



# GraphQL



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## GraphQL with Node.js and Apollo

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# Section 1: Introduction

## Why GraphQL & Installing Node.js and Visual Studio Code

Most current applications likely uses some form of a REST API where we are making HTTP requests between the client and the server to send and receive data. Below is a visual representation of a REST API application where we have a client and a backend database/server.



The REST API would have multiple different endpoints/URLs that can be used to communicate with the server. For example: one endpoint for signing up, another for logging in, creating new data, reading all data and so on.

When we introduce GraphQL not a lot will change. We will continue to be able to use any client and any server but we will replace the REST API (with many endpoints) with a GraphQL API that has a single endpoint exposed.

GraphQL stands for the Graph Query Language and is something that operates over HTTP and therefore we can use any backend language and any database we want as well as any client (web, mobile, server) we want.



Why use GraphQL? GraphQL is fast, flexible, easy to use and simple to maintain. Below is a visual representation of a typical example of loading the necessary data for a page with a REST API and then with a GraphQL API.

We have a client and a server but the glue between the two is either a REST API or a GraphQL API. In both examples we would make a HTTP request to fetch the data necessary to render a page which displays a blog post i.e. the post details, comments made on the post and other blog posts made by that author.

Starting with the REST API we have a dozen or so endpoints for managing our application data. We would make HTTP requests to the various endpoints to get all the necessary data from the server. The server would determine what data to retrieve and send back to the client based on the endpoint requests made to the server.



The GraphQL API exposes a single endpoint which is a very important piece to the puzzle. This endpoint could be called anything we like (in the example below it is named /graphql). When making a HTTP request to this single endpoint we would also send along a GraphQL query.



A GraphQL query allows the client to describe exactly what data it needs from a server, the server gets all the data ready to send back to the client. This is the second most powerful piece to the puzzle. Instead of the server determining what data gets sent back, it is up to the client to request all of the data it needs. Therefore in the GraphQL case, it can request the post details, the post comments and other posts by that author all within a single GraphQL request.

The important difference between a REST API and a GraphQL API is that the latter allows the client to determine what data it gets back as apposed to the former HTTP endpoint which allows the server to determine what data comes back from and endpoint. Clearly 3 HTTP requests is more than a single HTTP request and therefore GraphQL is going to be more faster.

The greatest advantage of GraphQL is the flexibility. We could argue that for the REST API we could have had one endpoint that would return everything.



The above would be a perfectly fine approach and it would give the client everything it needs to render that page with just a single HTTP request. However, the problem with this solution is that we now have this one endpoint which is making way more database request than it was before.

It is getting big and slow i.e. from one database request to three database request in order to get all of the data necessary. For the desktop version of the application this may be perfectly fine as we may use the data right away. However, if we have a mobile version of our application to use the same backend. The problem with this is that the mobile application cannot change the data it gets back.



On mobile devices we have a whole set of considerations to take into account such as screen real estate, battery life, hardware and slow/expensive data. We want to make sure that we do not abuse the device else the users are going to get a poor user experience and unlikely to use the mobile application. This was the original reason for why GraphQL was created i.e. a flexible way for the individual clients to request exactly the data that it requires to use i.e. nothing more and nothing less. This is not an issue we would run into with the GraphQL API because it is more flexible.





The GraphQL API exposes a single endpoint for both desktop and mobile applications; however, the GraphQL query allows us to specify what data we would like to get back for example the desktop application would want everything while the mobile application would only want the post details.

The desktop query would require the server to do a lot more work i.e. make three database requests to get all of the data. However, for mobile the server does less work as the query requests less data i.e. one database request to get only the post details.

The REST API does not provide the same flexibility as we get the same response with both clients. With GraphQL it is for the individual client that determines what data it gets back from the server while with a REST API it is the server that determines what data it gets back to what endpoints.

Finally, with a REST API if the client requires different data this typically requires us to add a new endpoint or change an existing one. Using a GraphQL API, the client would just need to change its query making GraphQL API's much simpler to maintain compared to REST API.

To conclude, GraphQL creates fast and flexible APIs, giving clients complete control to ask for just the



data they need. This results in fewer HTTP requests, flexible data querying and in general less code to manage.

Before we can dive into looking at GraphQL we would need to install some applications/packages on our machines.

## 1) Node.js

We can visit <https://nodejs.org/en/> homepage to download node.js for our operating system. There are two versions: The LTS version (Long Term Support) and the Current release version. It is advisable to download the Current release, as this will contain all the latest features of Node.js. As at January 2020, the latest version is 13.6.0 Current.

We can test by running a simple terminal command on our machine to see if node.js was actually installed correctly:

```
:~$ node -v
```

If node.js was installed on the machine correctly the command would return the version of node that is running on the machine. If “command not found” is returned, this means node was not installed on the machine.

## 2) Visual Studio Code

A text editor is required so that we can start writing out our node.js scripts. There are a couple of open source code editors (i.e. free) that we can use such as Atom, Sublime, notepad++ and Visual Studio Code to name a few.



It is highly recommended to download and install Visual Studio Code as your code editor of choice as it contains many great features, themes and extensions to really customise the editor to fit your needs. We can also debug our node.js scripts inside of the editor which is also a great feature.

### **Links:**

<https://code.visualstudio.com/>

<https://atom.io>

<https://www.sublimetext.com/>

Some useful extensions to install in Visual Studio Code are:

Babel ES6/7 (dzannotti), Beautify (HookyQR), Docker (Microsoft), Duplicate action (mrminc), GraphQL for VSCode (Kumar Harsh), npm (egamma), and npm Intellisense (Christian Kohler).

# Section 2: GraphQL Basics: Schemas and Queries

## What is a Graph?

When we talk about a 'graph' in GraphQL we are talking about a way to think about all of the application data and how that data relates to one another. Exploring what a graph is will provide a solid foundation for actually writing code in GraphQL.

We will use the example of a blogging application to explain what is a graph.



Types are things that we define when creating our GraphQL API, so in the above we have three types of User, Post and Comments.

When we define the types that make up our applications, we also define the fields associated with each type i.e. the individual data we want to store/track.

We also have relationships between the Types. In the above example, if a user creates a post that post is associated with the user. Therefore, the user can have many posts via the posts property. This also means each post belong to a user via the author property.

This should feel familiar because it is exactly how we would represent our data with any standard database applications whether SQL or NoSQL database (GraphQL does not care what backend database used to store the data).

To conclude a graph has types, fields and associations between various types and this is the mindset to have when thinking and representing data in GraphQL.

## GraphQL Queries?

There are three major operations we can perform on a GraphQL API: query, mutation and subscription. Query allows us to fetch data, mutation allows us to change data and subscription allows us to watch data for changes.

We start the GraphQL syntax with the operation type. For a query operation this is “query” keyword in all lower case followed by an opening and closing curly brackets. Inside of the curly brackets we need to specify what fields we want from the GraphQL API. This will be a valid GraphQL query which will

fetch some data based on the query we specified from the server. Example query operation below:

```
query { hello }
```

The above GraphQL syntax looks very similar to a JSON or JavaScript object. If we were to execute the code on a GraphQL API which has this field we would receive a JSON data response like the below example:

```
{ "data": { "hello": "Hello World!" } }
```

We have an object with a single property “data” which has all of the data requested. In this example we requested a single field “hello” which has the data that came back from the server which is the string “Hello World!”.

We can request as many or as less data from the server as we need with a GraphQL query but typically it would be more than just one field. We would use a space or a new line to add multiple fields and would not need a delimiter such as a comma as we would see with JSON or JavaScript objects.

```
query { first_name last_name }
```

If we were to query a field name that the server does not understand we would get back a feedback error before even sending the request within the GraphQL playground to inform us that the field does not exist and it would provide suggestion to other fields which do exist.

All GraphQL APIs are self documenting which is not a feature we get with REST APIs. With REST APIs someone needs to manually write and update documentations. We do not run into this problem with GraphQL because our request dictates our response because we specify the exact things we want

access to and so we know how the response is going to look like. This is all possible because GraphQL API exposes an application schema which describes all of the operations that could be performed and the data we have access to when making requests to the GraphQL API.

## GraphQL Nested Queries?

When we query on an object, we need to specify what fields on that object we would want to fetch. We cannot ask for everything because that defeats the purpose of GraphQL which requires the client to specify all the data it needs i.e. nothing more and nothing less.

To select fields from an object (Type) we use curly brackets after the object field name and within the curly brackets we would list the fields we want access to.

```
query { user { id name } }
```

When we query a custom Type (e.g. User!) this will return back an object with all of the fields we asked for i.e. in the above case this is the id and name fields:

```
{ "data": { "user": { "id": "123abc", "name": "John Doe" } } }
```

The structure of the data returned matches the structure of the query where “user” is on the top level and “id” and “name” are nested under “user” on the lower level.

We can query some data off of an array of objects of a custom Type (e.g. User![]) using the same syntax format as the above.

```
query { users { name } }
```

This will return an array of users object. For each user we are getting back the field we asked for i.e. the name field.

```
{ "data": { "users": [ { "name": "John Doe" }, { "name": "Sarah Browne" } ] } }
```

When looking at the Schema of a GraphQL API we would notice the syntax used which describe the fields available and the type of data we would get back from the field query, for example:

```
hello: String!
```

```
user: User!
```

```
users: [User!]!
```

The string to the left is the field we can query while the string on the right after the colon and space is the Type we would expect to get back. So in the above the field hello will return back a string data type while user will return a User object data type and users field will return an array of User object data type.

The exclamations mark indicates we would always get the data type specified before it and it cannot be null. If the exclamation mark was missing this would indicate that we may get back a null data from the field.

Useful link: <https://graphql-demo.mead.io/> — play around and write queries in the GraphQL playground.

# Setting up Babel

Babel is a JavaScript compiler which allows us to write some code to babel and babel returns other code. This allows us to take advantage of cutting edge features in our code but still have code (output from Babel) which runs in a wide range of environments. Therefore, if we write an application which takes advantage of the arrow function but we want to run our code in older browsers, we are going to need a way to convert that arrow function to something that the older browser can understand. Babel will compile the code into code that is understood by older browsers. We are using Babel to access the ES6 import/export syntax from node. We can learn more about and play around with Babel on the following link: <https://babeljs.io/>

We will be using Visual Studio Code and the integrated terminal for Linux/Mac users (if using Windows, it is suggested to use a terminal emulator such as cmdr at <https://cmdr.net/>).

For setup, we would want to create a new directory such as graphql-basics and navigate to that directory within the terminal. We would then run the npm init command to create a package.json file for our project directory using the default values.

After creating the package.json file we would run the following command to install babel-cli and babel-preset-env packages. This will add the packages to our package.json file and add a node\_modules directory within our project directory.

```
:~$ npm install babel-cli babel-preset-env
```



The babel-cli package will allow us to run a command to compile Babel while the babel-preset-env tells Babel exactly what it should change.

Once this has been installed we would create a new file in the root called .babelrc which will tell Babel to use the babel-preset-env preset so that our Import/Export code gets converted correctly and is compatible with node. The .babelrc is a JSON file whereby we set a presets property and set its value to an array where we provide as strings the names of all the presets we want to use, in this case we installed one which was the babel-preset-env (i.e. env). Babel is now all configured.

.babelrc:

```
{ "presets": [ "env" ] }
```

We need to create a src directory in the root of our project directory and within this directory we need a file as an entry point for our application which we can name as index.js. In the index.js we can add some content such as `console.log('Hello GraphQL!')` to make sure the file runs successfully.

Finally we need to update the package.json file to add a new script which we can run.

package.json:

```
{ ..., "scripts": { "start": "babel-node src/index.js" } }
```

We can now run the command in the terminal `npm run start` to run babel node in local development to compile and run our src/index.js file code. We should see "Hello GraphQL!" printed if successful.

# ES6 Import/Export Syntax

The ES6 import/export syntax (like with require) is going to allow us to break up our application into multiple distinct files. Therefore, instead of having one huge file we can break our application code into many smaller files each concerned with some specific logical goal. This also allows us to load in code from other third party libraries we install. Below is an example of using the import/export syntax:

src/myModule.js:

```
const message = 'Hello from myModule.js';  
export { message };
```

The export statement allows us to export variables, functions, objects from a file. We do this by using the export keyword followed by curly brackets and within the brackets we list all of the things we want to export from the file.

src/index.js:

```
import { message } from './myModule';  
console.log(message);
```

The import statement allows us to import files and have access to the things that was exported from that file. The import statement has four major components, the first in the import keyword, the second is the list of all the things we want to import from the file which we wrap in the curly brackets, the third is the from keyword and fourth is the path to the import file. We can leave off the extension of the file.

The above example is known as a named export because the export has a name. We can export as many named exports we would like and the file importing the exports can select some or all of the exported things.

Aside from the name export there is another export we can use which is known as the default export. The difference between the two exports is that the default export has no name and you can only have one.

src/myModule.js:

```
const message = 'Hello from myModule.js';  
const name = 'John Doe';  
export { message, name as default };
```

The syntax is the same as a named export but we tag it as a default by using the `as default` keyword. This will select the one named export as the default export.

src/index.js:

```
import myName, { message } from './myModule';  
console.log(myName);
```

To grab the default export we give it a name after the import keyword. We use a comma if we are also providing a named export. This will grab all export types i.e. default and named exports. The import name does not match the export name (and does not need to) because a default export has no name. We are importing by it's role of the default which is why we are getting the correct import.

# Creating Your Own GraphQL API

Using GraphQL Playground is a temporary way to make sure our server is working as expected when we perform various operations on it. In a real world scenario the queries will come from a mobile device, another server or a web browser. The GraphQL Playground is a great starting point for learning the various operations available to us.

It is important to note that the Graph Query Language is just a specification for how it should work e.g. how should queries work. At the end of the day it is not an implementation and therefore it is up to the individual developers to take the documents that describes GraphQL and actually implement it for that environment, whether Android, IOS, JavaScript, Node, Python, C#, etc. We need implementations of GraphQL in those environments. Therefore, we would need to find an implementation of the GraphQL spec that works with Node.js (as we are using Node.js as our backend language in this guide). This is similar to JavaScript EcmaScript specification describing how JavaScript should work and then we have various implementation of the JavaScript spec e.g. Chrome and Node use the V8 engine, Mozilla using Spidermonkey and Microsoft using Chakra.

We can go to the link to view the GraphQL spec: <https://spec.graphql.org/> — This document will describe/explain how GraphQL works. It is for the developer of the other languages for the implementation. This means we might have multiple options to pick from when we are using GraphQL in a specific environment. The tool we are going to be using to get GraphQL running on Node.js is GraphQL-Yoga which we can install by running the command in the terminal within our project directory.

```
:~$ npm install graphql-yoga
```

The documentation for graphql-yoga tool can be found on <https://github.com/prisma-labs/graphql-yoga>.

The reason for using this tools is because it provides the most advanced feature set allowing us to tap into everything that GraphQL has to offer and it also comes with a very easy setup process so that we can get up and running very quickly. We can use the same tools to build very advanced API with all the features we would expect.

Below is the code to setup our own GraphQL API.

src/index.js:

```
import { GraphQLServer } from 'graphql-yoga';
const typeDefs = `type Query { hello: String! }`
const resolvers = { Query: {
  hello( ) { return 'This is my first query!'; }
} };
const server = new GraphQLServer( { typeDefs: typeDefs, resolvers: resolvers } );
server.start( ( ) => { console.log('The server is up and running') } );
```

We import GraphQLServer named export from graphql-yogo which will provide us the tool to create a new server. Since the imports is from a npm library, we only need to reference the library name. This is all we need to import to get GraphQL up and running.

There are two things we need to define before we can start our server, the first is our Type definitions and the second are the resolvers for the API.

Type definitions is also know as the application schema. The application schema is important because it defines all of the operations that can be performed on the API and what are our custom data types look like. Resolvers are nothing more than functions that run for each of the operations that can be performed on our API.

The type “Query” which must be in all uppercase because it is one of the three builtin types. Within the curly brackets we define all of the queries we want to support (in the above example we define a single query). To define the query we start with the query name followed by a colon. We then define the type that should come back when the query is executed. This is a valid Type definition for our API. If we do not want a null to be a returned value we must use the exclamation mark at the end of the type definition e.g. String!

The resolver object typically resembles what is defined in the type definition. The Query is a property which holds various methods, one method for each query defined. In the above example there is only one Query and therefore there is only one method.

To start up the server and query for that data we use two lines of code. The first is to declare a new server. The GraphQLServer takes in an object as its arguments where we define two properties i.e. the typeDefs and resolvers. Note since the values match the property name we could use the ES6 shorthand syntax of just the property name (e.g. typeDefs: typeDefs can be written as typeDefs).

Finally, we use the start method on the server to start everything up. We pass to it a callback function

to return a string to confirm the server is running. When we run `npm run start` to run our index.js code, the graphql-yoga by default will start the server/application on `localhost:4000`.

We should now see a brand new instance of GraphQL Playground for the GraphQL API we have setup. We can now query for hello which is the only thing that exists in our API and should see something like the below screenshot:



We now have our very first and simple GraphQL API server up and running.

**Important note:** any changes we make to our code i.e. adding new queries, we would need to shut down the server using control + c on your keyboard and restart the server using the `npm run start` command and refresh the page to see the changes.



## Live Reload for GraphQL-Yoga

We can set things up to automatically restart the server (rather than manually) in the background anytime we make any changes to our application code using a library called nodemon.

We can run the following command in the terminal to install the library within our project directory:

```
:~$ npm install nodemon --save-dev
```

After installing the package as a dev dependency we would update the “start” script to use nodemon:

package.json:

```
{ ..., "scripts": { "start": nodemon src/index.js --exec babel-node } }
```

## GraphQL Scalar Types

GraphQL comes by default with five main scalar types that we can use for our Type Definitions: String, Boolean, Int, Float and ID. Integers holds full numbers while float holds decimal numbers. The ID type is unique to GraphQL and is used to represent unique identifiers as strings.

A scalar value is a single discrete value and so a scalar type is a type that stores a single value. This is the opposite of a non-scalar type such as an object or an array which is a collection of discrete values. So with an object we have many properties while with an array we can have many elements in that array.

If we define a type definition with an exclamation mark, this states the data query must return that type and cannot return null.

# Creating Custom Types

In GraphQL you are not limited to the five scalar types. We are able to create our own custom types which are essentially an objects i.e. a set of fields. To create a custom type it starts within the type definition. We use the type keyword followed by a type name of our choosing.

src/index.js:

```
const typeDefs = `
  type Query { me: User! }
  type User { id: ID! name: String! email: String! }
`

const resolver = { Query: { me() { return{ id: '012345', name: 'Beatrice', email: 'b.email.com' } } } }
```

When choosing a type name it is common practice to use a uppercase letter. The name also resembles the object we are modelling such as a User, Post, Product, etc.

Within the curly brackets we define all of the fields that make up the custom Type. This will look similar to defining Query definitions.

We would create a field name in the Query definition and set its value to the custom Type (previously we would set it to scalar types but are now able to use our custom Types).

Finally, we would setup the resolver function for the Query definition which returns data (an object) matching with the custom query type. We now have a query that returns a custom type.

**Important Note:** the resolver is returning static data back to the query and later on we will learn how to return dynamic data from a database.

In the above example we now have a query definition of me: User! that we can now query on. It is important to note when we are querying data in GraphQL, we have to be specific down to the individual scalar values and there querying the field “me” alone is not enough (unless it returned a scalar value). This is because the “me” field is returning an object which is not a scalar value. The individual fields within the “me” object are scalar values such as id, name, email and age. Therefore, our query would look something of the below screenshot in the GraphQL Playground:



The screenshot shows the GraphQL Playground interface. At the top, there's a tab labeled 'me' with a close button. Below it, there are buttons for 'PRETTIFY', 'HISTORY', and a URL bar showing 'http://localhost:4000/'. To the right of the URL bar is a 'COPY CURL' button. The main area is split into two panels. The left panel contains a query editor with the following code:

```
1 query {  
2   me {  
3     id  
4     name  
5     email  
6     age  
7   }  
8 }
```

The right panel shows the JSON response after clicking the play button (a large circle with a right-pointing triangle). The response is:

```
{  
  "data": {  
    "me": {  
      "id": "0123456",  
      "name": "John Doe",  
      "email": "j.doe@email.com",  
      "age": null  
    }  
  }  
}
```

On the far right, there are two vertical buttons: 'DOCS' and 'SCHEMA'.

Therefore, if we have a non scalar value, we have to provide a selection set for it using the curly brackets and selecting the actual scalar values want returning. We do not necessarily have to return all the values from the “me” object and can be selective on what we want returning back from our query statement.

We can now appreciate and see how we can model our application in terms of the custom types but there are a lot more questions we need to answer first for example how can we work with lists/array, how do we set relations between these custom types, etc.

# Operation Arguments

GraphQL operation arguments allows us to pass data from the client to the server. So far all the data has been flowing in the opposite direction i.e. from the server to the client. There are many reason for why we would want to get data from our client to the server for example a signup form on the front end where we need to get this information through to the server so that it can save a new record to the database.

To create an operation argument we start with creating a Query definition.

src/index.js:

```
const typeDefs = ` type Query { greeting(name: String): String! } `
const resolver = { Query: { greeting(parent, args, ctx, info) {
  if(args.name) { return `Hello, ${args.name}!` }
  return 'Hello!';
} } };
```

The query will return a scalar type at the end of the day; however, we can determine what arguments this query should accept by adding round brackets after the query name and before the colon. This is where we define/list all of the arguments that could be passed along with the query and define whether the arguments are required or optional for the query.

We would give a name for the argument and then after the colon we need to be explicit about what type we are expecting. To make an argument required we would add an exclamation mark after the type definition of the argument (leaving this off would make the argument optional).

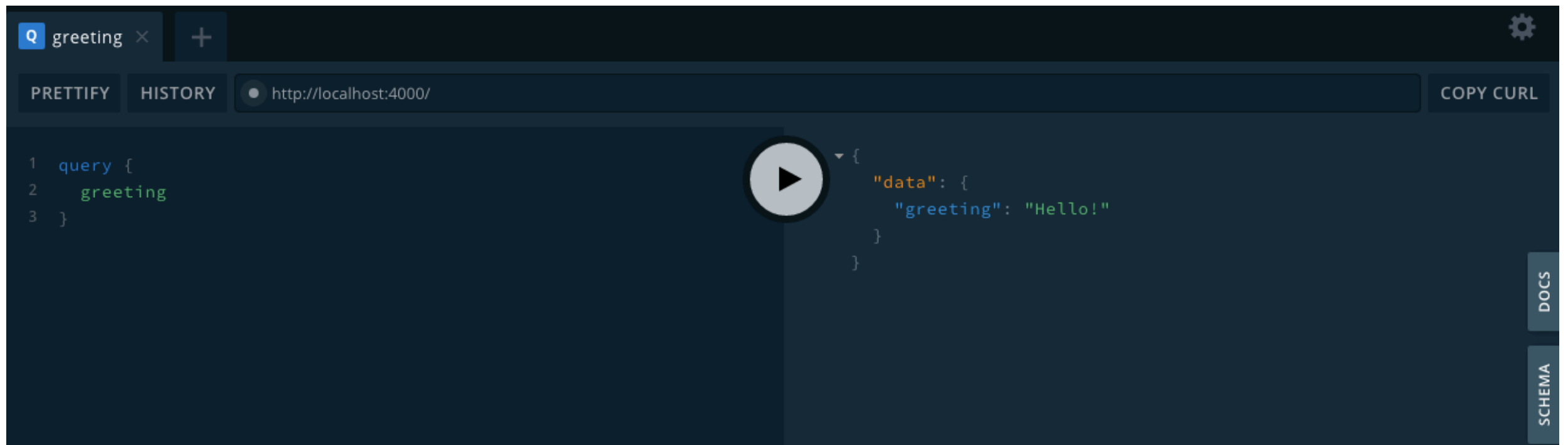
We would then setup the resolver method for this query. It is up to the resolver method to use the data to make some sort of dynamic response. There are four arguments in the specific order that get passed to all resolver functions and they are as follows:

- ◆ parent - this is a very common argument and is useful for working with relational data
- ◆ args - this contains the operation arguments supplied
- ◆ ctx - shortened for context and is useful for contextual data (e.g. if a user is logged in, context may contain the id of that user so that we can access it throughout the application)
- ◆ info - this contains information about the actual operation that were sent along to the server

When we want to make a query to the GraphQL API where a query has operational arguments setup, we would pass all of the arguments within the round brackets after the query field name. We specify the argument key we are setting a value for followed by a colon and then the value for that argument. This will allow us to successfully pass argument values from the client to the server:



If we were to query for greeting and leave the arguments off or use an empty string this would return only the greeting as seen in the below examples:



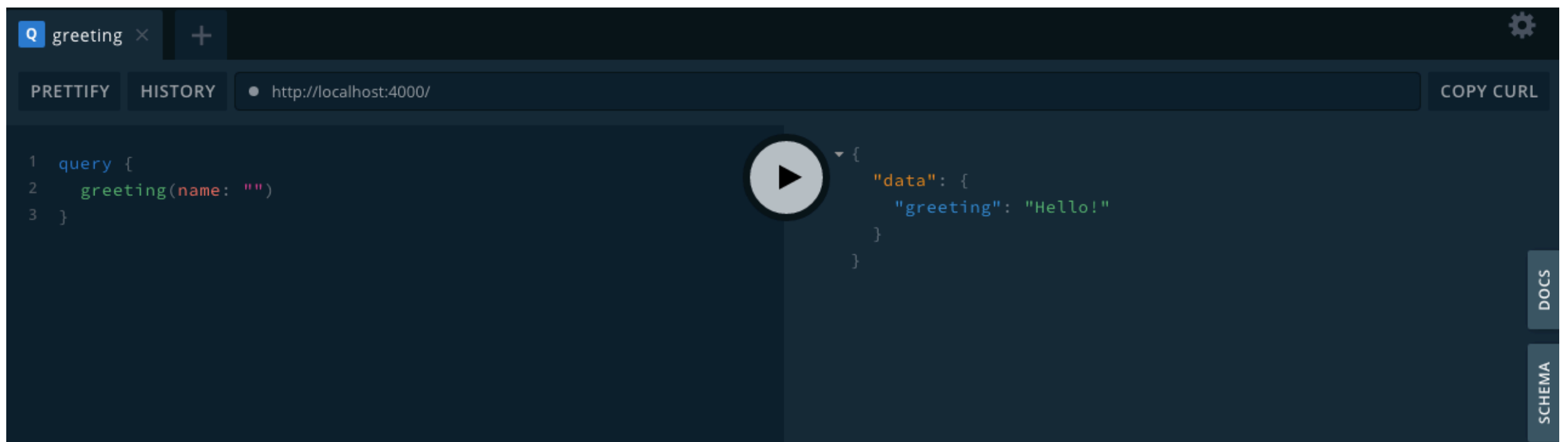
The screenshot shows the GraphQL Playground interface. The top bar includes a tab labeled 'greeting', a plus sign for new queries, and a settings gear. Below the bar are buttons for 'PRETTIFY', 'HISTORY', and a URL input field containing 'http://localhost:4000/'. A 'COPY CURL' button is on the right. The main area is split: the left pane contains the query 

```
1 query {  
2   greeting  
3 }
```

 and the right pane, after clicking the play button, shows the JSON response 

```
{  
  "data": {  
    "greeting": "Hello!"  
  }  
}
```

. On the far right, there are vertical buttons for 'DOCS' and 'SCHEMA'.



This screenshot is similar to the one above, showing the same GraphQL Playground interface. The query in the left pane is 

```
1 query {  
2   greeting(name: "")  
3 }
```

. After clicking the play button, the right pane displays the same JSON response: 

```
{  
  "data": {  
    "greeting": "Hello!"  
  }  
}
```

. The interface elements like the top bar, buttons, and URL are identical to the previous example.

This is how we can pass data from the client over to the server using operation arguments. There are also no limitation to the number of arguments we can setup for a query.