we make use of the [update](#) method. This method takes two parameters: an object that contains all of the properties and (updated) values for a record, and a second object that is used to specify options for the update - most importantly, the “**where**” property. The “where” property contains an object that is used to specify exactly *which* record should be updated. In this case, it is the row that has an **id** value of **2**.

## Delete

To **delete** existing names in our **Name** table, we can use the following code:

```
sequelize.sync().then(function () {

  // remove User 3 from the database
  Name.destroy({
    where: { id: 3 } // only remove user with id == 3
  }).then(function () { console.log("successfully removed user 3");});

});
```

The delete functionality is actually achieved via a method called [destroy](#). In this case, we invoke the **destroy** method on the model that contains the record that we wish to remove (ie, “Name”). It takes a single options object as it’s only parameter and like the **update** function, the most important option is the “**where**” property. The “where” property contains an object that is used to specify exactly *which* record should be removed. In this case, it is the row that has an **id** value of **3**.

## Putting it All Together

Now that we know to perform each of the **CRUD** operations when using the Sequelize module, why don’t we see what can create? [This week’s example](#) makes use of many of the modules that were discussed not only today, but in earlier weeks as well (such as [body-parser](#) and [express-handlebars](#)) to create a very simple “names registry” application. This web application allows users to manipulate a persistent list of full names (first name & last name) by **C**reating new names to add to the list, **R**eading the full list of names, **U**pserting existing names and finally, **D**eleting names from our back-end Postgres database.

To run this example locally, you will have to update your dependencies (see package.json) via **npm** in the **integrated terminal** as well as the connection to your **Postgres** database in the **server.js** file, under the comment “// define the connection to our Postgres instance”.

Once the application is running, you will be able to see all of the changes reflected in your Postgres database via pgAdmin (don’t forget to refresh your data) and every time you run the server and test the application in a browser, you will see the same, updated list of names!

## Sources

- <https://www.postgresql.org>
- <https://sequelize.org/master/>
- [https://en.wikipedia.org/wiki/Object-relational\\_mapping](https://en.wikipedia.org/wiki/Object-relational_mapping)