Building REST APIs with Flask

Create Python Web Services with MySQL

Kunal Relan

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Dedicated to caffeine and sugar, my companions through many long night of writing, and extra credits to my mom.

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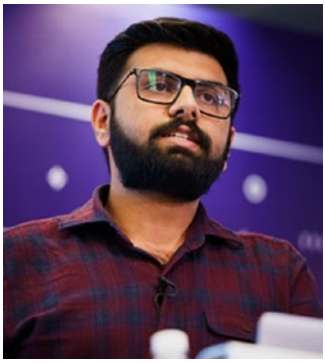
About the Author



Kunal Relan is an iOS security researcher and a full stack developer with more than four years of experience in various fields of technology, including network security, DevOps, cloud infrastructure, and application development, working as a consultant with start-ups around the globe. He is an Alibaba Cloud MVP and author of *iOS Penetration Testing* (Apress) and a variety of white papers. Kunal is a technology enthusiast and an active speaker. He regularly contributes to open source communities and writes articles for Digital Ocean and Alibaba Techshare.

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He is also passionate about working with open source communities and has been actively participating as a contributor in various domains, which involve development, testing, and community engagement. Saurabh has also been an active speaker at various conferences where he has been talking about performance of large-scale systems.

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Last but certainly not the least, I would like to acknowledge all the people who constantly reminded me about the deadlines and helped me write this book, especially my family and Aparna Abhijit for helping me out with editing.

Introduction

Flask is a lightweight microframework for web applications built on top of Python, which provides an efficient framework for building web-based applications using the flexibility of Python and strong community support with the capability of scaling to serve millions of users.

Flask has excellent community support, documentation, and supporting libraries; it was developed to provide a barebone framework for developers, giving them the freedom to build their applications using their preferred set of libraries and tools.

This book takes you through different stages of a REST API–based application development process using flask which explains the basics of the Flask framework assuming the readers understand Python. We'll cover database integration, understanding REST services, REST APIs performing CRUD operations, user authentication, third-party library integrations, testing, deployment, and application monitoring.

At the end of this book, you'll have a fair understanding of Flask framework, REST, testing, deploying, and managing Flask applications, which will open doors to understanding REST API development.

CHAPTER 1

Beginning with Flask

Flask is a BSD licensed, Python microframework based on Werkzeug and Jinja2. Being a microframework doesn't make it any less functional; Flask is a very simple yet highly extensible framework. This gives developers the power to choose the configuration they want, thereby making writing applications or plugins easy. Flask was originally created by Pocoo, a team of open source developers in 2010, and it is now developed and maintained by The Pallets Project who power all the components behind Flask. Flask is supported by an active and helpful developer community including an active IRC channel and a mailing list.

Introduction to Flask

Flask has two major components, Werkzeug and Jinja2. While Werkzeug is responsible for providing routing, debugging, and Web Server Gateway Interface (WSGI), Flask leverages Jinja2 as template engine. Natively, Flask doesn't support database access, user authentication, or any other high-level utility, but it does provide support for extensions integration to add all such functionalities, making Flask a micro- yet production-ready framework for developing web applications and services. A simple Flask application can fit into a single Python file or it can be modularized to create a production-ready application. The idea behind Flask is to build a good foundation for all applications leaving everything else on extensions.

K. Relan, *Building REST APIs with Flask*, https://doi.org/10.1007/978-1-4842-5022-8_1

Flask community is quite big and active with hundreds of open source extensions. The Flask core team continuously reviews extensions and ensures approved extensions are compatible with the future releases. Flask being a microframework provides flexibility to the developers to choose the design decisions appropriate to their project. It maintains a registry of extensions which is regularly updated and continuously maintained.

Starting Flask

Flask, just like all other Python libraries, is installable from the Python Package Index (PPI) and is really easy to setup and start developing with, and it only takes a few minutes to getting started with Flask. To be able to follow this book, you should be familiar with Python, command line (or at least PIP), and MySQL.

As promised, Flask is really easy to start with, and just five lines of code lets you get started with a minimal Flask application.

Listing 1-1. Basic Flask Application

```
from flask import Flask
app = Flask(__name__)

@app.route('/')
def hello_world():
    return 'Hello, From Flask!'

if __name__== '__main__':
      app.run()
```

The preceding code imports the Flask library, initiates the application by creating an instance of the Flask class, declares the route, and then defines the function to execute when the route is called. This code is enough to start your first Flask application.

The following code launches a very simple built-in server, which is good enough for testing but probably not when you want to go in production, but we will cover that in the later chapters.

When this application starts, the index route upon request shall return "Hello From Flask!" as shown in Figure 1-1.

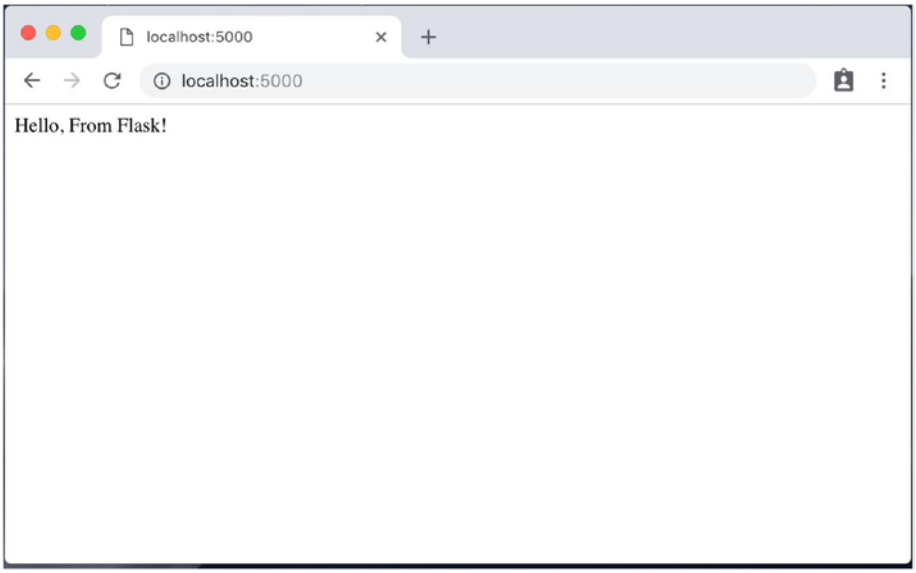

Figure 1-1. *Flask minimal application*

Flask Components Covered in This Book

Now that you have been introduced to Flask, we will discuss the components that we'll cover in Flask REST API development in this book.

This book will serve as a practical guide to REST API development using Flask, and we'll be using MySQL as the backend database. As already discussed, Flask doesn't come with native database access support, and to bridge that gap, we'll use a Flask extension called Flask-SQLAlchemy which adds support for SQLAlchemy in Flask. SQLAlchemy is essentially

a Python SQL toolkit and Object Relational Mapper which provides the developers the full power and flexibility of SQL.

SQLAlchemy provides full support for enterprise-level design patterns and is designed for high-performing database access while maintaining efficiency and ease of use. We'll build a user authentication module, CRUD (Create, Read, Update, and Delete) REST APIs for object creation, retrieval, manipulation, and deletion. We'll also integrate a documentation utility called Swagger for creating API documentation, write unit and integration tests, learn application debugging, and, finally, check out different methods of deploying and monitoring our REST APIs on cloud platforms for production use.

For unit tests, we'll use pytest which is a full-featured Python testing tool—pytest is easy to write tests with and yet is scalable to support complex use cases. We'll also use Postman which is a complete REST API Platform—Postman provides integration tools for every stage of the API lifecycle, making API development easier and more reliable.

API deployment and monitoring are critical parts of REST API development; development paradigm changes drastically when it comes to scaling the APIs for production use cases, and for the sake of this book, we'll deploy our REST APIs using uWSGI and Nginx on a cloud Ubuntu server. We'll also deploy our REST APIs on Heroku which is a cloud platform that facilitates Flask app deployment and scaling out of the box.

Last but not least, we'll discuss debugging common Flask errors and warnings and debugging Nginx requests and check out Flask application monitoring ensuring least amount on the downtime for production use.

Introduction to RESTful Services

Representational State Transfer (REST) is a software architectural style for web services that provides a standard for data communication between different kinds of systems. Web services are open standard

web applications that interact with other applications with a motive of exchanging data making it an essential part of client server architecture in modern web and mobile applications. In simple terms, REST is a standard for exchanging data over the Web for the sake of interoperability between computer systems. Web services which conform to the REST architectural style are called RESTful web services which allow requesting systems to access and manipulate the data using a uniform and predefined set of stateless operations.

Since its inception in 2000 by Roy Feilding, RESTful architecture has grown a lot and has been implemented in millions of systems since then. REST has now become one of the most important technologies for web-based applications and is likely to grow even more with its integration in mobile and IoT-based applications as well. Every major development language has frameworks for building REST web services. REST principles are what makes it popular and heavily used. REST is stateless, making it straightforward for any kind of system to use and also making it possible for each request to be served by a different system.

REST enables us to distinguish between the client and the server, letting us implement the client and the server independently. The most important feature of REST is its statelessness, which simply means that neither the client nor the server has to know the state of each other to be able to communicate. In this way, both the client and the server can understand any message received without seeing the previous message. Since we are talking about RESTful web services, let's take a dive into web services and compare other web service standards.

Web services in a simple definition is a service offered by one electronic device to another, enabling the communication via the World Wide Web. In practice, web services provide resource-oriented, web-based interface to a database server and so on utilized by another web client. Web services provide a platform for different kinds of systems to communicate to each other, using a solution for programs to be able to communicate with each other in a language they understand (Figure 1-2).

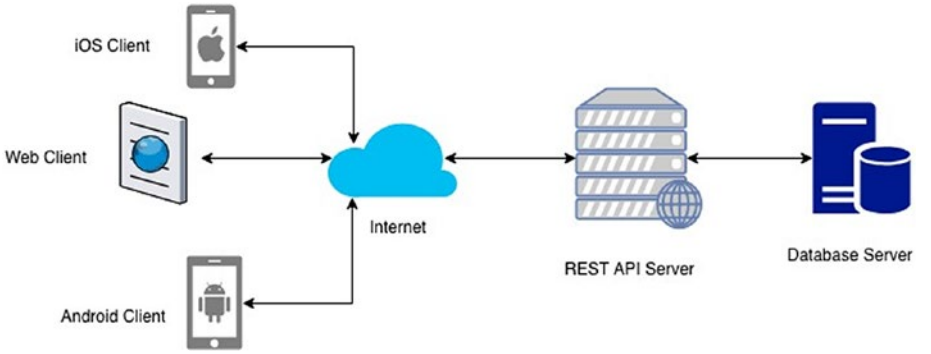

Figure 1-2. *REST architecture diagram*

SOAP (Simple Object Access Protocol) is another web service communication protocol which has been overtaken by REST in the recent years. REST services now dominate the industry representing more than 70% of public APIs according to Stormpath. They operate by exposing consistent interface to access named resources. SOAP, however, exposes components of application logic as services rather than data. SOAP is now a legacy protocol originally created by Microsoft and has a lot of other constraints when compared to REST. SOAP only exchanges data over XML, and REST provides the ability to exchange data over a variety of data formats. RESTful services are comparatively faster and less resource intensive. However, SOAP still has its own use cases in which it's a preferred protocol over REST.

SOAP is preferred when robust security is essential as it provides support for Web Services Security (WS-Security), which is a specification defining how security measures are implemented in web services to protect them from external attacks. Another advantage of SOAP over REST is its built-in retry logic to compensate for failed requests unlike REST in which the client has to handle failed requests by retrying. SOAP is highly extensible with other technologies and protocols like WS-Security, WS-addressing, WS-coordination, and so on which provides it an edge over other web service protocols.

Now, when we have briefly discussed web services—REST and SOAP—let's discuss features of REST protocol. In general, REST services are defined and implemented using the following features:

1. Uniform interface
2. Representations
3. Messages
4. Links between resources
5. Caching
6. Stateless

Uniform Interface

RESTful services should have a uniform interface to access resources, and as the name suggests, APIs' interface for the system should be uniform across the system. A logical URI system with uniform ways to fetch and manipulate data is what makes REST easy to work with. HTTP/1.1 provides a set of methods to work on noun-based resources; the methods are generally called verbs for this purpose.

In REST architecture, there is a concept of safe and idempotent methods. Safe methods are the ones that do not modify resources like a GET or a HEAD method. An idempotent method is a method which produces the same result no matter how many times it is executed. Table 1-1 provides a list of commonly used HTTP verbs in RESTful services.

Table 1-1. *Commonly used HTTP verbs useful in RESTful services*

Verb	CRUD	Operation	Safe	Idempotent
GET	Read	Fetch a single or multiple resource	Yes	Yes
POST	Created	Insert a new resource	No	No
PUT	Update/ Create	Insert a new resource or update existing	No	Yes
DELETE	Delete	Delete a single or multiple resource	No	Yes
OPTIONS	READ	List allowed operations on a resource	Yes	Yes
HEAD	READ	Return only response headers and no body	Yes	Yes
PATCH	Update/ Modify	Only update the provided changes to the resource	No	No

Representations

RESTful services focus on resources and providing access to the resources. A resource can be easily thought of as an object in OOP. The first thing to do while designing RESTful services is identifying different resources and determining the relation between them. A representation is a machine-readable explanation defining the current state of a resource.

Once the resources are identified, representations are the next course of action. REST provides us the ability to use any format for representing the resources in the system. Unlike SOAP which restricts us to use XML to represent the data, we can either use JSON or XML. Usually, JSON is the preferred method for representing the resources to be called by mobile or web clients, but XML can be used to represent more complex resources.

Here is a small example of representing resources in both formats.

Listing 1-2. XML Representation of a Book Resource

```
<?xml version="1.0" encoding="UTF-8"?>
<Book>
  <ID> 1 </ID>
  <Name> Building REST APIs with Flask </Name>
  <Author> Kunal Relan </Author>
  <Publisher > Apress </ Publisher >
</Book>
```

Listing 1-3. JSON Representation of a Book resource

```
{
      "ID": "1",
      "Name": "Building REST APIs wiith Flask",
      "Author": "Kunal Relan",
      "Publisher": "Apress"
}
```

In REST Systems, you can use either of the methods or both the methods depending on the requesting client to represent the data.

Messages

In REST architecture, which essentially established client–server style way of data communication, messages are an important key. The client and the server talk to each other via messages in which the client sends a message to the server which is often called as a request and the server sends a response. Apart from the actual data exchanged between the client and the server in the form of request and response body, there is some metadata exchanged by the client and the server both in the form of request and response headers. HTTP 1.1 defines request and response headers formats in the following way in order to achieve a uniform way of data communication across different kinds of systems (Figure 1-3).

Figure 1-3. *HTTP sample request*

In Figure 1-4, GET is the request method, "/comments" is the path in the server, "postId=1" is a request parameter, "HTTP/1.1" is the protocol version that the client is requesting, "jsonplaceholder.typicode.com" is the server host, and content type is a part of the request headers. All of these combined is what makes a HTTP request that the server understands.

In return, the HTTP server sends the response for the requested resources.

```
[
  {
    "postId": 1,
    "id": 1,
    "name": "id labore ex et quam laborum",
    "email": "Eliseo@gardner.biz",
    "body": "laudantium enim quasi est quidem magnam voluptate
            ipsam eos\ntempora quo necessitatibus\ndolor quam
            autem quasi\nreiciendis et nam sapiente accusantium"
  },
  {
    "postId": 1,
    "id": 2,
    "name": "quo vero reiciendis velit similique earum",
    "email": "Jayne_Kuhic@sydney.com",
```

```
  "body": "est natus enim nihil est dolore omnis voluptatem
          numquam\net omnis occaecati quod ullam at\nvoluptatem
          error expedita pariatur\nnihil sint nostrum voluptatem
          reiciendis et"
},
{
  "postId": 1,
  "id": 3,
  "name": "odio adipisci rerum aut animi",
  "email": "Nikita@garfield.biz",
  "body": "quia molestiae reprehenderit quasi aspernatur\naut
          expedita occaecati aliquam eveniet laudantium\nomnis
          quibusdam delectus saepe quia accusamus maiores nam
          est\ncum et ducimus et vero voluptates excepturi
          deleniti ratione"
},
{
  "postId": 1,
  "id": 4,
  "name": "alias odio sit",
  "email": "Lew@alysha.tv",
  "body": "non et atque\noccaecati deserunt quas accusantium
          unde odit nobis qui voluptatem\nquia voluptas
          consequuntur itaque dolor\net qui rerum deleniti ut
          occaecati"
},
{
  "postId": 1,
  "id": 5,
  "name": "vero eaque aliquid doloribus et culpa",
  "email": "Hayden@althea.biz",
```

```
    "body": "harum non quasi et ratione\ntempore iure ex
            voluptates in ratione\nharum architecto fugit
            inventore cupiditate\nvoluptates magni quo et"
}]
```

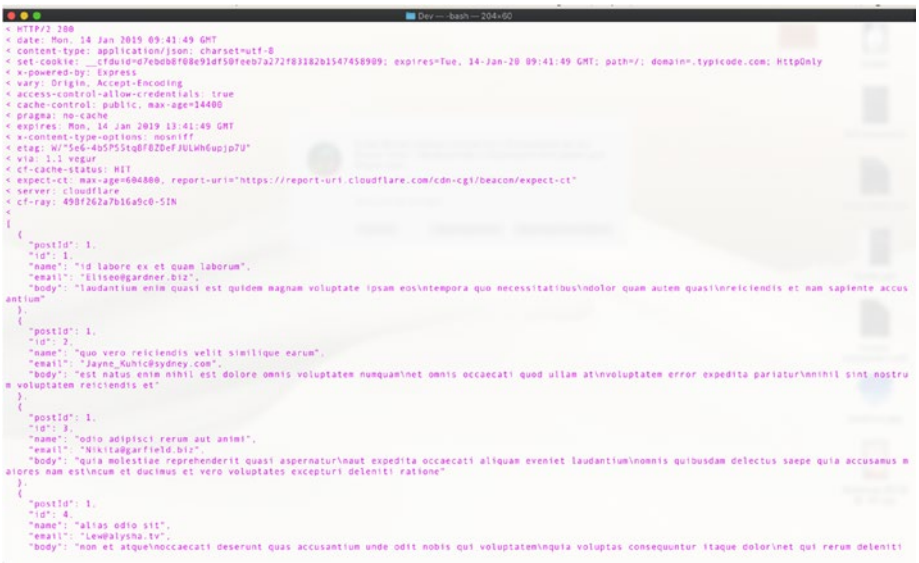

Figure 1-4. *HTTP sample response*

In the preceding figure, "HTTP/2" is the response HTTP version and "200" is the response code. The part below that till "cf-ray" is the response headers, and the array of post comments below "cf-ray" is the response body of the request.

Links Between Resources

A resource is the fundamental concept in the world of REST architecture. A resource is an object with a type, associated data, and relationships to other resources alongside a set of methods that can be executed on it. The resource in a REST API can contain link to other resources which should drive the process flow. Such as in the case of a HTML web page in

which the links in the homepage drive the user flow, resources in REST API should be able to drive the flow without the user knowing the process map.

Listing 1-4. A Book with Link to Buy

```
{
      "ID": "1",
      "Name": "Building REST APIs wiith Flask",
      "Author": "Kunal Relan",
      "Publisher": "Apress",
       "URI" : "https://apress.com/us/book/123456789"
}
```

Caching

Caching is a technique that stores a copy of a given resource and serves it back when requested, saving extra DB calls and processing time. It can be done at different levels like the client, the server, or a middleware proxy server. Caching is an important tool for increasing the API performance and scaling the application; however, if not managed properly, it results in the client being served old results. Caching in REST APIs is controlled using HTTP headers. Cache headers have been an essential part of HTTP header specifications and have been an important part of scaling web services with efficiency. In REST specification, when a safe method is used on a resource URL, usually the reverse proxy caches the results to use the cached data when the same resource is requested the next time.

Stateless

> Each request from client to server must contain all of the information necessary to understand the request, and cannot take advantage of any stored context on the server. Session state is therefore kept entirely on the client
>
> —Roy Fielding

Statelessness here means that every HTTP response is a complete entity in itself and enough to serve the purpose of providing information to be executed without any need of another HTTP request. The point of statelessness is to defeat the purpose of accord with the server allowing intended flexibility in the infrastructure. To facilitate the same, REST servers provide enough information in the HTTP response that the client may need. Statelessness is an essential part of being able to scale the infrastructure enabling us to deploy multiple servers to serve millions of concurrent users given the fact that there is no server session state dependency. It also enables the caching feature of REST infrastructure as it lets the caching server to decide whether to cache the request or not, just by looking at the particular request irrespective of any previous requests.

Planning REST API

Here is a list of things we need to check while planning to create REST APIs:

1. Understanding the use case. It is really important to know why you are building the API and what services will the API provide.
2. Listing down API features to understand what all actions your APIs are going to do. This also includes listing down actions and grouping them together to tackle redundant endpoints.
3. Identify different platforms that'll use the API and provide support accordingly.
4. Plan long term on supporting growth and scaling the infrastructure.
5. Plan API versioning strategy ensuring continuous support is maintained over different versions of the APIs.

6. Plan API access strategy, that is, authentication, ACL, and throttling.
7. Plan API documentation and testing.
8. Understand how to use hypermedia with your APIs.

So, these are the eight important things to ensure while planning your API and are really crucial for developing a stable, production-focused API system.

API Design

Now let's look into API design. Here we'll cover the standards of designing REST APIs keeping in mind the list of things we just talked about.

Long-Term Implementation

Long-term implementation helps you analyze the flaws in design before actual implementation. This helps the developers to choose the right kind of platforms and tools to build upon making sure the same system can be scaled for more users later.

Spec-Driven Development

Spec-driven development enforces API design using definition and not just the code, which ensures that the changes are made to the codebase while the API design is intact. It is good practice to use a tool like API Designer to understand the API design before development which also lets you foresee the flaws. Tools like swagger or RAML let you keep the API design standardized and enable you to port the API to different platforms if needed.

Prototyping

Once the API specs are put in place, prototyping helps you visualize the API before actual development by letting the developers create MOCK API to help them understand every potential aspect of the API.

Authentication and Authorization

Authentication involves the verification process to know who the person is, but it just doesn't involve giving access to all the resources yet, and that's where authorization comes in, which involves authorizing an authenticated person to keep a check on resources allowed to access using an Access Control List (ACL).

We have different ways of authenticating and authorizing users like basic authentication, HMAC, and OAuth. OAuth 2.0 is however a preferred method for the same and is a standard protocol used by enterprises as well as small companies for authentication and authorization in their REST APIs.

So, these are the key features of the REST infrastructure, and we'll discuss more about how REST works and enables better communication in later chapters.

Now, we'll start with setting up our development environment and understand some key factors of developing applications with Python.

Setting Up Development Environment

In this part, we'll discuss setting up Python development environment for a Flask application. We'll use virtual environments for a separate isolated environment for our dependencies. We'll use PIP for installing and managing our dependencies and a couple of other helpful utilities in the process of setting up our development environment. For the sake of this book, we'll be doing everything on macOS Mojave and Python 2.7, but you

can feel free to use any operating system as per your convenience. So if you don't have the right version of Python installed in your operating system, you can go ahead with installing Python on your choice of operating system using this link: www.python.org/downloads/ (Figure 1-5).

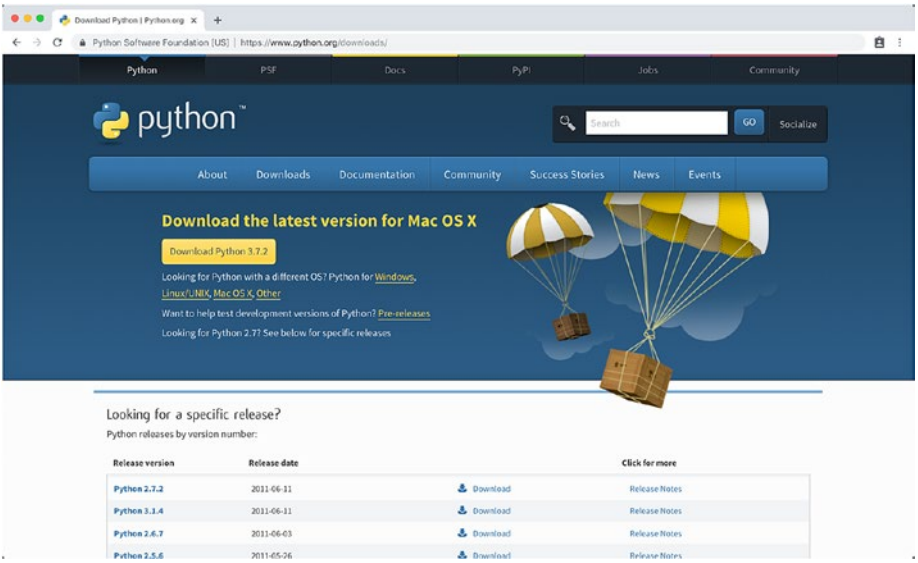

Figure 1-5. *Python download*

Working with PIP

PIP is a PyPi recommended tool for project dependency management. PIP comes preinstalled with Python if you are using Python downloaded from www.python.org.

However, if you don't have PIP installed in your system, follow the guide here to install PIP.

In order to install PIP, download get-pip.py by using the following command in your terminal (or command line in Windows).

```
$ curl https://bootstrap.pypa.io/get-pip.py -o get-pip.py
```

Once you have the get-pip.py file, install and run the next command:

```
$ python get-pip.py
```

The previous command will install PIP, setuptools (required for installing source distributions), and wheel.

If you already have PIP, you can upgrade to the latest version of pip using the following command:

```
$ pip install -U pip
```

To test your installation, you should run the following command (Figure 1-6) in your terminal (or command line in Windows):

```
$ python -V
$ pip -V
```

Figure 1-6. *Checking Python and PIP installation*

Choosing the IDE

Before we start writing the code, we'll need something to write with. Throughout this book, we'll use Visual Studio Code which is an open source and free IDE available on all major operating systems. Visual Studio Code is available to download from `www.code.visualstudio.com`, and it provides good support for developing Python applications with plenty of handy plugins to facilitate development. You can choose to use your own preferred text editor or IDE to follow this book (Figure 1-7).

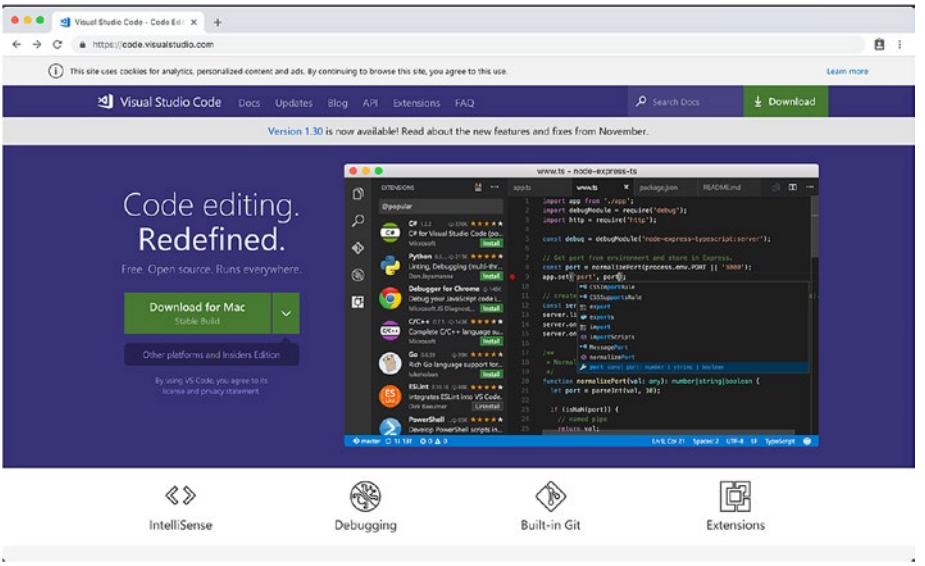

Figure 1-7. *Visual Studio Code*

Once we have the IDE setup, we can move to installing and setting up the virtual environment.

Understanding Python Virtual Environments

Python, just like other modern programming languages, provides a huge amount of third-party libraries and SDKs. Different applications might need various specific versions of third-party modules, and it won't be possible for one Python installation to meet such requirements of every application. So, in the world of Python, the solution for this problem is virtual environment, which creates a separate self-contained directory tree containing a Python installation of the required version alongside the required packages.

At its core, the main purpose of a virtual environment is to create an isolated environment to contain an installation of Python and required packages for the application. There is no limit to the number of virtual environments you can create, and it's super easy to create them.

Using Virtual Environments

In Python 2.7 we need a module called **virtualenv** which is installed using PIP to get started with Python virtual environments.

Note In Python 3 the venv module comes preshipped as a part of the standard library.

To install virtualenv, type the following command in your terminal (or command line in case of Windows).

```
$ pip install virtualenv
```

Once we have the virtualenv module installed in our system, next we'll create a new directory and create a virtual environment in it.

Now, type the following command to create a new directory and open it in your terminal.

```
$ mkdir pyenv && cd pyenv
```

The preceding command will create a directory and open it in your terminal, and then we'll use the virtualenv module to create a new virtual environment inside the directory.

```
$ virtualenv venv
```

The previous command will use the virtualenv module and create a virtual environment called venv. You can name your virtual environment anything, but for this book, we'll just use venv for the sake of uniformity.

Once this command stops executing, you'll see a directory called venv. This directory will now hold your virtual environment.

The directory structure of the venv folder should be similar to the one in Figure 1-8.

Figure 1-8. *Virtual environment directory structure*

Here is what each folder in the structure contains:

1. bin: Files to interact with the virtual environment.
2. include: C headers to compile the Python packages.
3. lib: This folder contains a copy of the Python version and all the other third-party modules.

Next, there are copies of, or symlinks to, different Python tools to ensure all the Python code and commands are executed within the current environment. The important part here is the activation scripts in bin folder, which sets the shell to use the virtual environment's Python and site packages. In order to do so, you need to activate the virtual environment by typing the following command in your terminal.

```
$ source venv/bin/activate
```

Once this command is executed, your shell prompt will be prefixed with the name of the virtual environment, just as in Figure 1-9.

Figure 1-9. *Activating virtual environment*

Now, let's install Flask in our virtual environment using the following command:

```
$ pip install flask
```

The preceding command should install Flask in our virtual environment. We'll use the same code we did in our sample Flask application.

```
$ nano app.py
```

And type the following code in the nano text editor:

```
from flask import Flask
app = Flask(__name__)

@app.route('/')
def hello_world():
    return 'Hello, From Flask!'
```

```
Now,  try running your app.py using python app.py command.

$ FLASK_APP=app.py flask run
```

With the preceding command, you should be able to run the simple Flask application, and you should see similar output in your terminal (Figure 1-10).

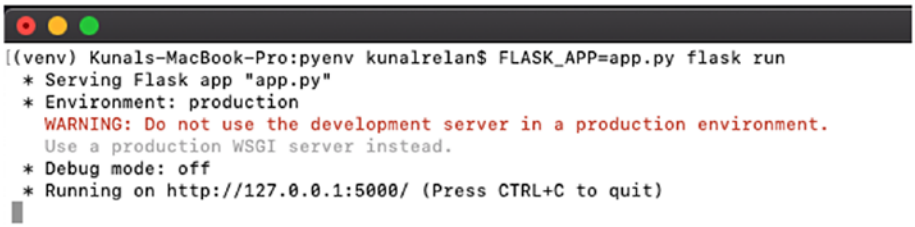

Figure 1-10. *Running Flask application in virtual environment*

Now, to deactivate the virtual environment, you need to execute the following command:

```
$ deactivate
```

After this command executes, (venv) prefix from the shell will go away, and if you try running the application again, it will throw an error (Figure 1-11).

Figure 1-11. *Running Flask application without virtual environment*

So now you understand the concept of virtual environments, we can dig a little deeper and understand what's happening inside the virtual environment.

Understanding how virtual environments work can really help you debug the application and understand the execution environment. To start with, let's check out the Python executable with virtual environment activated and deactivated, in order to understand the basic difference.

Let's execute the following command with virtual environment activated (Figure 1-12):

```
$ which python
```

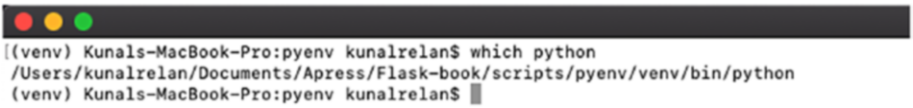

Figure 1-12. *Checking Python executable with virtual environment*

As you see in the following figure, the shell is using virtual environment's Python executable, and if you deactivate the environment and re-run the Python command, you'll notice the shell is now using the system's Python (Figure 1-13).

Figure 1-13. *Checking Python executable without virtual environment*

So once you activate the virtual environment, the $path environment variable is modified to point at our virtual environment, and thus the Python in our virtual environment is used rather than the system one. However, an important thing to notice here is that it is basically a copy of, or a symlink to, the system's Python executable.

Setting Up Flask

We have already installed Flask in the earlier module, but let's start over and setup the Flask microframework.

Installing Flask

With virtual environment activated, execute the following command to install the latest version of Flask.

```
$pip install flask
```

The preceding command will install Flask in your virtual environment.

However, if you wish to work with the latest Flask before release, install/update the Flask module using the master branch of its repository by executing the following command:

```
$pip install -U https://github.com/pallets/flask/archive/
master.tar.gz
```

When you install Flask, the following distributions are installed with the main framework:

1. *Werkzeug (http://werkzeug.pocoo.org/):* Werkzeug implements WSGI, the standard Python interface between the application and the server.
2. Jinja (http://jinja.pocoo.org/): Jinja is the templating engine in Flask which renders the pages for the application.
3. MarkupSafe (https://pypi.org/project/MarkupSafe/): Markupsafe comes preshipped with Jinja, which helps escape an untrusted user input to escalate injection attacks.
4. ItsDangerous(https://pythonhosted.org/itsdangerous/): ItsDangerous is responsible for securely signing data to ensure data integrity and is used to protect Flask session cookies.

5. Click (http://click.pocoo.org/): Click is a framework to write CLI applications. It provides the "Flask" CLI command.

Conclusion

Once you have Flask installed in your virtual environment, you are ready to go to the next step of the development phase. Before we do that, we'll discuss about MySQL and Flask-SQLAlchemy which is the ORM that we'll use in our Flask application. Database is an essential part of a REST application, and in the next chapter, we'll discuss the MySQL database and Flask-SQLAchemy ORM and also learn how to connect our Flask application with Flask-SQLAlchemy.

CHAPTER 2

Database Modeling in Flask

This chapter covers one of the most important aspects of REST application development, that is, connecting and interacting with database systems. In this chapter, we'll discuss about NoSQL and SQL databases, connecting and interacting with them.

In this chapter we'll cover the following topics:

1. NoSQL vs. SQL databases
2. Connecting with Flask-SQLAlchemy
3. Interacting with MySQL DB using Flask-SQLAlchemy
4. Connecting with Flask-MongoEngine
5. Interacting with MongoDB using Flask-MongoEngine

Introduction

Flask being a microframework provides flexibility of the data source for applications and also provides library support for interacting with different kinds of data sources. There are libraries to connect to SQL- and NoSQL-

K. Relan, *Building REST APIs with Flask*, https://doi.org/10.1007/978-1-4842-5022-8_2

based databases in Flask. It also provides the flexibility to interact with databases using raw DB libraries or using ORM (Object Relational Mapper) /ODM (Object Document Mapper). In this chapter, we'll briefly discuss NoSQL- and SQL-based databases and learn using ORM layer for our Flask application using Flask-SQLAlchemy, after which we'll use ODM layer using Flask-MongoEngine.

Most applications do need databases at some point, and MySQL and MongoDB are just two of the many tools for doing it. Choosing the right one for your application will entirely depend on the data you are going to store. If your datasets in tables are related to each other, SQL databases is the way to go or NoSQL databases can serve the purpose too.

Now, let's have a brief look over SQL vs. NoSQL databases.

SQL Databases

SQL databases use Structured Query Language (SQL) for data manipulation and definition. SQL is a versatile, widely used and accepted option which makes it a great choice for data storing. SQL systems work great when the data in use needs to be relational and the schema is predefined. However, a predefined schema also serves as a con, as it requires the whole dataset to follow the same structure which might turn out to be tough in some situations. SQL databases store data in forms of tables made up of rows and columns and are vertically scalable.

NoSQL Databases

NoSQL databases have a dynamic schema for unstructured data and store data in different ways ranging from column-based (Apache Cassandra), document-based (MongoDB), and graph-based (Neo4J) or as a key-value store (Redis). This provides the flexibility to store data without a predefined structure and versatility to add fields to the data structure on the go. Being schemaless is the key distinction of NoSQL databases,

and it also makes them better suited for distributed systems. Unlike SQL databases, NoSQL databases are horizontally scalable.

Now that we have briefly explained SQL and NoSQL databases, we'll jump to functional differences between MySQL and MongoDB since these are the two database engines we'll be looking at in this chapter.

Key Differences: MySQL vs. MongoDB

So as discussed earlier, MySQL is a SQL-based database which stores data in tables with columns and rows and only works on structured data. MongoDB, on the other hand, can handle unstructured data and stores JSON-like documents rather than tables and uses MongoDB query language to communicate with the DB. MySQL is an extremely established database with a huge community and great stability, and MongoDB is a fairly new technology with growing community and is developed by MongoDB Inc. MySQL is vertically scalable in which the load on the single server can be increased by upgrading the RAM, SSD, or CPU, while in the case of MongoDB, which is horizontally scalable, it needs to share and add more servers in order to increase server load. MongoDB is the preferred choice for high write loads and big datasets, and MySQL is a perfect fit for applications that depends highly on multi-row transactions like accounting systems. MongoDB is a great choice for applications with dynamic structure and high data load such as that of a real-time analytics application or a content management system.

Flask provides support for interacting with both MySQL and MongoDB. There are various native drivers as well as ORM/ODM for communication with the database. Flask-MySQL is a Flask extension that allows native connection to MySQL; Flask-PyMongo is a native extension for working with MongoDB in Flask and is recommended by MongoDB as well. Flask-MongoEngine is a Flask extension, ODM for Flask to work with MongoDB. Flask-SQLAlchemy is an ORM layer for Flask applications to connect with MySQL.

Next, we'll discuss about Flask-SQLAlchemy and Flask- MongoEngine and create Flask CRUD applications using them.

Creating a Flask Application with SQLAlchemy

Flask-SQLAlchemy is an extension for flask which adds support for SQLAlchemy to the application. SQLAlchemy is a Python toolkit and Object Relational Mapper that provides access to the SQL database using Python. SQLAlchemy comes with enterprise-level persistence patterns and efficient and high performing database access. Flask-SQLAlchemy provides support for the following SQL-based database engines given the appropriate DBAPI driver is installed:

- PostgreSQL
- MySQL
- Oracle
- SQLite
- Microsoft SQL Server
- Firebird SyBase

We'll be using MySQL as the database engine in our application, so let's get started with installing SQLAlchemy and start setting up our application.

Let's create a new directory called flask-MySQL, create a virtual environment, and then install flask-sqlalchemy.

```
$ mkdir flask-mysql && cd flask-mysql
```

Now, create a virtual environment inside the directory using the following command:

```
$ virtualenv venv
```

As discussed earlier, we can activate the virtual environment using the following command:

```
$ source venv/bin/activate
```

Once the virtual environment is activated, let's install flask-sqlalchemy.

Flask and Flask-SQLAlchemy can be installed using PIP with the following command.

```
(venv)$ pip install flask flask-sqlalchemy
```

Other than SQLite, all other database engines need separate libraries to be installed alongside Flask-SQLAlchemy for it to work. SQLAlchemy uses MySQL-Python as the default DBAPI for connecting with MySQL.

Now, let's install PyMySQL to enable MySQL connection with Flask-SQLAlchemy.

```
(venv) $ pip install pymysql
```

Now, we should have everything we need to create our sample flask-MySQL application with.

Let's start by creating app.py which will contain the code for our application. After creating the file, we'll initiate the Flask application.

```
from flask import Flask
from flask_sqlalchemy import SQLAlchemy

app = Flask(__name__)
app.config['SQLALCHEMY_DATABASE_URI'] =
'mysql+pymysql://<mysql_username>:<mysql_password>@<mysql_
host>:<mysql_port>/<mysql_db>'
db = SQLAlchemy(app)

if __name__ == "__main__":
    app.run(debug=True)
```

Here, we import the Flask framework and Flask-SQLAlchemy and then initiate an instance of Flask. After that, we configure the SQLAlchemy database URI to use our MySQL DB URI, and then we create an object of SQLAlchemy named as db, which will handle our ORM-related activities.

Now, if you are using MySQL, make sure you supply connection strings of a running MySQL server and that the database name supplied does exist.

Note Use environment variables for supplying database connection strings in your applications.

Make sure that you have a running MySQL server to follow this application. However, you can also use SQLite in its place by supplying the SQLite config details in the SQLAlchemy database URI which should look like this:

```
app.config['SQLALCHEMY_DATABASE_URI'] = 'sqlite:////tmp/
<db_name>.db'
```

In order to run the application, you need to execute the following code in your terminal:

```
(venv) $ python app.py
```

And if there are no errors, you should see a similar output in your terminal:

```
(venv) $ python app.py
* Serving Flask app "app" (lazy loading)
 * Environment: production
   WARNING: Do not use the development server in a production
   environment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

```
 * Restarting with stat
 * Debugger is active!
 * Debugger PIN: 779-301-240
```

Creating an Author Database

We'll now create an author database application which will provide RESTful CRUD APIs. All the authors will be stored in a table titled "authors".

After the declared db object, add the following lines of code to declare a class as Authors which will hold the schema for the author table:

```
class Author (db.Model):
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(20))
    specialisation = db.Column(db.String(50))

    def __init__(self, name, specialisation):
        self.name = name
        self.specialisation = specialisation
    def __repr__(self):
      return '<Product %d>' % self.id
db.create_all()
```

With this code, we have created a model titled "Authors" which has three fields—ID, name, and specialisation. Name and specialisation are strings, but ID is a self-generated and auto-incremented integer which will serve as a primary key. Notice the last line "db.create_all()" which instructs the application to create all the tables and database specified in the application.

In order to serve JSON response from our API using the data returned by SQLAlchemy, we need another library called marshmallow which is an add-on to SQLAlchemy to serialize SQLAlchemy-returned data objects to JSON.

```
(venv)$ pip install flask-marshmallow
```

The following command will install the Flask version of marshmallow in our application, and we'll define our output schema from the Authors model using marshmallow.

Add the following lines on the top, below the other imports in your application file to import marshmallow.

```
from marshmallow_sqlalchemy import ModelSchema
from marshmallow import fields
```

After the db.create_all(), define your output schema using the following code:

```
class AuthorSchema(ModelSchema):
    class Meta(ModelSchema.Meta):
        model = Authors
        sqla_session = db.session

    id = fields.Number(dump_only=True)
    name = fields.String(required=True)
    specialisation = fields.String(required=True)
```

The preceding code maps the variable attribute to field objects, and in Meta, we define the model to relate to our schema. So this should help us return JSON from SQLAlchemy.

After setting up our model and return schema, we can jump to creating our endpoints. Let's create our first GET /authors endpoint to return all the registered authors. This endpoint will query for all the objects in the Authors model and return them in JSON to the user. But before we write the endpoint, edit the first import line to the following to import jsonify, make_response, and request from Flask.

```
from flask import Flask, request, jsonify, make_response
```

And after the AuthorSchema, write your first endpoint /authors with the following code:

```
@app.route('/authors', methods = ['GET'])
def index():
    get_authors = Authors.query.all()
    author_schema = AuthorSchema(many=True)
    authors, error = author_schema.dump(get_authors)
    return make_response(jsonify({"authors": authors}))
```

In this method, we are fetching all the authors in the DB, dumping it in the AuthorSchema, and returning the result in JSON.

If you start the application and hit the endpoint now, it will return an empty array since we haven't added anything in the DB yet, but let's go ahead and try the endpoint.

Run the application using Python app.py, and then query the endpoint using your preferred REST client. I'll be using Postman to request the endpoint.

So just open your Postman and GET `http://localhost:5000/authors` to query the endpoint (Figure 2-1).

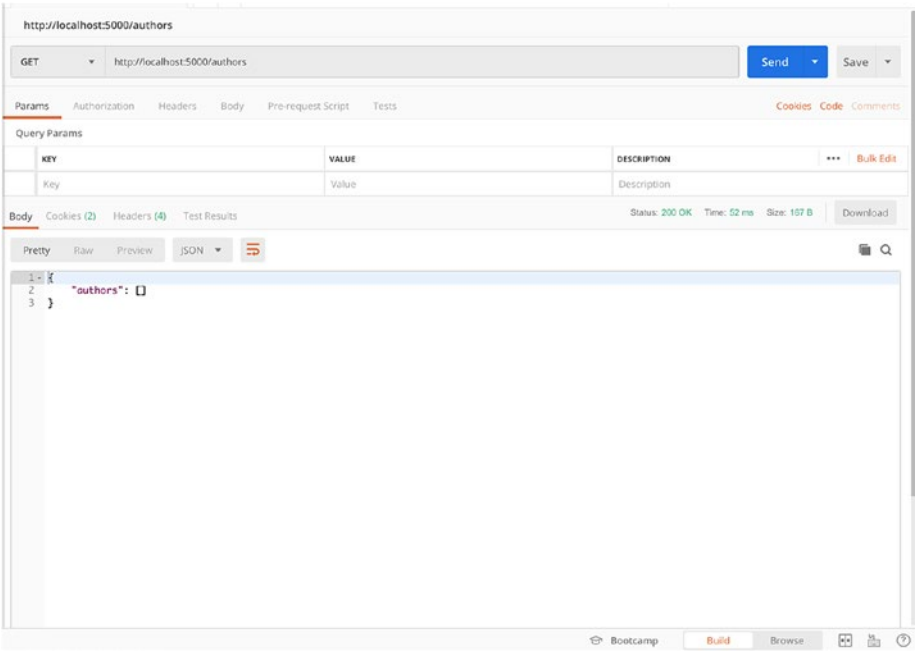

Figure 2-1. *GET /authors response*

You should see a similar result in your Postman client. Now let's create the POST endpoint to add authors to our database.

We can add an object to the table by either directly creating an Authors class in our method or by creating a classMethod to create a new object in Authors class and then calling the method in our endpoint. Let's add the class Method in Authors class to create a new object.

Add the following code in Authors class after fields definition:

```
def create(self):
    db.session.add(self)
    db.session.commit()
    return self
```

The preceding method creates a new object with the data and then returns the created object. Now your Authors class should look like this:

```
class Authors(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(20))
    specialisation = db.Column(db.String(50))

    def create(self):
      db.session.add(self)
      db.session.commit()
      return self

    def __init__(self, name, specialisation):
        self.name = name
        self.specialisation = specialisation
    def __repr__(self):
        return '<Author %d>' % self.id
```

Now we'll create our POST authors endpoint and write the following code after the GET endpoint:

```
@app.route('/authors', methods = ['POST'])
def create_author():
    data = request.get_json()
    author_schema = AuthorsSchema()
    author, error = author_schema.load(data)
    result = author_schema.dump(author.create()).data
    return make_response(jsonify({"author": authors}),201)
```

The previous method will take the JSON request data, load the data in the marshmallow schema, and then call the create method we created in the Authors class which will return the created object with 201 status code.

So let's request the POST endpoint with sample data and check the response. Let's open Postman and POST /authors with JSON request body.

We need to add name and specialisation fields in our body to create the object. Our sample request body should look like the following:

```
{
      "name" : "Kunal Relan",
      "specialisation" : "Python"
}
```

Once we request the endpoint, we shall get Author object in response with our newly created Author. Notice that in this case, the return status code is 201 which is the status code for a new object (Figure 2-2).

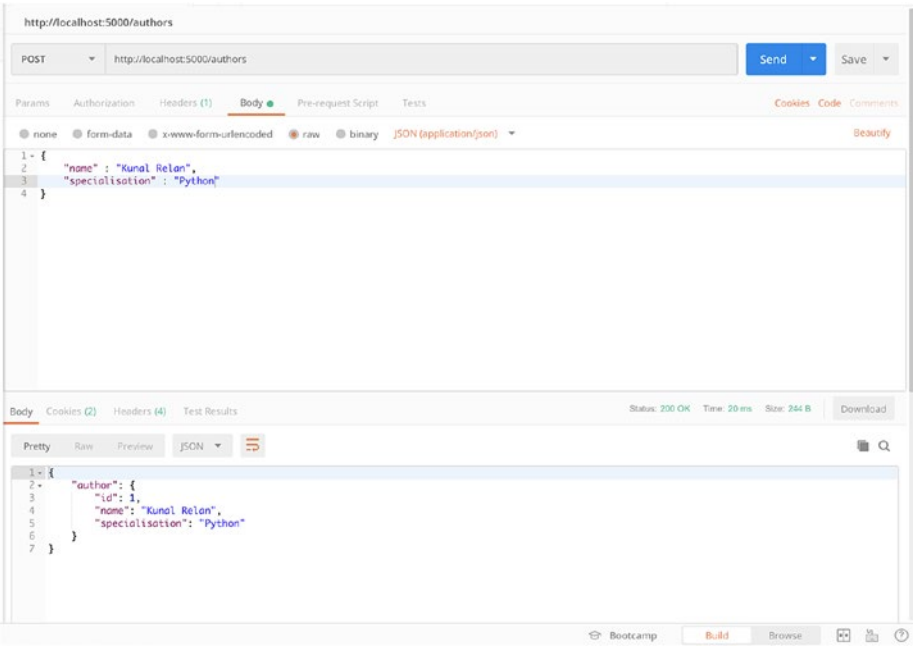

Figure 2-2. *POST /authors endpoint*

So now, if we request our GET /authors endpoint, we shall get our newly created author in the response.

Revisit the GET /authors tab in Postman and hit the request again; this time you should get an array of authors with our newly created Author (Figure 2-3).

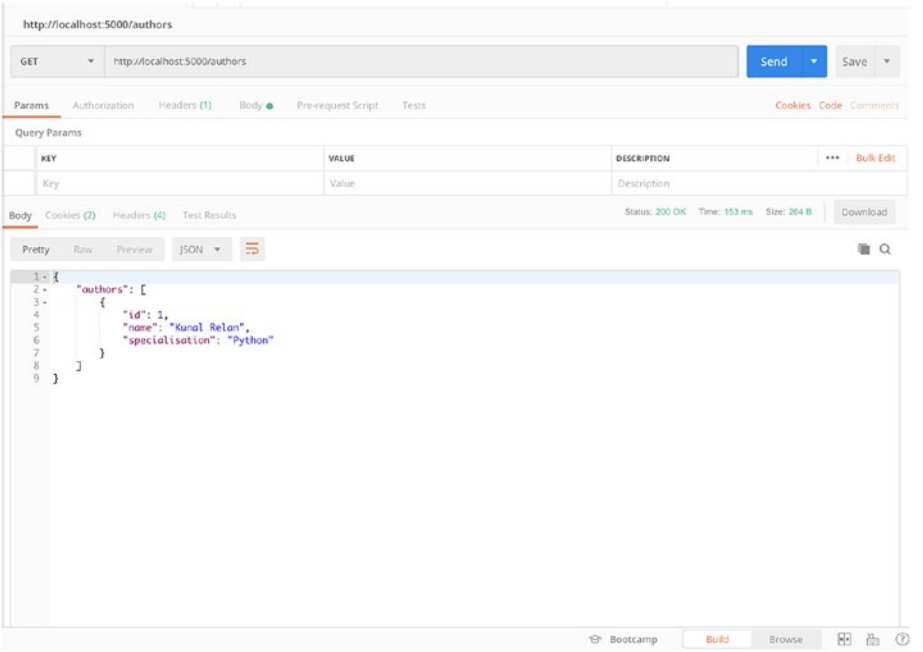

Figure 2-3. *GET all authors with new object*

So far, we have created endpoints to register new authors and to fetch a list of authors. Next we'll create an endpoint to return author using the author ID and then update endpoint to update author details using author ID and the last endpoint to delete an author using author ID.

For GET author by ID, we'll have a route like /authors/<id> which will take author ID from the request parameter and find the matching author.

Add the following code for the GET author by ID endpoint below your GET all authors route.

```
@app.route('/authors/<id>', methods = ['GET'])
def get_author_by_id(id):
```

```
    get_author = Authors.query.get(id)
    author_schema = AuthorsSchema()
    author, error = author_schema.dump(get_author)
    return make_response(jsonify({"author": author}))
```

Next we need to test this endpoint, and we'll request for author with ID 1 as we see in the preceding GET all authors API response, so let's open Postman again and request /authors/1 on our application server to check the response.

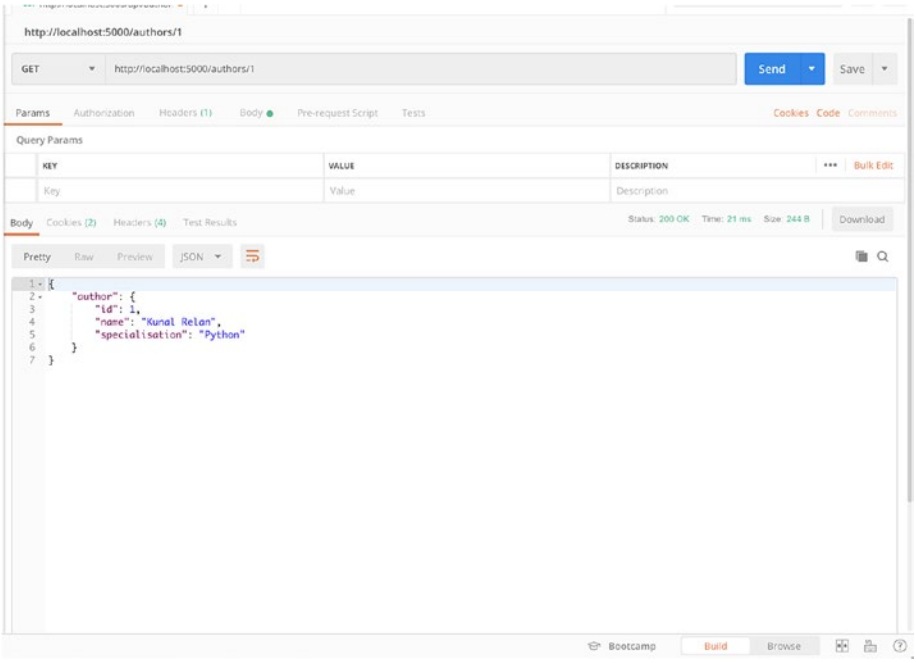

Figure 2-4. *GET author by ID endpoint*

As you see in the preceding screenshot, we are returning an object with a key author containing the author object with ID 1. You can now add more authors using the POST endpoint and fetch them using the returned ID.

Next, we need to create an endpoint to update the author name or specialisation, and for updating any object, we'll use PUT HTTP verb as we discussed in the "Introduction to RESTful Services" section. This endpoint will be similar to the GET authors by ID endpoint but will use PUT verb rather than the GET one.

Here is the code for the PUT endpoint to update an author object

```
@app.route('/authors/<id>', methods = ['PUT'])
def update_author_by_id(id):
    data = request.get_json()
    get_author = Authors.query.get(id)
    if data.get('specialisation'):
        get_author.specialisation = data['specialisation']
    if data.get('name'):
        get_author.name = data['name']
    db.session.add(get_author)
    db.session.commit()
    author_schema = AuthorsSchema(only=['id', 'name',
    'specialisation'])
    author, error = author_schema.dump(get_author)
    return make_response(jsonify({"author": author}))
```

So let's test our PUT endpoint and change the specialisation of author ID 1.

We'll PUT the following JSON body to update the author specialisation.

```
{
      "specialisation" : "Python Applications"
}
```

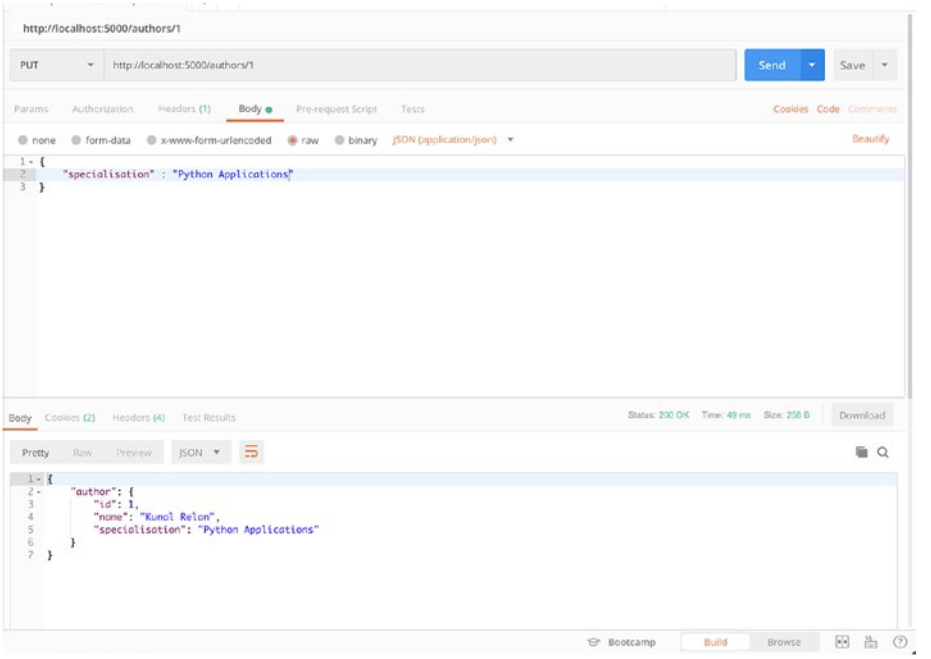

Figure 2-5. *UPDATE author by ID endpoint*

As you can see in Figure 2-5, we updated the author with ID 1, and now the specialisation has been updated to "Python Applications".

Now, the last endpoint to remove an author from the database. Add the following code to add a delete endpoint which will look like get author by ID endpoint but will use DELETE verb and return 204 status code with no content.

```
@app.route('/authors/<id>', methods = ['DELETE'])
def delete_author_by_id(id):
    get_author = Authors.query.get(id)
    db.session.delete(get_author)
    db.session.commit()
    return make_response("",204)
```

And now we'll request the delete endpoint to remove our author with ID 1 (Figure 2-6).

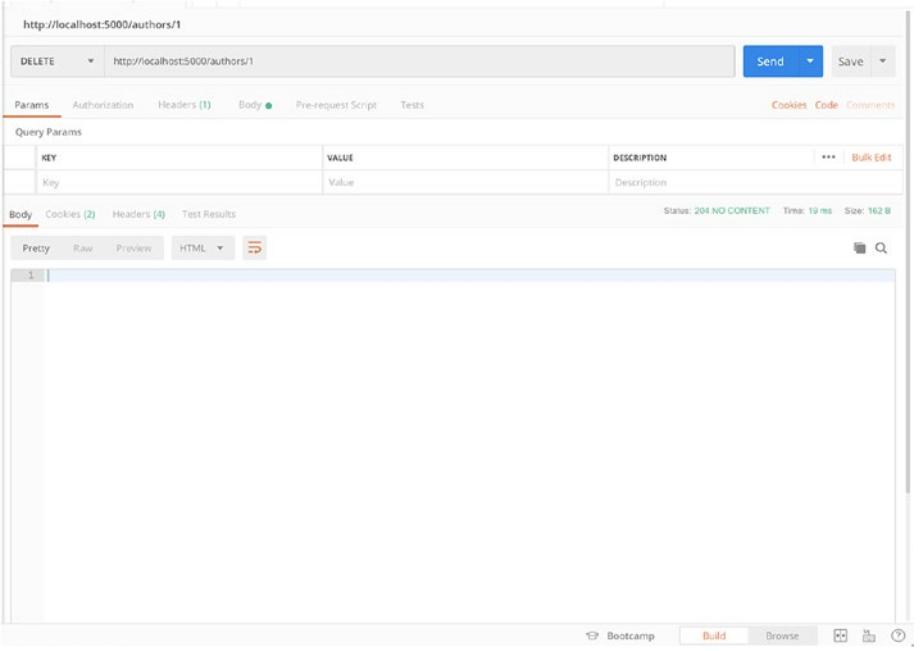

Figure 2-6. *DELETE author by ID*

And now if you request GET all authors endpoint, it shall return an empty array.

Now your app.py should have the following code:

```
from flask import Flask, request, jsonify, make_response
from flask_sqlalchemy import SQLAlchemy
from marshmallow_sqlalchemy import ModelSchema
from marshmallow import fields

app = Flask(__name__)
app.config["SQLALCHEMY_DATABASE_URI"] = 'mysql+pymysql://<mysql_
username>:<mysql_password>@<mysql_host>:<mysql_port>/<mysql_db>'
```

```
db = SQLAlchemy(app)

class Authors(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(20))
    specialisation = db.Column(db.String(50))

    def create(self):
      db.session.add(self)
      db.session.commit()
      return self

    def __init__(self, name, specialisation):
        self.name = name
        self.specialisation = specialisation

    def __repr__(self):
        return '<Author %d>' % self.id

db.create_all()

class AuthorsSchema(ModelSchema):
    class Meta(ModelSchema.Meta):
        model = Authors
        sqla_session = db.session

    id = fields.Number(dump_only=True)
    name = fields.String(required=True)
    specialisation = fields.String(required=True)

@app.route('/authors', methods = ['GET'])
def index():
    get_authors = Authors.query.all()
    author_schema = AuthorsSchema(many=True)
    authors, error = author_schema.dump(get_authors)
    return make_response(jsonify({"authors": authors}))
```

```
@app.route('/authors/<id>', methods = ['GET'])
def get_author_by_id(id):
    get_author = Authors.query.get(id)
    author_schema = AuthorsSchema()
    author, error = author_schema.dump(get_author)
    return make_response(jsonify({"author": author}))

@app.route('/authors/<id>', methods = ['PUT'])
def update_author_by_id(id):
    data = request.get_json()
    get_author = Authors.query.get(id)
    if data.get('specialisation'):
        get_author.specialisation = data['specialisation']
    if data.get('name'):
        get_author.name = data['name']
    db.session.add(get_author)
    db.session.commit()
    author_schema = AuthorsSchema(only=['id', 'name',
    'specialisation'])
    author, error = author_schema.dump(get_author)
    return make_response(jsonify({"author": author}))

@app.route('/authors/<id>', methods = ['DELETE'])
def delete_author_by_id(id):
    get_author = Authors.query.get(id)
    db.session.delete(get_author)
    db.session.commit()
    return make_response("",204)

@app.route('/authors', methods = ['POST'])
def create_author():
    data = request.get_json()
    author_schema = AuthorsSchema()
```

```
    author, error = author_schema.load(data)
    result = author_schema.dump(author.create()).data
    return make_response(jsonify({"author": result}),200)

if __name__ == "__main__":
    app.run(debug=True)
```

So, we have now created and tested our sample Flask-MySQL CRUD application. We'll go over complex object relationships using Flask-SQLAlchemy in the later chapters, and next we'll create a similar Flask CRUD application using MongoEngine.

Sample Flask MongoEngine Application

MongoDB, as we discussed, is a powerful document-based NoSQL database. It uses a JSON-like document schema structure and is highly scalable. In this example, we'll create an Authors database CRUD application again, but this time we'll use MongoEngine rather than SQLAlchemy. MongoEngine adds MongoDB support for Flask and is quite similar to SQLAlchemy, but it lacks a couple of features due to the fact that MongoDB is still not widely used with Flask.

Let's get started with setting up our project for the flask-mongodb application. Just like the last time, create a new directory flask-mongodb and initiate a new virtual environment in there.

```
$ mkdir flask-mongodb && cd flask-mongodb
```

After creating the directory, let's spawn our virtual environment and activate it.

```
$ virtualenv venv
$ source venv/bin/activate
```

Now let's install our project dependencies using PIP.

```
(venv) $ pip install flask
```

We'll need Flask-MongoEngine and Flask-marshmallow, so let's install them as well.

```
(venv) $ pip install flask-mongoengine
(venv) $ pip install flask-marshmallow
```

After we are done installing the dependencies, we can create our app.py file and start writing the code.

So, the following code is the skeleton of the app where are import flask, create an app instance, and then import MongoEngine to create a db instance.

```
from flask import Flask, request, jsonify, make_response
from flask_mongoengine import MongoEngine
from marshmallow import Schema, fields, post_load
from bson import ObjectId

app = Flask(__name__)
app.config['MONGODB_DB'] = 'authors'
db = MongoEngine(app)

Schema.TYPE_MAPPING[ObjectId] = fields.String

if __name__ == "__main__":
    app.run(debug=True)
```

```
Here TYPE_MAAPPING helps marshmallow understand the ObjectId
type while serializing and de-serializing the data.
```

Note We don't need db.create_all() here since MongoDB will create it on the fly, during the first time you save the value in your collection.

If you now run the application, your server should start, but it'll have nothing to process but just create the db instance and make the connection. Next, let's create an author model using MongoEngine.

The code for creating the author model is fairly simple in this case and looks like this:

```
class Authors(db.Document):
    name = db.StringField()
    specialisation = db.StringField()
```

Let's now create the marshmallow schema which we'll need to dump our db objects into serialized JSON.

```
class AuthorsSchema(Schema):
    name = fields.String(required=True)
    specialisation = fields.String(required=True)
```

The preceding code lets us create the schema which we'll use to map our db object to marshmallow. Notice that here we are not using marshmallow-sqlalchemy which has an extra layer of support for SQLAlchemy and the code looks slightly changed due to that here.

Now we can write our GET endpoint to fetch all the authors from our DB.

```
@app.route('/authors', methods = ['GET'])
def index():
    get_authors = Authors.objects.all()
    author_schema =AuthorsSchema(many=True,only=['id','name',
    'specialisation'])
    authors, error = author_schema.dump(get_authors)
    return make_response(jsonify({"authors": authors}))
```

Note MongoEngine returns the unique ObjectId in "id" field which is autogenerated and hence not specified in the schema.

Now, let's start the application again using the following command.

```
(venv) $ python app.py
```

If there were no errors, you should see the following output, and your application should be up and running.

```
(venv) $ python app.py
* Serving Flask app "app" (lazy loading)
 * Environment: production
   WARNING: Do not use the development server in a production
   environment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
 * Restarting with stat
 * Debugger is active!
 * Debugger PIN: 779-301-240
```

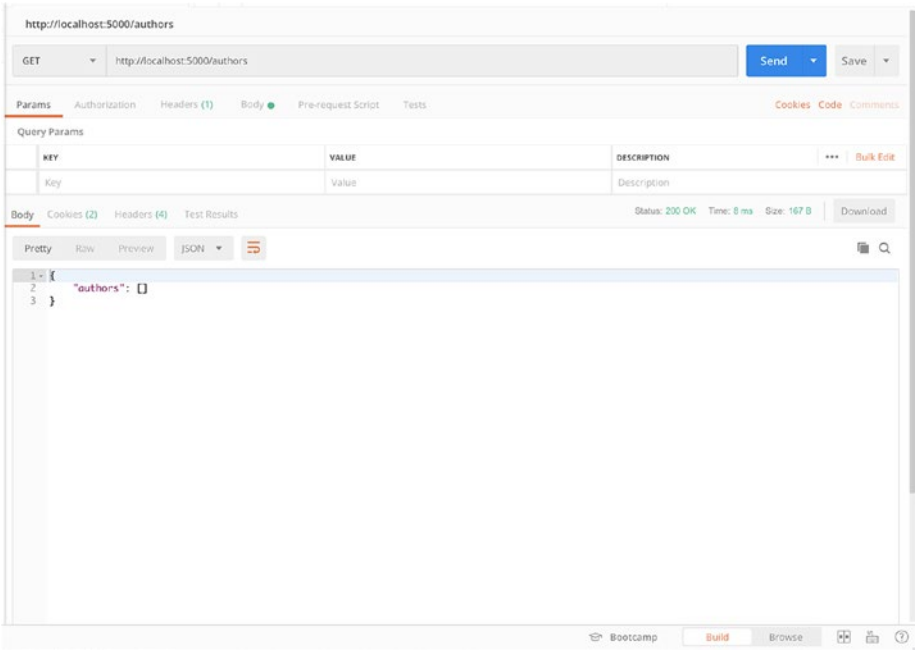

Figure 2-7. *Requesting GET /authors*

Now that our GET endpoint is working (Figure 2-7), let's create a POST /authors endpoint to register authors in the database.

```
@app.route('/authors', methods = ['POST'])
def create_author():
    data = request.get_json()
    author = Authors(name=data['name'],specialisation=data
    ['specialisation'])
    author.save()
    author_schema = AuthorsSchema(only=['name',
    'specialisation'])
    authors, error = author_schema.dump(author)
    return make_response(jsonify({"author": authors}),201)
```

The preceding code puts the request JSON data in data variable, creates an object of class Authors, and invokes the save() method on it. Next it creates a schema using the AuthorsSchema and dumps the new object to return it back to the user confirming the user was created with a 201 status code.

Now re-run the application and request the POST endpoint with sample author details to register.

We'll use the same JSON data to post to this application like we did in the other application.

```
{
      "name" : "Kunal Relan",
      "specialisation" : "Python"
}
```

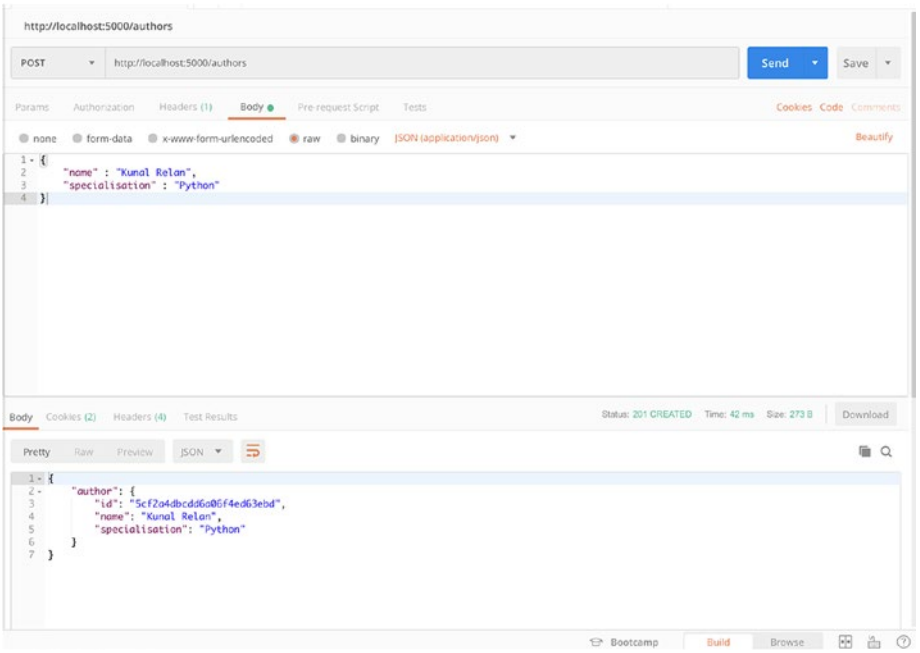

Figure 2-8. *Requesting POST /authors*

Upon requesting you should get a similar output to what you see in Figure 2-8, and now just to confirm that our GET endpoint works fine, we'll request it again to see if it returns the data.

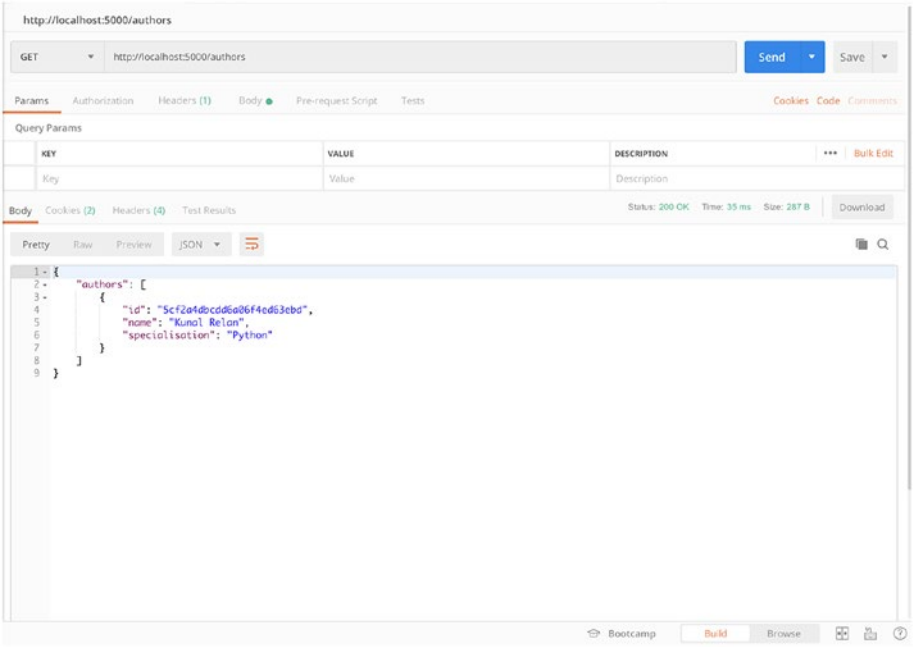

Figure 2-9. *Requesting GET /authors*

As you see in Figure 2-9, we get our recently registered author in the GET /authors endpoint.

Next we'll create an endpoint to return authors using the author ID and then update endpoint to update author details using author ID and the last endpoint to delete an author using author ID.

For GET author by ID, we'll have a route like /authors/<id> which will take author ID from the request parameter and find the matching author.

Add the following code for the GET author by ID endpoint below your GET all authors route.

```
@app.route('/authors/<id>', methods = ['GET'])
def get_author_by_id(id):
    get_author = Authors.objects.get_or_404(id=ObjectId(id))
    author_schema = AuthorsSchema(only=['id', 'name',
    'specialisation'])
    author, error = author_schema.dump(get_author)
    return make_response(jsonify({"author": author}))
```

And now when you request the endpoint /authors/<id>, it shall return the user with the matching ObjectId (Figure 2-10).

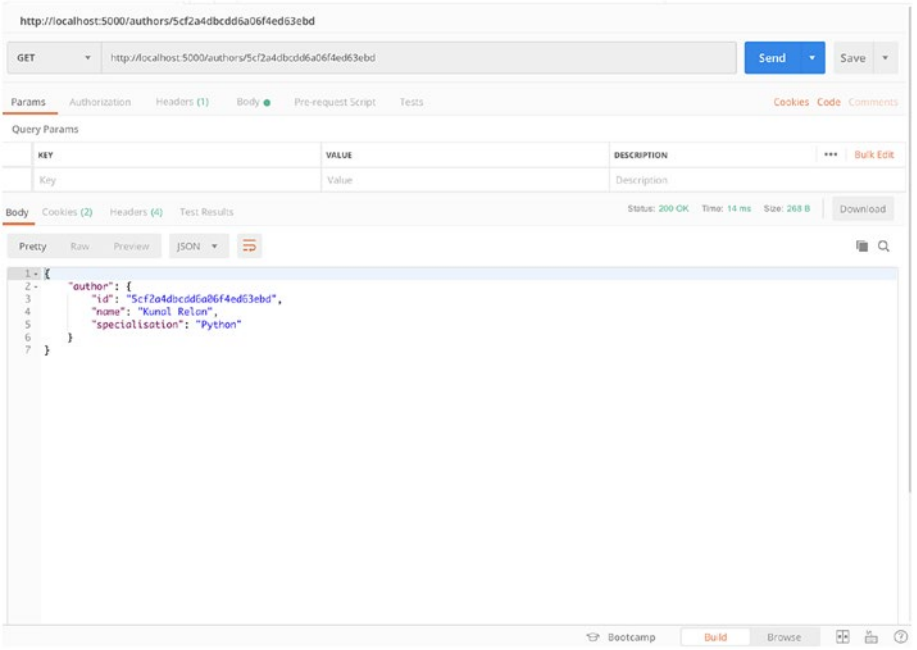

Figure 2-10. *GET author by ID*

So next we'll create PUT endpoint to update author info using author ID. Add the following code for the PUT author endpoint.

```
@app.route('/authors/<id>', methods = ['PUT'])
def update_author_by_id(id):
    data = request.get_json()
    get_author = Authors.objects.get(id=ObjectId(id))
    if data.get('specialisation'):
        get_author.specialisation = data['specialisation']
    if data.get('name'):
        get_author.name = data['name']
    get_author.save()
    get_author.reload()
    author_schema = AuthorsSchema(only=['id', 'name',
    'specialisation'])
    author, error = author_schema.dump(get_author)
    return make_response(jsonify({"author": author}))
```

Open Postman and hit the same route as we did in the other module to update author info, but here use the ObjectID returned in the GET endpoint instead.

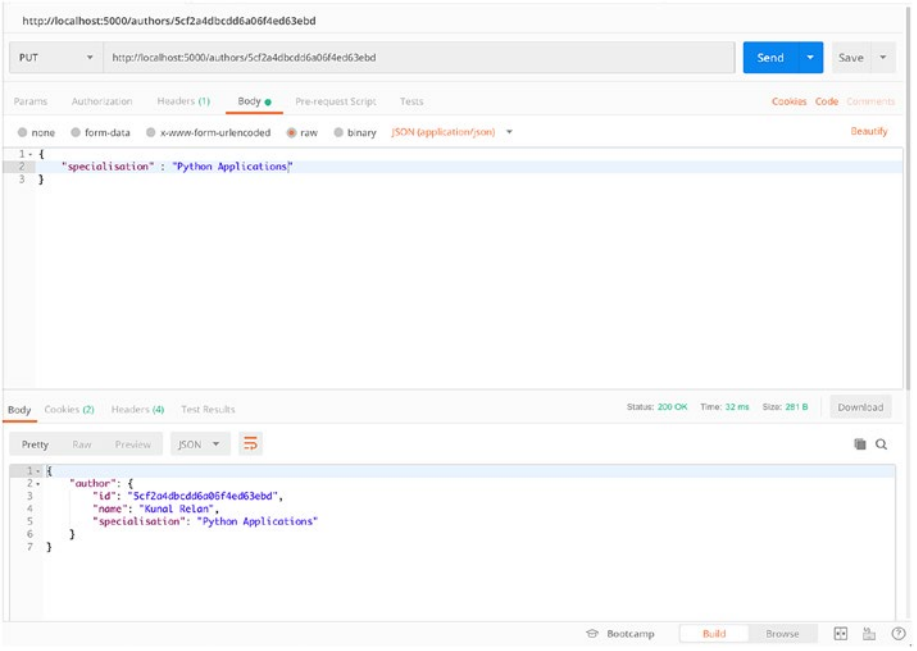

Figure 2-11. *PUT author endpoint*

As you can see in Figure 2-11, we were able to update the author specialisation using the PUT endpoint. Next we'll create the DELETE endpoint to delete an author using the author ID to complete our CRUD application.

Add the following code to create the DELETE endpoint to our application.

```
@app.route('/authors/<id>', methods = ['DELETE'])
def delete_author_by_id(id):
    Authors.objects(id=ObjectId(id)).delete()
    return make_response("",204)
```

Now let's delete our newly created author using the author ID, and similar to the last application, this endpoint will not return any data but a 204 status code.

Request the delete endpoint using the author ID you did previously, and it shall return a similar response as in Figure 2-12.

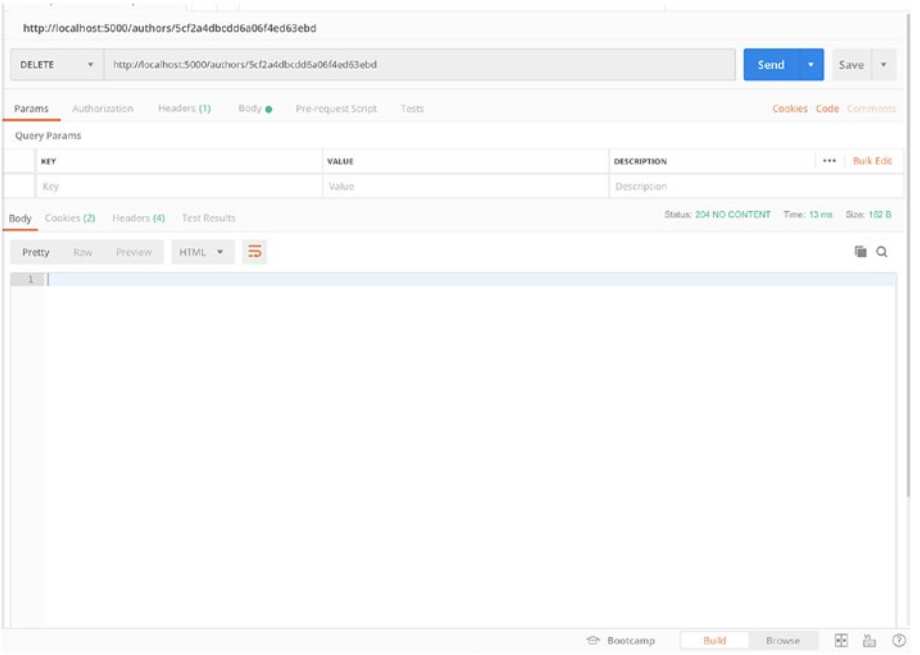

Figure 2-12. *DELETE author endpoint*

So this wraps up our flask-mongo CRUD application, and the final code in your app.py should look like this.

```
from flask import Flask, request, jsonify, make_response
from flask_mongoengine import MongoEngine
from marshmallow import Schema, fields, post_load
from bson import ObjectId

app = Flask(__name__)
app.config['MONGODB_DB'] = 'DB_NAME'
db = MongoEngine(app)

Schema.TYPE_MAPPING[ObjectId] = fields.String

class Authors(db.Document):
    name = db.StringField()
```

```
    specialisation = db.StringField()

class AuthorsSchema(Schema):
    name = fields.String(required=True)
    specialisation = fields.String(required=True)

@app.route('/authors', methods = ['GET'])
def index():
    get_authors = Authors.objects.all()
    author_schema = AuthorsSchema(many=True, only=['id',
    'name', 'specialisation'])
    authors, error = author_schema.dump(get_authors)
    return make_response(jsonify({"authors": authors}))

@app.route('/authors/<id>', methods = ['GET'])
def get_author_by_id(id):
    get_author = Authors.objects.get_or_404(id=ObjectId(id))
    author_schema = AuthorsSchema(only=['id', 'name',
    'specialisation'])
    author, error = author_schema.dump(get_author)
    return make_response(jsonify({"author": author}))

@app.route('/authors/<id>', methods = ['PUT'])
def update_author_by_id(id):
    data = request.get_json()
    get_author = Authors.objects.get(id=ObjectId(id))
    if data.get('specialisation'):
        get_author.specialisation = data['specialisation']
    if data.get('name'):
        get_author.name = data['name']
    get_author.save()
    get_author.reload()
```

```
    author_schema = AuthorsSchema(only=['id', 'name',
    'specialisation'])
    author, error = author_schema.dump(get_author)
    return make_response(jsonify({"author": author}))

@app.route('/authors/<id>', methods = ['DELETE'])
def delete_author_by_id(id):
    Authors.objects(id=ObjectId(id)).delete()
    return make_response("",204)

@app.route('/authors', methods = ['POST'])
def create_author():
    data = request.get_json()
    author = Authors(name=data['name'],specialisation=data
    ['specialisation'])
    author.save()
    author_schema = AuthorsSchema(only=['id','name',
    'specialisation'])
    authors, error = author_schema.dump(author)
    return make_response(jsonify({"author": authors}),201)

if __name__ == "__main__":
    app.run(debug=True)
```

Conclusion

So now we have covered the introduction to SQLAlchemy and MongoEngine and have created sample CRUD applications using them. In the next chapter, we'll discuss architecting REST APIs in detail and set up the base for our Flask REST API application.

CHAPTER 3

CRUD Application with Flask (Part 1)

In the last chapter, we discussed about databases and implemented NoSQL- and SQL-based examples. In this chapter we'll be creating a RESTful Flask application from scratch. Here we'll maintain a database of Author objects alongside the books they have written. This application will have a user authentication mechanism to only allow logged-in users to execute certain functions. We'll now create the following API endpoints for our REST applications:

1. GET /authors: This gets list of authors alongside their books.
2. GET /authors/<id>: This gets author with the specified ID alongside their books.
3. POST /authors: This creates a new Author object.
4. PUT /authors/<id>: This will edit author object with the given ID.
5. DELETE /authors/<id>: This will delete the author with the given ID.
6. GET /books: This will return all the books.
7. GET /books/<id>: This gets the book with the specified ID.

K. Relan, *Building REST APIs with Flask*, https://doi.org/10.1007/978-1-4842-5022-8_3

8. POST /books: This creates a new book object.
9. PUT / books/<id>: This will edit book object with the given ID.
10. DELETE /book/<id>: This will delete the book with the given ID.

Let's jump right into it, and we'll start by creating a new project and name it author-manager. So create a new directory and start by creating a new virtual environment.

```
$ mkdir author-manager && cd author-manager

$ virtualenv venv
```

And now we shall have our virtual environment setup; next we need to activate the environment and install the dependencies just like we did in the previous chapter.

We'll start by installing the following dependencies to start with and add on more as we need them.

```
(venv) $ pip install flask flask-sqlalchemy marshmallow-
sqlalchemy
```

We'll also use blueprints in this application. Flask uses the concept of blueprints to make application components and support common patterns across the application. Blueprints help create smaller modules for the application making it easy to manage. Blueprint is highly valuable for larger applications and simplifies how large applications work.

We'll structure the application into small modules and keep all our application code in the /src folder inside our app folder. So, go ahead and create a src folder inside your current working directory and then create run.py file inside it.

```
(venv) $ mkdir src && cd src
```

In src folder we'll have our run.py file and another directory called api which will export our modules, so go ahead and create an api folder inside src. We'll initialize our Flask app in main.py file inside src and then create another file run.py which will import main.py, config file, and run the application.

Let's start with main.py.

Add the following code to import the needed libraries and then initialize the app object. Here we'll define a function which will accept app config and then initialize our application.

```
import os
from flask import Flask
from flask import jsonify

app = Flask(__name__)

if os.environ.get('WORK_ENV') == 'PROD':
    app_config = ProductionConfig
elif os.environ.get('WORK_ENV') == 'TEST':
    app_config = TestingConfig
else:
    app_config = DevelopmentConfig

app.config.from_object(app_config)

if __name__ == "__main__":
    app.run(port=5000, host="0.0.0.0", use_reloader=False)
```

So that is our skeleton of main.py; next we'll create run.py to call app and run the application. Later we'll add routes, initialize our db object, and configure logging in main.py.

Add the following code to run.py to import create_app and run the application.

```
from main import app as application

if __name__ == "__main__":
    application.run()
```

Here we have defined the config, imported create_app, and initialized the application. Next we'll move the config to a separate directory and specify environment-specific configuration. We'll create another directory /api inside src and export config, models, and routes from api directory, so now create a directory inside src called api and then create another directory called config inside api.

Note Create an empty file called __init__.py inside every directory for Python to know it contains modules.

Now create config.py inside config directory and also __init__.py. Next add the following code in config.py

```
class Config(object):
    DEBUG = False
    TESTING = False
    SQLALCHEMY_TRACK_MODIFICATIONS = False

class ProductionConfig(Config):
    SQLALCHEMY_DATABASE_URI =  <Production DB URL>

class DevelopmentConfig(Config):
    DEBUG = True
    SQLALCHEMY_DATABASE_URI =  <Development DB URL>
    SQLALCHEMY_ECHO = False

class TestingConfig(Config):
    TESTING = True
    SQLALCHEMY_DATABASE_URI = <Testing DB URL>
    SQLALCHEMY_ECHO = False
```

The preceding code defines the basic config that we did in main.py and then adds environment-specific configuration on the top.

So alongside main, we import development, testing, and production config from config module and import OS module to read environment modules. After that we check if WORK_ENV environment variable is supplied to start the application accordingly; otherwise we start the application using development config by default.

So we have supplied the DB config already but haven't initialized DB in our application; next, let's do that now.

Now create another directory inside api called utils which will hold our utility modules; for now we'll initiate our db object there.

Create database.py inside utility and add the following code in it.

```
from flask_sqlalchemy import SQLAlchemy
db = SQLAlchemy()
```

And this shall initiate to create our db object; next we'll import the db object in main.py and initialize it.

Add the following code where we import libraries to import the db object.

```
from api.utils.database import db

def create_app(config):
    app = Flask(__name__)

    app.config.from_object(config)

    db.init_app(app)
    with app.app_context():
        db.create_all()
    return app
```

And update create_app to initialize the db object.

So now we have the base of our REST application, and your app structure should look like this.

```
venv/
src
├── api/
│   ├── __init__.py
│   ├── utils
│   │     └── __init__.py
│   │     └── database.py
│   └── config
│           └── __init__.py
│           └── database.py
├── run.py
├── main.py
└── requirements.txt
```

Next let's define our db schema. Here we'll deal with two resources, namely, author and book. So let's create book schema first. We'll put all the schema inside a directory called models in api directory, so go ahead and initiate the models module and then create books.py

Add the following code to books.py to create the books model.

```
from api.utils.database import db
from marshmallow_sqlalchemy import ModelSchema
from marshmallow import fields

class Book(db.Model):
    __tablename__ = 'books'

    id = db.Column(db.Integer, primary_key=True,
    autoincrement=True)
    title = db.Column(db.String(50))
    year = db.Column(db.Integer)
```

```
    author_id = db.Column(db.Integer, db.ForeignKey('authors.id'))

    def __init__(self, title, year, author_id=None):
        self.title = title
        self.year = year
        self.author_id = author_id

    def create(self):
        db.session.add(self)
        db.session.commit()
        return self

class BookSchema(ModelSchema):
    class Meta(ModelSchema.Meta):
        model = Book
        sqla_session = db.session

    id = fields.Number(dump_only=True)
    title = fields.String(required=True)
    year = fields.Integer(required=True)
    author_id = fields.Integer()
```

Here we are importing db module, marshmallow, like we did earlier to map the fields and help us return JSON objects.

Notice that we have a field here author_id which is a foreign key to ID field in authors model. Next we'll create the authors.py and create authors model.

```
from api.utils.database import db
from marshmallow_sqlalchemy import ModelSchema
from marshmallow import fields
from api.models.books import BookSchema

class Author(db.Model):
    __tablename__ = 'authors'
```

```
    id = db.Column(db.Integer, primary_key=True,
    autoincrement=True)
    first_name = db.Column(db.String(20))
    last_name = db.Column(db.String(20))
    created = db.Column(db.DateTime, server_default=db.func.now())
    books = db.relationship('Book', backref='Author',
    cascade="all, delete-orphan")

    def __init__(self, first_name, last_name, books=[]):
        self.first_name = first_name
        self.last_name = last_name
        self.books = books

    def create(self):
        db.session.add(self)
        db.session.commit()
        return self

class AuthorSchema(ModelSchema):
    class Meta(ModelSchema.Meta):
        model = Author
        sqla_session = db.session

    id = fields.Number(dump_only=True)
    first_name = fields.String(required=True)
    last_name = fields.String(required=True)
    created = fields.String(dump_only=True)
    books = fields.Nested(BookSchema, many=True,
    only=['title','year','id']
```

The preceding code will create our authors model. Notice we also import the books model here and create the relationship between the author and their books so that when we retrieve the author object, we can also get the books associated with their ID, and thus we have set up a one-to-many relationship between author and books in this model.

Now once we have our DB schema in place, next we need is to start creating our routes, but before we jump onto writing the routes, there is one more thing we should do as part of modularizing our application and create another module responses.py to create a standard class of HTTP responses.

After that we'll create global HTTP configurations in main.py

Create responses.py inside api/utils, and here we'll use jsonify and make_response from Flask library to create standard responses for our APIs.

So write the following code in responses.py to initiate the module.

```
from flask import make_response, jsonify

def response_with(response, value=None, message=None,
error=None, headers={}, pagination=None):
    result = {}
    if value is not None:
        result.update(value)

    if response.get('message', None) is not None:
        result.update({'message': response['message']})

    result.update({'code': response['code']})

    if error is not None:
        result.update({'errors': error})

    if pagination is not None:
        result.update({'pagination': pagination})

    headers.update({'Access-Control-Allow-Origin': '*'})
    headers.update({'server': 'Flask REST API'})

    return make_response(jsonify(result), response['http_
    code'], headers)
```

The preceding code exposes a function response_with for our API endpoints to use and respond back; alongside this we'll also create standard response codes and messages.

So here is a list of responses that our application will support.

Table 3-1 provides the HTTP responses we'll use in our application. Add the following code above response_with to define them in responses.py.

Table 3-1. *HTTP responses*

200	200 Ok	Standard response to HTTP requests
201	201 Created	Implies the request was fulfilled and a new resource has been created
204	204 No Content	Successful request and no data has been returned
400	400 Bad Request	Implies that the server can't process the request due to a client error
403	403 Not Authorized	Valid request but the requesting client is not authorized to obtain the resource
404	404 Not Found	The requested resource doesn't exist on the server
422	422 Unprocessable Entity	Request can't be processed due to semantic error
500	500 Internal Server Error	Generic error to imply an unexpected condition in server

```
INVALID_FIELD_NAME_SENT_422 = {
    "http_code": 422,
    "code": "invalidField",
    "message": "Invalid fields found"
}

INVALID_INPUT_422 = {
    "http_code": 422,
```

```
    "code": "invalidInput",
    "message": "Invalid input"
}

MISSING_PARAMETERS_422 = {
    "http_code": 422,
    "code": "missingParameter",
    "message": "Missing parameters."
}

BAD_REQUEST_400 = {
    "http_code": 400,
    "code": "badRequest",
    "message": "Bad request"
}

SERVER_ERROR_500 = {
    "http_code": 500,
    "code": "serverError",
    "message": "Server error"
}

SERVER_ERROR_404 = {
    "http_code": 404,
    "code": "notFound",
    "message": "Resource not found"
}

UNAUTHORIZED_403 = {
    "http_code": 403,
    "code": "notAuthorized",
    "message": "You are not authorised to execute this."
}
```

```
SUCCESS_200 = {
    'http_code': 200,
    'code': 'success'
}

SUCCESS_201 = {
    'http_code': 201,
    'code': 'success'
}

SUCCESS_204 = {
    'http_code': 204,
    'code': 'success'
}
```

And now we shall have our working responses.py module; next we'll add global HTTP configurations for handling errors.

Next import the status and response_with function in main.py. Add the following lines in the top section of main.py import.

```
from api.utils.responses import response_with
import api.utils.responses as resp
```

And then just above db.init_app function, add the following code to configure global HTTP configs.

```
    @app.after_request
    def add_header(response):
        return response

    @app.errorhandler(400)
    def bad_request(e):
        logging.error(e)
        return response_with(resp.BAD_REQUEST_400)
```

```
    @app.errorhandler(500)
    def server_error(e):
        logging.error(e)
        return response_with(resp.SERVER_ERROR_500)

    @app.errorhandler(404)
    def not_found(e):
        logging.error(e)
        return response_with(resp. SERVER_ERROR_404)
```

The following code adds global responses in error situations. Now your main.py should look like this.

```
from flask import Flask
from flask import jsonify
from api.utils.database import db
from api.utils.responses import response_with
import api.utils.responses as resp

app = Flask(__name__)

if os.environ.get('WORK_ENV') == 'PROD':
    app_config = ProductionConfig
elif os.environ.get('WORK_ENV') == 'TEST':
    app_config = TestingConfig
else:
    app_config = DevelopmentConfig

app.config.from_object(app_config)

db.init_app(app)
with app.app_context():
    db.create_all()

# START GLOBAL HTTP CONFIGURATIONS
@app.after_request
```

```
def add_header(response):
    return response

@app.errorhandler(400)
def bad_request(e):
    logging.error(e)
    return response_with(resp.BAD_REQUEST_400)

@app.errorhandler(500)
def server_error(e):
    logging.error(e)
    return response_with(resp.SERVER_ERROR_500)

@app.errorhandler(404)
def not_found(e):
    logging.error(e)
    return response_with(resp.SERVER_ERROR_404)

db.init_app(app)
with app.app_context():
    db.create_all()

if __name__ == "__main__":
    app.run(port=5000, host="0.0.0.0", use_reloader=False)
```

Next we need to create our API endpoints and include them in our main.py using Blueprints.

We'll put our routes inside a directory named routes in api, so go ahead and create the folder; next add authors.py to create the books route.

Next import the required modules using the following code.

```
from flask import Blueprint
from flask import request
from api.utils.responses import response_with
from api.utils import responses as resp
```

```
from api.models.authors import Author, AuthorSchema
from api.utils.database import db
```

Here we import Blueprint and request modules from Flask, response_ with and resp method from responses util, Author schema, and the db object.

Next we'll configure the Blueprint.

```
author_routes = Blueprint("author_routes", __name__)
```

Once done, we can start with our POST author route, and add the following code below book_routes.

```
@author_routes.route('/', methods=['POST'])
def create_author():
    try:
        data = request.get_json()
        author_schema = AuthorSchema()
        author, error = author_schema.load(data)
        result = author_schema.dump(author.create()).data
        return response_with(resp.SUCCESS_201, value={"author":
        result})
    except Exception as e:
        print e
        return response_with(resp.INVALID_INPUT_422)
```

So the preceding code will take JSON data from the request and execute create method on the Author schema and then return the response using response_with method, supplying the response type which is 201 for this endpoint and the data value which is a JSON object with the newly created author.

Now before we set up all other routes, let's register author routes Blueprint in the app and run the application to test if everything is alright.

So in your main.py, import the author routes and then register the blueprint.

```
from api.routes.authors import author_routes
```

And then add the following line right above @app.after_request.

```
app.register_blueprint(author_routes, url_prefix='/api/
authors')
```

Now run the application using Python run.py command, and our Flask server should be up and running.

Let's try out POST authors endpoint, so open up postmand request at `http://localhost:5000/api/authors/` with the following JSON data.

```
{
       "first_name" : "kunal",
       "last_name" : "Relan"
 }
```

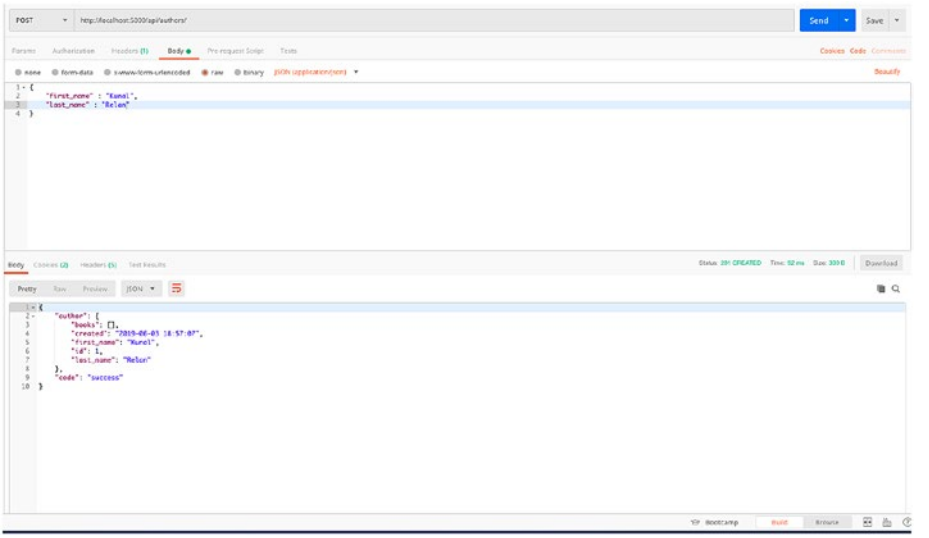

Figure 3-1. *POST authors endpoint*

As you can see, books is an empty array since we haven't created any book yet; next let's add GET authors endpoint (Figure 3-1).

```
@author_routes.route('/', methods=['GET'])
def get_author_list():
    fetched = Author.query.all()
    author_schema = AuthorSchema(many=True, only=['first_name',
    'last_name','id'])
    authors, error = author_schema.dump(fetched)
    return response_with(resp.SUCCESS_200, value={"authors":
    authors})
```

The preceding code will add GET all authors route, and here we'll respond with an array of authors only containing their ID, First Name, and Last Name. So let's go ahead and test it.

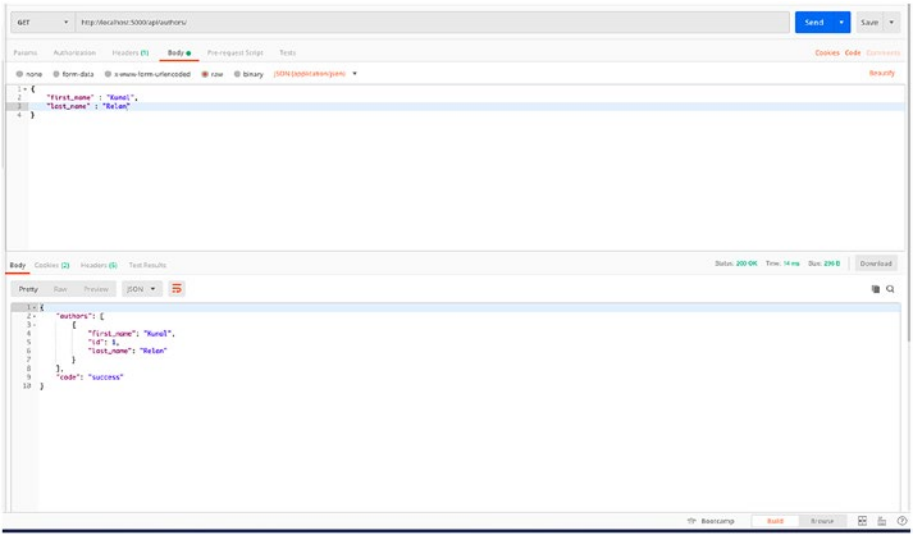

Figure 3-2. *GET authors route*

As you can see in Figure 3-2, the endpoint responded with an array of authors.

Next let's add another GET route to fetch a specific author using their ID and add the following code to add the route.

```
@author_routes.route('/<int:author_id>', methods=['GET'])
def get_author_detail(author_id):
    fetched = Author.query.get_or_404(author_id)
    author_schema = AuthorSchema()
    author, error = author_schema.dump(fetched)
    return response_with(resp.SUCCESS_200, value={"author":
    author})
```

The preceding code takes an integer from the route parameters and finds the author with the respective ID and return the author object.

So let's try fetching author with ID 1 (Figure 3-3).

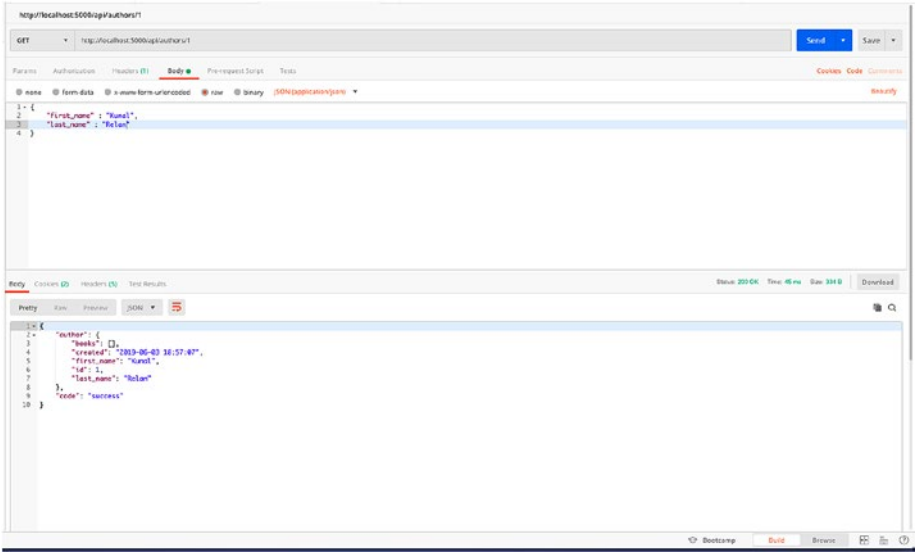

Figure 3-3. *Fetching author with ID 1*

If the author with the ID exists, we shall get the response back with 200 status code and the author object, otherwise 404 like in the following screenshot. As you can see, there is no author with ID 2, and the get_or_404

method throws 404 error on the endpoint which is then handled by app.errorhandler(404) as per what we mentioned in our main.py (Figure 3-4).

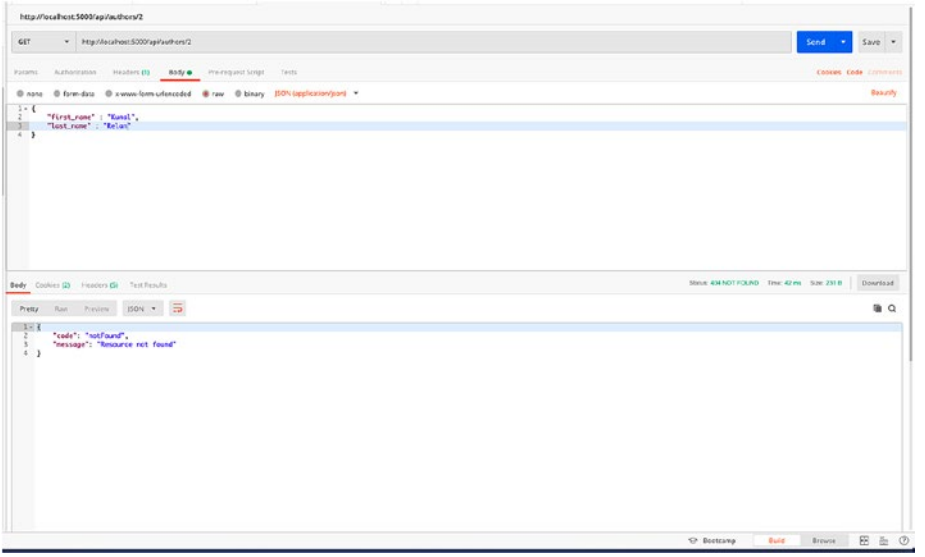

Figure 3-4. *No author is found with ID 2*

Before we move on to creating PUT and DELETE endpoints for author object, let's initiate book routes. Create books.py in the same routes folder and add the following code to initiate the route.

```
from flask import Blueprint, request
from api.utils.responses import response_with
from api.utils import responses as resp
from api.models.books import Book, BookSchema
from api.utils.database import db

book_routes = Blueprint("book_routes", __name__)
```

And then register the book routes in main.py like we did for author routes. Add the following code right below where you imported author routes.

```
from api.routes.books import book_routes
```

Then right below where you added the author route blueprint registration, add the following code.

```
app.register_blueprint(book_routes, url_prefix='/api/books')
```

Now your main.py should have the following code.

```
import logging
import sys
import api.utils.responses as resp
from flask import Flask, jsonify
from api.utils.database import db
from api.utils.responses import response_with
from api.routes.authors import author_routes
from api.routes.books import book_routes

def create_app(config):
    app = Flask(__name__)

    app.config.from_object(config)

    db.init_app(app)
    with app.app_context():
        db.create_all()
    app.register_blueprint(author_routes, url_prefix='/api/
    authors')
    app.register_blueprint(book_routes, url_prefix='/api/books')

    @app.after_request
    def add_header(response):
        return response

    @app.errorhandler(400)
    def bad_request(e):
        logging.error(e)
        return response_with(resp.BAD_REQUEST_400)
```

```
    @app.errorhandler(500)
    def server_error(e):
        logging.error(e)
        return response_with(resp.SERVER_ERROR_500)

    @app.errorhandler(404)
    def not_found(e):
        logging.error(e)
        return response_with(resp.SERVER_ERROR_404)

    db.init_app(app)
    with app.app_context():
        db.create_all()

    logging.basicConfig(stream=sys.stdout,
                        format='%(asctime)s|%(levelname)
                        s|%(filename)s:%(lineno)s|%(message)s',
                        level=logging.DEBUG)
    return app
```

Next let's start by creating POST book endpoint; open books.py inside routes folder and add the following code below book_routes.

```
@book_routes.route('/', methods=['POST'])
def create_book():
    try:
        data = request.get_json()
        book_schema = BookSchema()
        book, error = book_schema.load(data)
        result = book_schema.dump(book.create()).data
        return response_with(resp.SUCCESS_201, value={"book":
        result})
    except Exception as e:
        print e
        return response_with(resp.INVALID_INPUT_422)
```

The preceding code will take user data and then execute the create() method on book schema just like what we did in author object; let's save the file and test the endpoint.

```
{
        "title" : "iOS Penetration Testing",
        "year" : 2016,
        "author_id": 1
 }
```

We'll use the preceding JSON data to POST to the endpoint, and we should get a response with 200 status code and the newly created book object. Also as we discussed earlier, we have set up a relationship between authors and books, and in the preceding example, we have specified author with ID 1 for the new book, so once this API succeeds, we shall be able to fetch author with ID 1, and the books array in response shall have this book as an object (Figure 3-5).

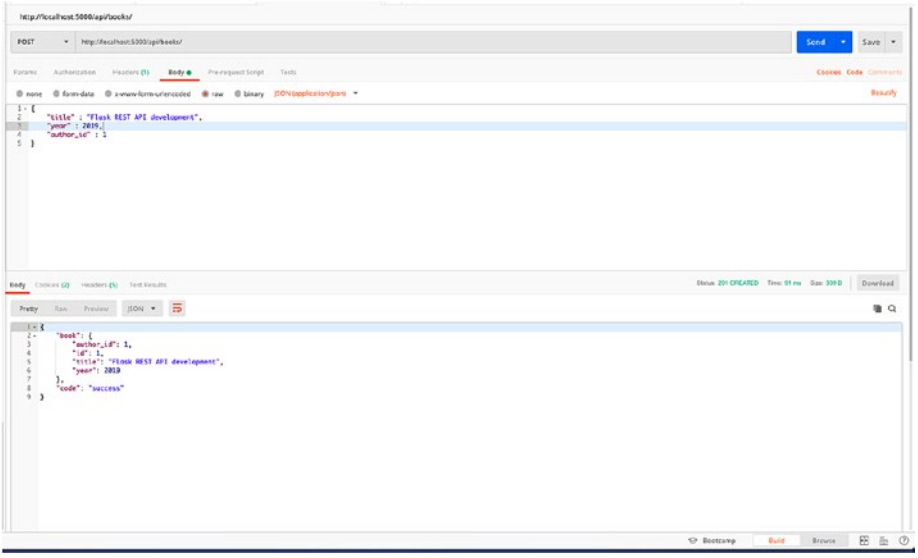

Figure 3-5. *Fetch author with ID 1*

And as you can see in Figure 3-6, when we request /authors/1 endpoint, alongside author details, we also get the books array with the list of books the author is linked to.

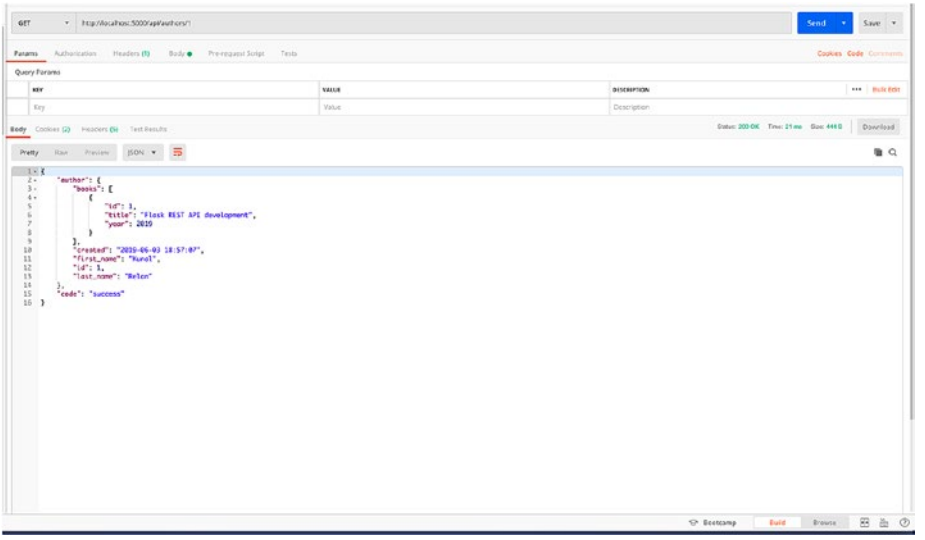

Figure 3-6. *GET author endpoint*

So our model relationship is working fine; now we can move on to creating the rest of the endpoints for author routes. Go ahead and add the following code to get the PUT endpoint for the author route to update the author object.

```
@author_routes.route('/<int:id>', methods=['PUT'])
def update_author_detail(id):
    data = request.get_json()
    get_author = Author.query.get_or_404(id)
    get_author.first_name = data['first_name']
    get_author.last_name = data['last_name']
    db.session.add(get_author)
    db.session.commit()
    author_schema = AuthorSchema()
```

```
    author, error = author_schema.dump(get_author)
    return response_with(resp.SUCCESS_200, value={"author":
    author})
```

The preceding code will create our PUT endpoint to update author object. In the previous code, we take a request JSON in the data variable and then fetch the author with the provided ID in request parameter. If the author with that ID is not found, the request ends with 404 status code, or else get_author contains the author object, and then we update the first_name and last_name with the data supplied in request JSON and then we save the session.

So let's go ahead and update the first and the last name of the author we created a while ago (Figure 3-7).

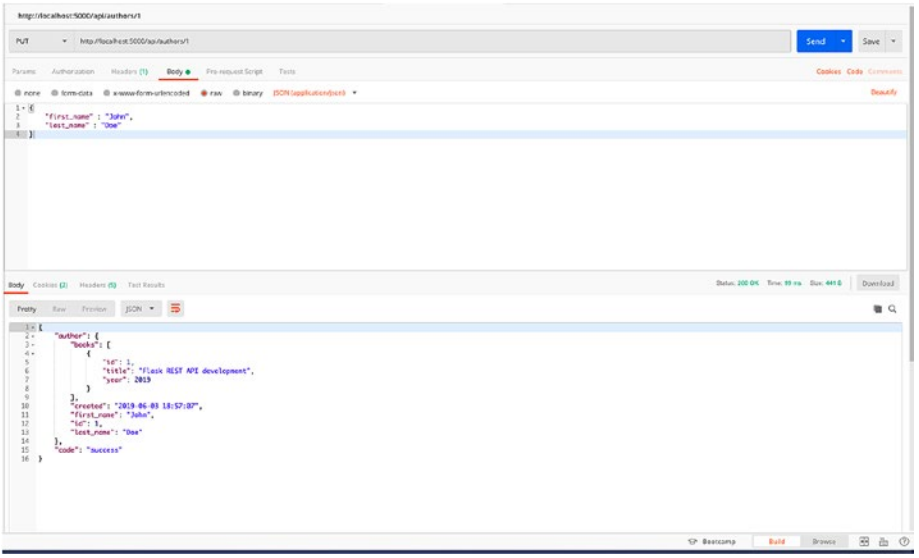

Figure 3-7. *PUT author endpoint*

So here we updated the first name and the last name of the author. However in PUT we need to send the whole request body of the object as we discussed in the second chapter, so next we'll create a PATCH endpoint to update only a part of the author object. Add the following code for the PATCH endpoint.

```
@author_routes.route('/<int:id>', methods=['PATCH'])
def modify_author_detail(id):
    data = request.get_json()
    get_author = Author.query.get(id)
    if data.get('first_name'):
        get_author.first_name = data['first_name']
    if data.get('last_name'):
        get_author.last_name = data['last_name']
    db.session.add(get_author)
    db.session.commit()
    author_schema = AuthorSchema()
    author, error = author_schema.dump(get_author)
    return response_with(resp.SUCCESS_200, value={"author":
    author})
```

The preceding code gets the request JSON like the other endpoint but doesn't expect the whole request body but only the field that needs to be updated in the request body, and similarly it updates the author object and saves the session. Let's try this out and this time we'll only change the first name of the author object.

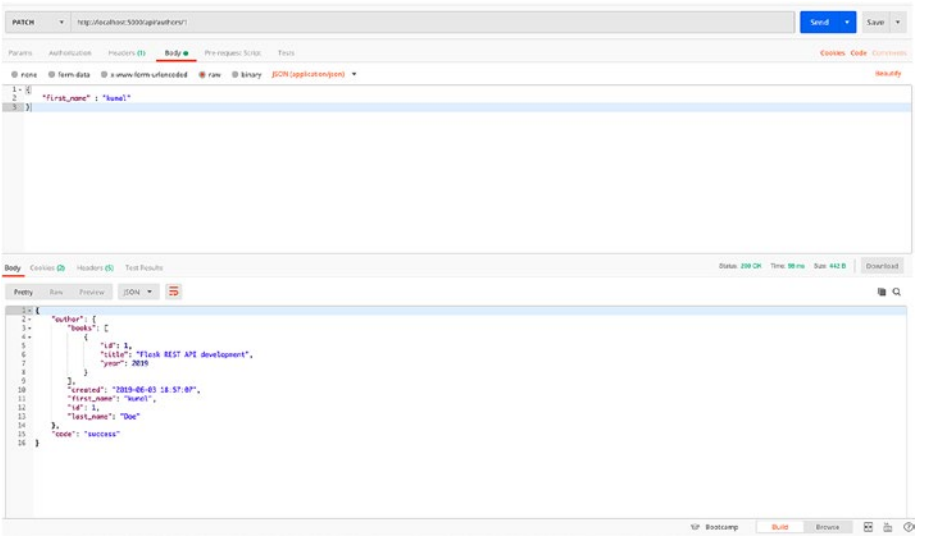

Figure 3-8. *Change the first name of the author object*

As you see in Figure 3-8, we only supply the first name in the request body and it got updated. So next we'll finally create our DELETE author endpoint which will take the author ID from the request parameter and delete the author object. Notice that in this one, we'll respond with 204 status code and no content.

```
@author_routes.route('/<int:id>', methods=['DELETE'])
def delete_author(id):
    get_author = Author.query.get_or_404(id)
    db.session.delete(get_author)
    db.session.commit()
    return response_with(resp.SUCCESS_204)
```

Add the previous code and now this shall create our DELETE endpoint. Let's go ahead and try deleting our author with ID 1 (Figure 3-9).

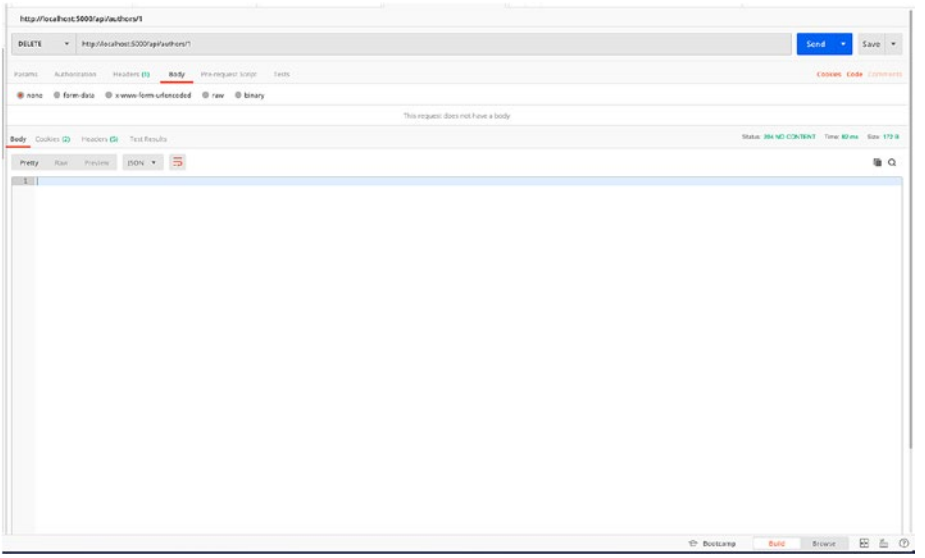

Figure 3-9. *DELETE author endpoint*

With this endpoint, our author object should be deleted from the database, and while creating the author schema, we configured all cascade in the book relationship. Thus all the books related to author ID 1 shall also be deleted ensuring we don't have any books without an author ID.

So this is it for our author routes and next we'll work on the rest of our book endpoints. Next add the following code in books.py to create GET books endpoint.

```
@book_routes.route('/', methods=['GET'])
def get_book_list():
    fetched = Book.query.all()
    book_schema = BookSchema(many=True, only=['author_id',
    'title', 'year'])
    books, error = book_schema.dump(fetched)
    return response_with(resp.SUCCESS_200, value={"books": books})
```

Save the file and try the endpoint; for now you shall get an empty array since the book with author ID 1 was deleted when we deleted the author.

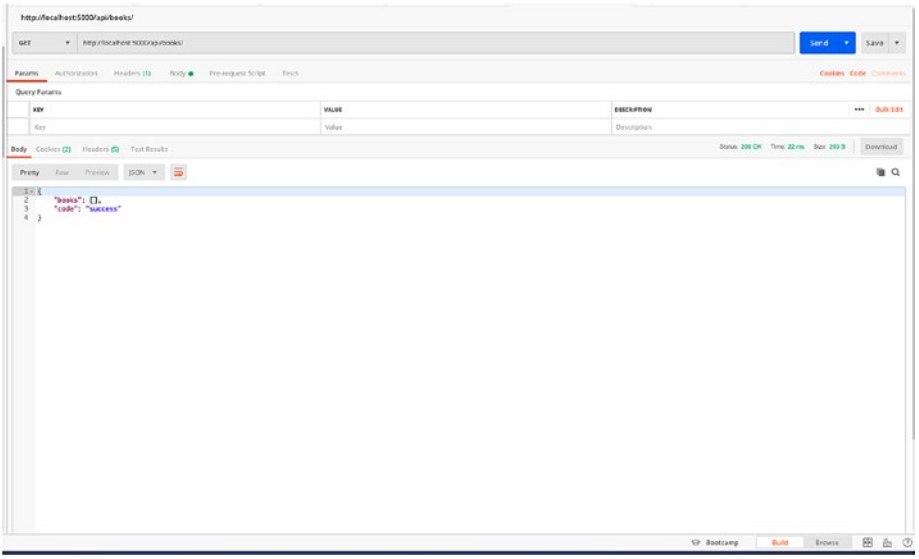

Figure 3-10. *GET books endpoint*

As you see in Figure 3-10, there are no books in the table as of now, so go ahead and create an author, and then add a couple of books with that author ID, since we can't add a book without an author, or else it'll end in 422 unprocessable entity error.

Next we'll create GET Book by ID endpoint.

```
@book_routes.route('/<int:id>', methods=['GET'])
def get_book_detail(id):
    fetched = Book.query.get_or_404(id)
    book_schema = BookSchema()
    books, error = book_schema.dump(fetched)
    return response_with(resp.SUCCESS_200, value={"books": books})
```

The following code will create GET Book by ID endpoint; next we'll create PUT, PATCH, and DELETE endpoints, and add the following code for the same.

```
book_routes.route('/<int:id>', methods=['PUT'])
def update_book_detail(id):
    data = request.get_json()
    get_book = Book.query.get_or_404(id)
    get_book.title = data['title']
    get_book.year = data['year']
    db.session.add(get_book)
    db.session.commit()
    book_schema = BookSchema()
    book, error = book_schema.dump(get_book)
    return response_with(resp.SUCCESS_200, value={"book": book})

@book_routes.route('/<int:id>', methods=['PATCH'])
def modify_book_detail(id):
    data = request.get_json()
    get_book = Book.query.get_or_404(id)
    if data.get('title'):
        get_book.title = data['title']
    if data.get('year'):
        get_book.year = data['year']
    db.session.add(get_book)
    db.session.commit()
    book_schema = BookSchema()
    book, error = book_schema.dump(get_book)
    return response_with(resp.SUCCESS_200, value={"book": book})

@book_routes.route('/<int:id>', methods=['DELETE'])
def delete_book(id):
    get_book = Book.query.get_or_404(id)
    db.session.delete(get_book)
    db.session.commit()
    return response_with(resp.SUCCESS_204)
```

So this shall wrap up our book and author routes, and now we have a working REST application. Now you can try executing CRUD on the author and book routes.

User Authentication

Once we have all our routes in place, we need to add in user authentication to make sure only logged-in users can access certain routes, so now we'll add in user login and signup routes, but before that we need to add user schema.

Create users.py inside models. In the schema we'll add two static methods to encrypt the password and verify password, and for the same we'll need a Python library called passlib, so before we create the schema, let's install passlib using PIP.

```
(venv)$ pip install passlib
```

Once done add the following code to add user schema and the methods.

```
from api.utils.database import db
from passlib.hash import pbkdf2_sha256 as sha256
from marshmallow_sqlalchemy import ModelSchema
from marshmallow import fields

class User(db.Model):
    __tablename__ = 'users'

    id = db.Column(db.Integer, primary_key = True)
    username = db.Column(db.String(120), unique = True,
    nullable = False)
    password = db.Column(db.String(120), nullable = False)

    def create(self):
        db.session.add(self)
```

```
        db.session.commit()
        return self

    @classmethod
    def find_by_username(cls, username):
        return cls.query.filter_by(username = username).first()

    @staticmethod
    def generate_hash(password):
        return sha256.hash(password)

    @staticmethod
    def verify_hash(password, hash):
        return sha256.verify(password, hash)

class UserSchema(ModelSchema):
    class Meta(ModelSchema.Meta):
        model = User
        sqla_session = db.session

    id = fields.Number(dump_only=True)
    username = fields.String(required=True)
```

So here we have added a class method to find a user by username, and create a user and then two static methods to generate the hash and verify it. We'll use these methods when we create the user routes.

Next create users.py in routes directory, and this is where we'll add our user login and signup routes.

For user authentication across the application, we'll use JWT (JSON Web Tokens) authentication. JWT is an open standard which defines a compact and self-contained way of securely transmitting information as a JSON object. JWT is a popular way of user authorization in the REST world. In Flask there is an open source extension called Flask-JWT-Extended which provides JWT support and other helpful methods.

Let's go ahead and install Flask-JWT-Extended.

```
(venv)$ pip install flask-jwt-extended
```

Next we'll initialize JWT module in the app in main.py so import the library in main.py.

```
from flask_jwt_extended import JWTManager
```

Next initialize JWTManager with the following code right above db.init_app().

```
jwt = JWTManager(app)
```

Once installed and initialized, let's import the needed modules for our user routes file.

```
from flask import Blueprint, request
from api.utils.responses import response_with
from api.utils import responses as resp
from api.models.users import User, UserSchema
from api.utils.database import db
from flask_jwt_extended import create_access_token
```

These are the modules we'll need for the user routes; next we'll configure the route using Blueprint with the following code.

```
user_routes = Blueprint("user_routes", __name__)
```

Next, we'll import and register the /users routes in our main.py file, so add the following code in main.py to import the user routes.

```
from api.routes.users import user_routes
```

And now right below where we have declared the other routes, add the following line of code.

```
app.register_blueprint(user_routes, url_prefix='/api/users')
```

Next, we'll create our POST user route to create a new user and add the following code in users.py inside routes.

```
@user_routes.route('/', methods=['POST'])
def create_user():
    try:
        data = request.get_json()
        data['password'] = User.generate_hash(data['password'])
        user_schmea = UserSchema()
        user, error = user_schmea.load(data)
        result = user_schmea.dump(user.create()).data
        return response_with(resp.SUCCESS_201)
    except Exception as e:
        print e
        return response_with(resp.INVALID_INPUT_422)
```

Here we are taking the user request data in a variable and then executing the generate_hash() function on the password and creating the user. Once done we'll return a 201 response.

Next we'll create a login route for the signed up users to login. Add the following code for the same.

```
@user_routes.route('/login', methods=['POST'])
def authenticate_user():
      try:
        data = request.get_json()
        current_user = User.find_by_username(data['username'])
        if not current_user:
            return response_with(resp.SERVER_ERROR_404)
        if User.verify_hash(data['password'], current_user.
        password):
            access_token = create_access_token(identity =
            data['username'])
```

```
            return response_with(resp.SUCCESS_201,
            value={'message': 'Logged in as {}'.format(current_
            user.username), "access_token": access_token})
        else:
            return response_with(resp.UNAUTHORIZED_401)
    except Exception as e:
        print e
        return response_with(resp.INVALID_INPUT_422)
```

The following code will take the username and password from request data and check if the user with the provided username exists using the find_by_username() method we created in the schema. Next if the user doesn't exist, we'll respond with 404, or else verify the password using verify_hash() function in the schema. If the user exists, we'll generate a JWT Token and respond with 200; otherwise respond with 401. So now we have our user login in place. Next we need to add jwt required decorator to the routes we want to protect. So navigate to authors.py in routes and import the decorator using the following code.

```
from flask_jwt_extended import jwt_required
```

And then before the endpoint definition, add the decorator using the following code.

```
@jwt_required
```

We'll add the decorator to the DELETE, PUT, POST, and PATCH endpoints of authors.py and books.py, and the functions should now look like this.

```
@author_routes.route('/', methods=['POST'])
@jwt_required
def create_author():
    ....Function code
```

Let's go ahead and test our user endpoints. Open Postman and request the POST users endpoint with a username and password. We'll use the following sample data.

```
{
        "username" : "admin",
        "password" : "flask2019"
 }
```

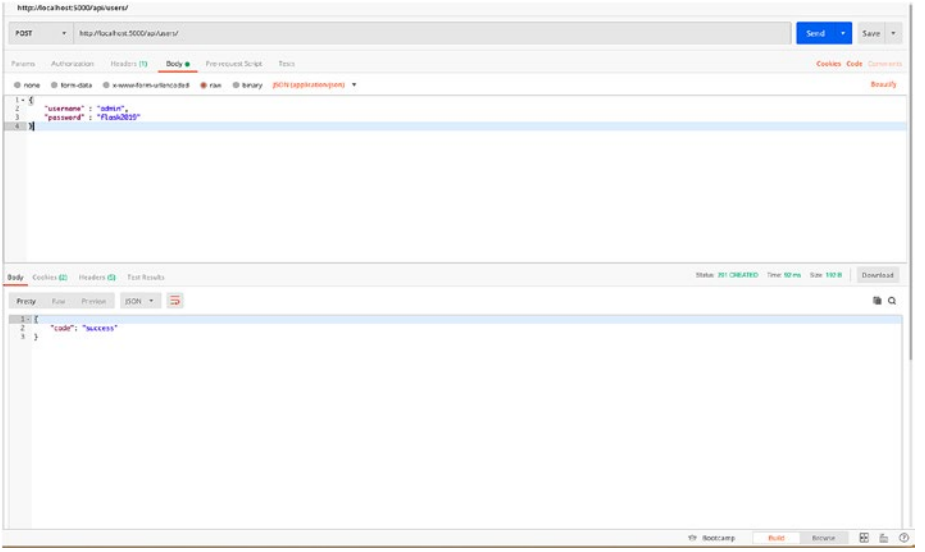

Figure 3-11. *User signup endpoint*

So our new user has been created (Figure 3-11); next we'll try logging in with the same credentials and get the JWT.

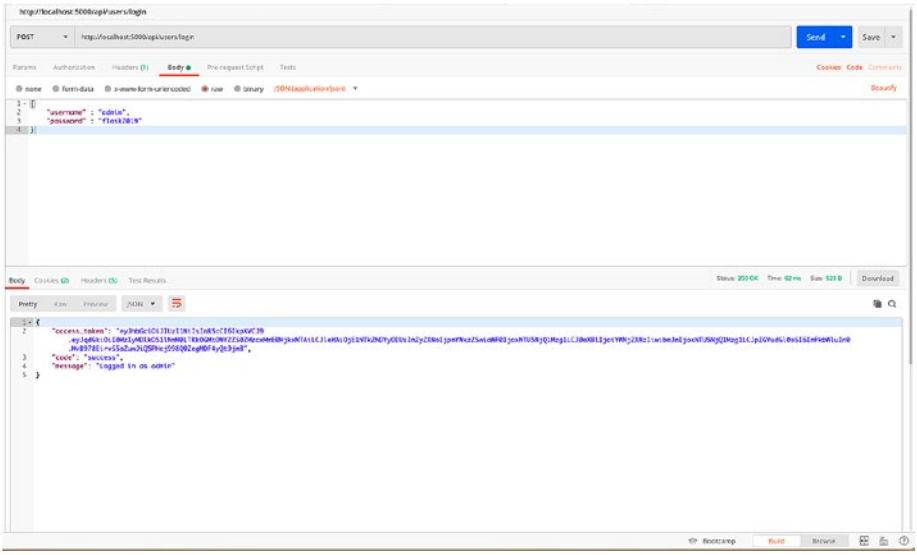

Figure 3-12. *User login endpoint*

As you see in Figure 3-12, we have successfully logged in using the newly created users. Now let's try accessing the POST author route to which we recently added jwt_required decorator (Figure 3-13).

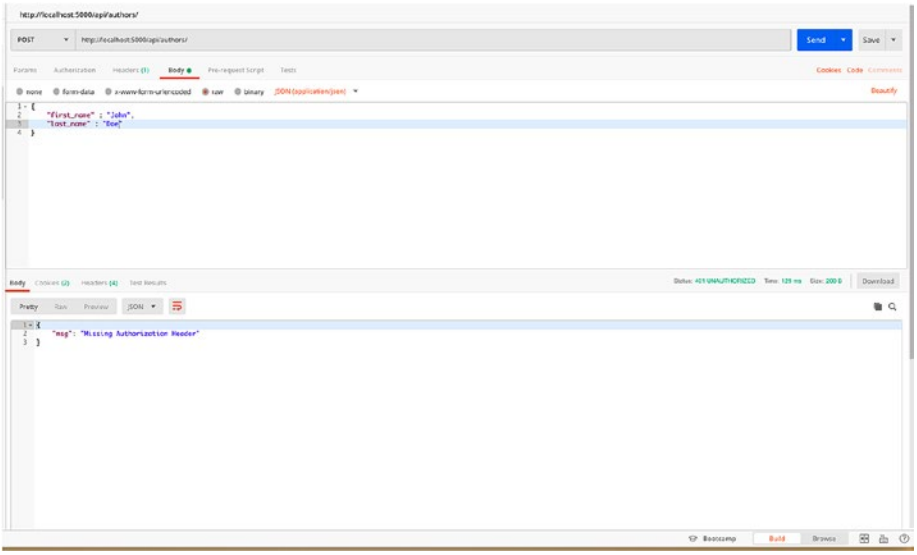

Figure 3-13. *POST author route without JWT Token*

As you see in Figure 3-14, we are not able to access the POST author route anymore, and the jwt_required decorator responded back with 401 error. Now let's try accessing the same route by supplying the JWT in header. In the header section of the request in Postman, add the token with a key called Authorization, and then in the value add Bearer <token> to supply the JWT Token like in Figure 3-14.

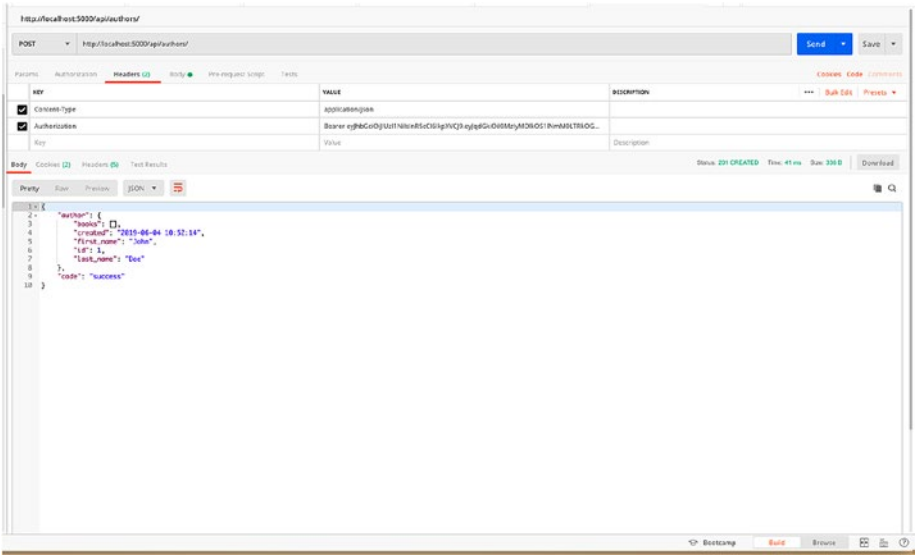

Figure 3-14. *POST author route with JWT*

As you can see, after adding the JWT Token, we are able to access the endpoint again, and this is how we can protect our REST endpoints.

So in the following scenario, we enabled anyone to login to the platform and then access the routes. However, in real-world application, we can also have email verification and restricted user signup alongside that we can also enable user-based access control in which different types of users can access certain APIs.

Conclusion

So this concludes this chapter, and we have successfully created a REST application with user authentication. In the next chapter, we'll work on documenting REST APIs, integrating unit tests, and deploying our application.

CHAPTER 4

CRUD Application with Flask (Part 2)

In the last chapter, we created REST APIs using Flask, and now we have a working CRUD application. In this chapter, we'll discuss and implement features to support and extend our REST APIs. While we have everything ready to deploy, however, here are a few more things we'll discuss before deploying the application.

1. Email verification
2. File upload
3. Discuss API documentation
4. Integrate Swagger

Introduction

In the last chapter, we created a REST application using Flask and MySQL. In this chapter we'll discuss about extending the application for additional features. We'll start by adding email verification to our users model. Next we'll also add file upload endpoint to users object, and we'll also discuss about the need of API documentation, best practices for documenting APIs, and using Swagger as an API documentation tool.

K. Relan, *Building REST APIs with Flask*, https://doi.org/10.1007/978-1-4842-5022-8_4

Email Verification

In the last chapter, we created user signup and login using a unique username and password. In this chapter we'll extend the user authentication by adding email signup to the user model and also add email verification. To do the same, we'll add email field to the model, and once a new user object is created using signup API, we'll create a verification token and send an email to the user with the link to verify the account. We'll also disable user login till the email is verified. First let's add the required fields in the user model.

Browse to users.py in models and add the following lines below password in User class.

```
isVerified = db.Column(db.Boolean,  nullable=False,
default=False)
email = db.Column(db.String(120), unique = True, nullable =
False)
```

And add the following line below username in UserSchema class.

```
email = db.Column(db.String(120), unique = True, nullable =
False)
```

Also since now we have user emails, we'll update find_by_username class method to find by email. So update find_by_username method to the following.

```
@classmethod
def find_by_email(cls, email):
    return cls.query.filter_by(email = email).first()
```

Now your User class should have the following code.

```
class User(db.Model):
    __tablename__ = 'users'
```

```
    id = db.Column(db.Integer, primary_key = True)
    username = db.Column(db.String(120), unique = True,
    nullable = False)
    password = db.Column(db.String(120), nullable = False)
    isVerified = db.Column(db.Boolean,  nullable=False,
    default=False)
    email = db.Column(db.String(120), unique = True, nullable =
    False)
    def create(self):
        db.session.add(self)
        db.session.commit()
        return self
    @classmethod
    def find_by_email(cls, email):
        return cls.query.filter_by(email = email).first()

    @classmethod
    def find_by_username(cls, email):
        return cls.query.filter_by(username = username).first()

    @staticmethod
    def generate_hash(password):
        return sha256.hash(password)

    @staticmethod
    def verify_hash(password, hash):
        return sha256.verify(password, hash)
```

And UserSchema should have the following code.

```
class UserSchema(ModelSchema):
    class Meta(ModelSchema.Meta):
        model = User
        sqla_session = db.session
```

```
    id = fields.Number(dump_only=True)
    username = fields.String(required=True)
    email = fields.String(required=True)
```

Notice here, isVerified field is set to False by default, and once the user verifies the email, we'll set it to True enabling the user to log in.

Next we'll add a util called token.py which will contain methods to generate verification token and confirm the verification token. The verification link in the mail will contain a unique URL with the verification token which should look like `http://host/api/users/confirm/<verification_token>` and the token here should always be unique. We'll use itsdangerous package to encode the user email along with a timestamp, so let's go ahead and create token.py in api/utils.

Before we write the code to generate token, we need to add a few more variables to app config since itsdangerous needs a secret key and password salt for it to work which we'll supply from our config.py. Add the following lines in config/config.py under Development, Testing, as well as Production configs ensuring all the keys and salts are different.

```
    SECRET_KEY= 'your_secured_key_here'
    SECURITY_PASSWORD_SALT= 'your_security_password_here'
```

Next, in token.py add the following code to import the requirements.

```
from itsdangerous import URLSafeTimedSerializer
from flask import current_app
```

And then add the following code to generate the token.

```
def generate_verification_token(email):
    serializer = URLSafeTimedSerializer(current_app.
    config['SECRET_KEY'])
    return serializer.dumps(email,salt=current_app.
    config['SECURITY_PASSWORD_SALT'])
```

In the previous method, we use URLSafeTimedSerializer to generate a token using email address, and the email is encoded in the token. Next we'll create another method to validate the token and expiration, and as long as the token is valid and not expired, we'll return the email and verify the user email.

```
def confirm_verification_token(token, expiration=3600):
serializer = URLSafeTimedSerializer(current_app.
config['SECRET_KEY'])
try:
    email = serializer.loads(
        token,
        salt=current_app.config['SECURITY_PASSWORD_SALT'],
        max_age=expiration
    )
except Exception as e :
    return e
return email
```

Once we have our token utility in place, we can now modify user routes. Let's start by disabling user login before email verification. Update the login route to have the following code; here we have changed find_by_username to find_by_email, and now we will expect the user to send the email address in login endpoint JSON data, and if the user isn't verified, we'll return the request with a 400 bad code without the token.

Now your login method should contain the following code.

```
@user_routes.route('/login', methods=['POST'])
def authenticate_user():
      try:
        data = request.get_json()
        if data.get('email') :
            current_user = User.find_by_email(data['email'])
```

```
        elif data.get('username') :
            current_user = User.find_by_username(data['username'])
        if not current_user:
            return response_with(resp.SERVER_ERROR_404)
        if current_user and not current_user.isVerified:
            return response_with(resp.BAD_REQUEST_400)
        if User.verify_hash(data['password'], current_user.
        password):
            access_token = create_access_token(identity =
            current_user.username)
            return response_with(resp.SUCCESS_201,
            value={'message': 'Logged in as {}'.format(current_
            user.username), "access_token": access_token})
        else:
            return response_with(resp.UNAUTHORIZED_401)
      except Exception as e:
        return response_with(resp.INVALID_INPUT_422)
```

Now let's create an endpoint to verify the email token.

We'll start by importing the recently created methods in user.py

```
from api.utils.token import generate_verification_token,
confirm_verification_token
```

Next, add the following GET endpoint to handle email validation right below the user signup method.

```
@user_routes.route('/confirm/<token>', methods=['GET'])
def verify_email(token):
    try:
        email = confirm_verification_token(token)
    except:
        return response_with(resp.SERVER_ERROR_401)
```

```
    user = User.query.filter_by(email=email).first_or_404()
    if user.isVerified:
        return response_with(resp. INVALID_INPUT_422)
    else:
        user.isVerified = True
        db.session.add(user)
        db.session.commit()
        return response_with(resp.SUCCESS_200, value={'message':
        'E-mail verified, you can proceed to login now.'})
```

The next step is to update the user signup method to generate the token and send the email to the specified address for verification, so here we'll start with creating an email utility in our utils to send out emails.

In order to do so, we'll need a flask-mail library; let's start by installing the same. Making sure you are still in the virtual environment, use the following line to install flask-mail in your terminal.

```
(venv) $ pip install Flask-Mail
```

Once installed, let's initiate and configure flask-mail. Add the following variables in config.py to configure mail.

```
    MAIL_DEFAULT_SENDER= 'your_email_address'
    MAIL_SERVER= 'email_providers_smtp_address'
    MAIL_PORT= <mail_server_port>
    MAIL_USERNAME= 'your_email_address'
    MAIL_PASSWORD= 'your_email_password'
    MAIL_USE_TLS= False
    MAIL_USE_SSL= True
```

Next create email.py in utils and add the following code.

```
from flask_mail import Message,Mail
from flask import current_app
mail = Mail()
```

Next let's import mail in our main.py and initiate it with app config.

```
from api.utils.email import mail
```

Add this among other imports in main.py, and then right below where we initiated our JWTManager inside create_app, add the following code.

```
    mail.init_app(app)
```

And now our mail object should be initiated with the app config; next in email.py, let's write a method to send out emails.

Add the following code in email.py to create a method send_email which will take the sender's address, subject, and mail template to send.

```
def send_email(to, subject, template):
    msg = Message(
        subject,
        recipients=[to],
        html=template,
        sender=current_app.config['MAIL_DEFAULT_SENDER']
    )
    mail.send(msg)
```

So this is all we need to do in order to send out the verification email; let's go back to users.py and update the user signup method to incorporate the changes.

Let's start by importing the send_email, url_for, and render_template_string method in users.py using the following line.

```
from api.utils.email import send_email
from flask import url_for, render_template_string
```

Update the following code for create_user() method in users.py, right before the return function.

```
try:
    data = request.get_json()
    if(User.find_by_email(data['email']) is not None or
    User.find_by_username(data['username']) is not None):
        return response_with(resp.INVALID_INPUT_422)
    data['password'] = User.generate_hash(data['password'])
    user_schmea = UserSchema()
    user, error = user_schmea.load(data)
    token = generate_verification_token(data['email'])
    verification_email = url_for('user_routes.verify_
    email', token=token, _external=True)
    html = render_template_string("<p>Welcome! Thanks for
    signing up. Please follow this link to activate your
    account:</p> <p><a href='{{ verification_email }}'>{{
    verification_email }}</a></p> <br> <p>Thanks!</p>",
    verification_email=verification_email)
    subject = "Please Verify your email"
    send_email(user.email, subject, html)
    result = user_schmea.dump(user.create()).data
    return response_with(resp.SUCCESS_201)
except Exception as e:
    print e
    return response_with(resp.INVALID_INPUT_422)
```

Here we are supplying the email to generate_verification_token and getting the token in return. Next we use Flask's url_for to generate the verification URL using the verification route we just created and the token. After that we render HTML template using render_template_string of Jinja2 where we supply the HTML string and the verification variable and then we supply all the user-provided email, subject, and HTML to send_email method to send out the verification email.

So this is all we need to setup email verification. Let's start testing out the signup, login, and verification routes to check if everything is working.

Let's start by signup endpoint; open your Postman and request the POST /users API; however, in the JSON body, add a valid email address.

```
{
      "username" : "kunalrelan",
      "password" : "helloworld",
      "email" : "kunal.relan@hotmail.com"
 }
```

We'll use the following JSON in the request data and access the endpoint; the response should be similar to earlier; however, you should get a verification email from your configured mail address on the email you specify in the JSON data with the token (Figure 4-1).

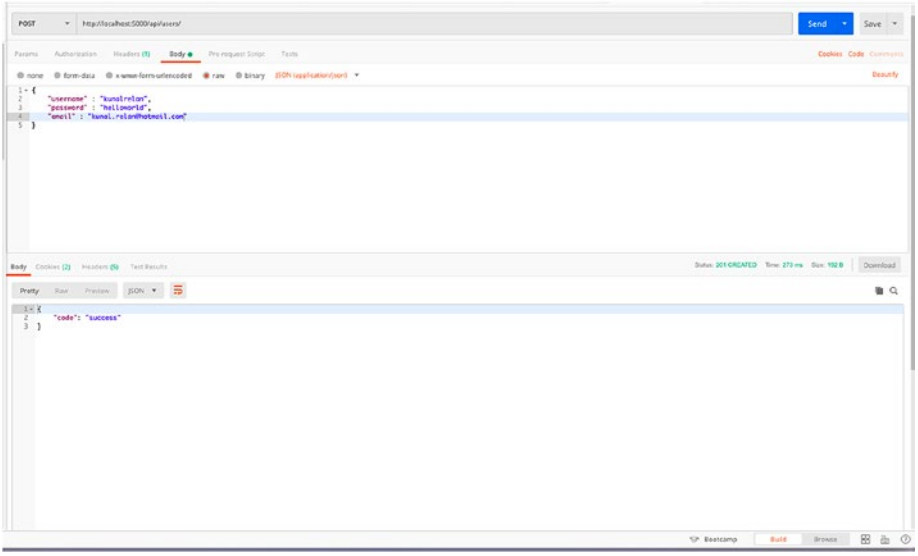

Figure 4-1. *User signup API*

Next, let's check the email inbox to check if the email arrived and verify the user.

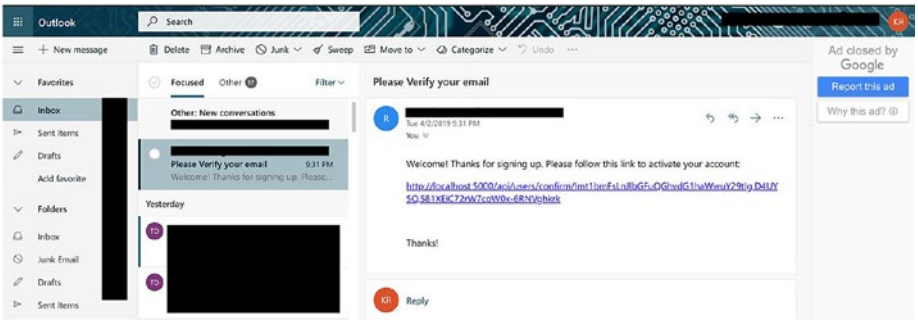

Figure 4-2.

As you can see in Figure 4-2, the verification email arrived with the link to validate the user account. Before we activate the user account, let's try logging in with the user credentials to check if email validation works fine (Figure 4-3).

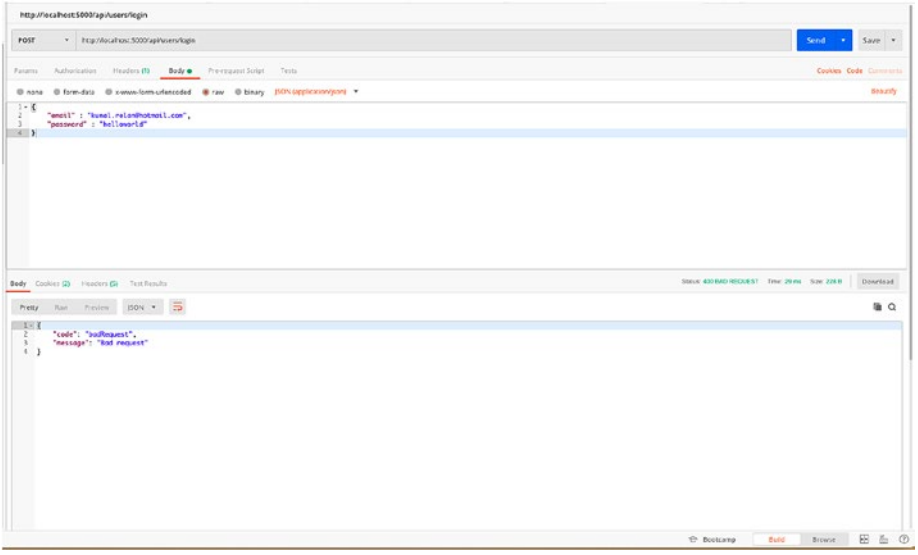

Figure 4-3. *User login without verification*

As you can see in Figure 4-4, the user is not verified and thus can't login. Now let's open the link provided in the email to verify the user which shall then allow the user to login and obtain the JWT token.

Figure 4-4. *User email verification*

Once the user is verified, let's try logging in again, and nowwe should be able to login and obtain the JWT token.

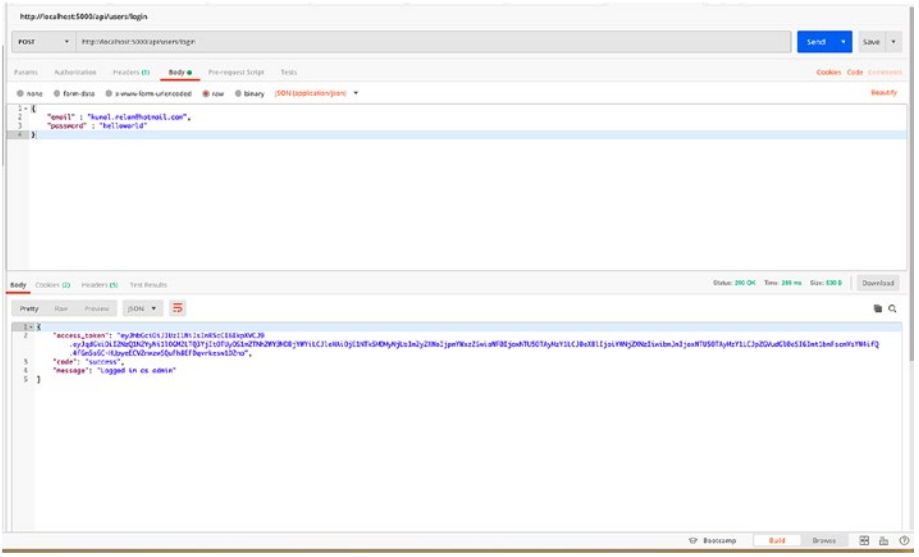

Figure 4-5. *User login after verification*

As you can see in Figure 4-5, we are now again able to login to the account after verifying the email address.

So this is it for this section. We have successfully implemented user email verifications, and what we did here was just once use case of email verification; there are a lot of ways email verification can be used. In a lot of applications, users are able to login even before email verification; however, there are certain functions which are disabled for the unverified users which can be replicated similarly with the change we did in the login endpoint. In the next section we'll implement file upload and handling.

File Upload

File uploads is another common use case in REST APIs. In this section we'll implement avatar upload for author model and an endpoint to access avatar. The idea is pretty straightforward here; we'll update the author model to store avatar URL, create another endpoint for a logged in user to upload avatar for an author using author ID, save the file in the file system, and create another endpoint to handle static image files.

Before we start developing the feature, let's talk a bit more about handling file uploads in Flask. Here we'll use multipart/form-data content type which indicates the media type of the request resource to the client and use request.files. We'll also define a set of allowed file extensions since we don't need any other file types except images to be uploaded which otherwise can lead to big security vulnerability. We'll then escape the uploaded file's name with werkzeug.secure_filename() which revolves around the principle "never trust user input," and hence the filename may contain malicious code which can lead to security vulnerability exploitation. Hence the method will escape special characters from the filename.

To start with let's update the author model to add avatar field. So open authors.py in models, and in the model declaration, add the following line in Author class

```
avatar = db.Column(db.String(20), nullable=True)
```

and the following line in AuthorSchema class

```
avatar = fields.String(dump_only=True)
```

After that, create a new folder in /src and name it images, and add upload folder config in the app config which we'll later use to save and fetch the uploaded avatars.

So open config.py in config and add the following parameter.

```
UPLOAD_FOLDER= 'images'
```

Now we'll import werkzeug.secure_filename() and url_for from Flask which we'll need in the endpoint we are going to create, so add the following lines of code below the other imports in authors.py in routes.

```
from werkzeug.utils import secure_filename
```

Next where we imported Blueprint and request from Flask, add url_for like the following.

```
from flask import Blueprint, request, url_for, current_app
```

Right after the import, declare allowed_extensions which will contain a set of allowed file extensions.

```
allowed_extensions = set(['image/jpeg', 'image/png', 'jpeg'])
```

Once we have the set, let's create a method to check if the uploaded file's extension is that of an image.

Add the following code right below allowed_extensions.

```
def allowed_file(filename):
       return filetype in allowed_extensions
```

```
The above function will take the filename from the file and
check if the extension is valid and return.
```

Now add the following endpoint to add avatar upload endpoint.

```
@author_routes.route('/avatar/<int:author_id>',
methods=['POST'])
@jwt_required
def upsert_author_avatar(author_id):
    try:
        file = request.files['avatar']
        get_author = Author.query.get_or_404(author_id)
        if file and allowed_file(file.content_type):
            filename = secure_filename(file.filename)
            file.save(os.path.join(current_app.config['UPLOAD_
            FOLDER'], filename))
        get_author.avatar = url_for('uploaded_file',
        filename=filename, _external=True)
        db.session.add(get_author)
        db.session.commit()
        author_schema = AuthorSchema()
        author, error = author_schema.dump(get_author)
        return response_with(resp.SUCCESS_200, value={"author":
        author})
    except Exception as e:
        print e
        return response_with(resp.INVALID_INPUT_422)
```

In the following code, we look for avatar field in request.files and then look for the user with the provided user ID. Once we have that, we'll then check if a file was uploaded and then escape the filename using the secure_filename function we just imported. Then we'll use file.save method and save the file in images folder by supplying the path by concatenating UPLOAD_FOLDER from config and filename. Now once the file is saved, we'll use url_for method to create a URL for accessing the uploaded file, for that we'll create a route with a method uploaded_file that accepts a filename and serves it from the configured upload folder which

we'll create next. Once done, we'll update the author model and update the avatar field with the URL for the uploaded avatar.

Next move to main.py and add the following route right after Blueprint declarations for the routes in create_app function.

```
@app.route('/avatar/<filename>')
 def uploaded_file(filename):
     return send_from_directory(app.config['UPLOAD_
     FOLDER'],filename)
```

So this function will accept the filename and return the file from the configured UPLOAD_FOLDER in the response.

So this is it for file upload, and now we should be able to upload an avatar for an author and fetch it back. Let's go back to Postman and try it out.

So now request the update avatar endpoint with form-data, andspecify the key avatar, select the image you want to upload, and send it. We shall get 200 success response with user object in response; now notice the avatar field with the link to the file (Figure 4-6).

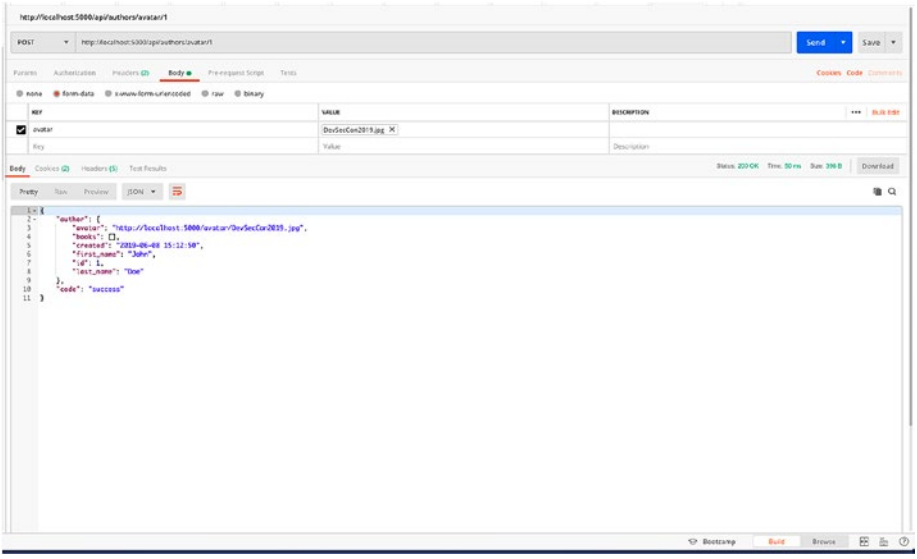

Figure 4-6. *Author avatar upload endpoint*

Next click the avatar link to fetch the image you just created to check if it exists.

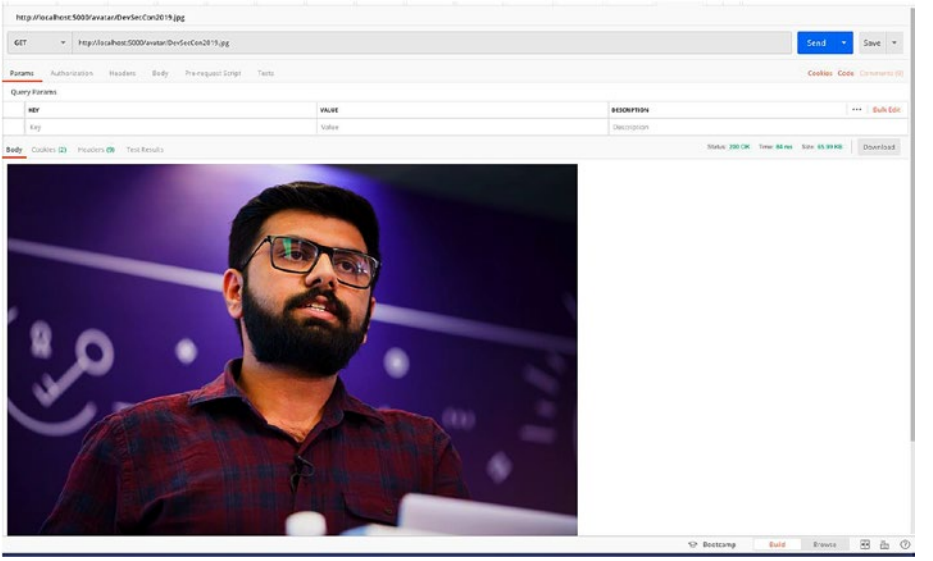

Figure 4-7. *Fetch avatar endpoint*

As you can see in Figure 4-7, we are able to fetch the image using the route we created. Next let's try uploading an HTML file to check if the allowed extension check works well. For this just create an HTML file with any text in it or use any HTML file you have and try uploading it.

Now, as you see in Figure 4-8, we got an error trying to upload an HTML file which is not allowed on this endpoint, ensuring the extension check is working fine for us.

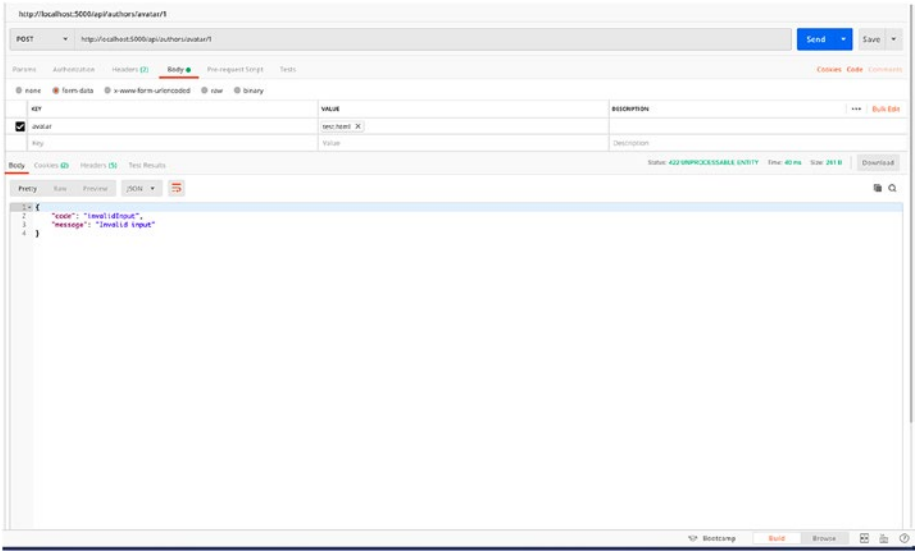

Figure 4-8. *Upload avatar endpoint with invalid file type*

API Documentation

The process of API development does not end just after programming them. Since REST APIs are used by a variety of clients and hence are used by other developers who either access them directly using a REST client or integrate with some kind of REST client, API documentation provides an easy way to understand the functioning of REST endpoints which makes API documentation an essential part of developing a REST-based application.

In this section we'll discuss about the basics of API documentation, OpenAPI spec, and Swagger, generating API docs using OpenAPI spec, publishing API docs, and testing APIs using Swagger UI.

Building Blocks of API Documentation

In REST API reference documentation, there are five sections on which the documentation is based, namely:

1. Resource Description: As discussed earlier, resources refer to the information returned from the API; in context of this book, author, books, and users are resources. Resource description is generally brief ranging from one to two sentences. Every resource has certain verbs which can be accessed.
2. Endpoints and Methods: Endpoints define how the provided resources can be accessed, and methods indicate the allowed interactions or verbs on the resource, for example, GET, POST, PUT, DELETE, and so on. Any resource will have related endpoints with different paths and methods but will revolve around the same resource.
3. Parameters: Parameters are the variable parts of the endpoint which specifies the data you are working on.
4. Request Example: Request example includes a sample request containing the required fields, optional fields, and their sample value. Request example should usually be as rich as possible and contains all acceptable fields.
5. Response Example and Schema: As the name suggests, response example contains an elaborate example of the API response in accordance to the request. Schema on the other hand defines how the response is formatted and labeled. The description of the response is usually called as response schema which is a complex document describing all the possible parameters and response types.

OpenAPI Specification

The OpenAPI Specification (OAS) defines a standard, language-agnostic interface for REST API allowing both humans and computers to understand the capabilities of the application without looking into source code or doing network inspection enabling the API consumers to understand the working of the application without knowing the implementation logic.

OpenAPI definitions can have multiple use cases including documentation generation to display APIs, testing tools, and so on.

For the context of this book, we'll use OpenAPI specification with Swagger UI to generate and display the API reference documentation.

OpenAPI defines a standard set which is then used to describe each part of the API; by doing this, publishing tools like Swagger UI can programmatically parse information and display it with customized styling and interactivity feature. An OpenAPI specification document can either be expressed in YAML (YAML Ain't Markup Language) or JSON, but ultimately the spec file will be a JSON document. Since YAML is more readable and a more common format, we'll use YAML for creating OpenAPI specification document here which then will be published using Swagger UI.

So before we jump into writing OpenAPI specs for our endpoints, let's understand the basics of OpenAPI specs. An OpenAPI specification document has three required components, namely, openapi which defines the semantic version number of the OpenAPI specification which is essential for users to understand how the document is formatted and for the parsing tools to parse the document accordingly; Info which contains the metadata of the API which essentially has title and API version as required fields alongside additional fields like description, legal information, and contact; and Paths which contains information about the endpoints and their available operations.

The Paths object is the heart of the OpenAPI specification document which contains the details to the available endpoints which is basically the five components we discussed in the previous section.

OpenAPI specification 3.0 is the newest version; the older version of it is Swagger specification 2.0 which was updated and made into OpenAPI spec later on. For this book we'll use Swagger 2.0 specification and define the API documentation; to do so you can use Inspector from Swagger or generate them using the build time Swagger generation tool. Let's check out both the approaches. We'll start with checking out Swagger Inspector and move on to build time generator which we'll integrate in our application.

To start with, open `https://inspector.swagger.io` in your browser window (Chrome browser) and login/signup with your preferred modem (Figure 4-9).

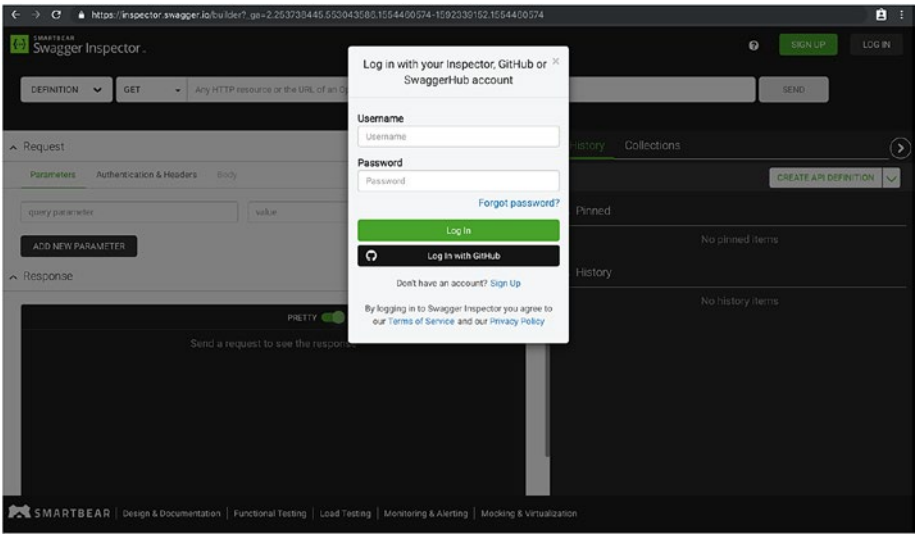

Figure 4-9. *Swagger Inspector*

Once you have logged in, you'll be able to use all the features of Swagger Inspector; next we'll need to access our API resources using their REST client, and once we do so, it'll appear in the history and we'll be able to convert it into an OpenAPI specification file, but before we can access our application running on our local server, we'll need to add Swagger Inspector Chrome Extension, and to do so, add the extension using

https://chrome.google.com/webstore/detail/swagger-inspector-extensi/biemppheiopfggogojnfpkngdkchelik. Once you have the extension installed, Swagger Inspector will be able to run with requests on your local server as well.

Once done, let's start with accessing our Create user endpoint. So go ahead and similar to what we did in Postman, add the URL and choose POST method, and in body add the JSON body data and click send (Figure 4-10).

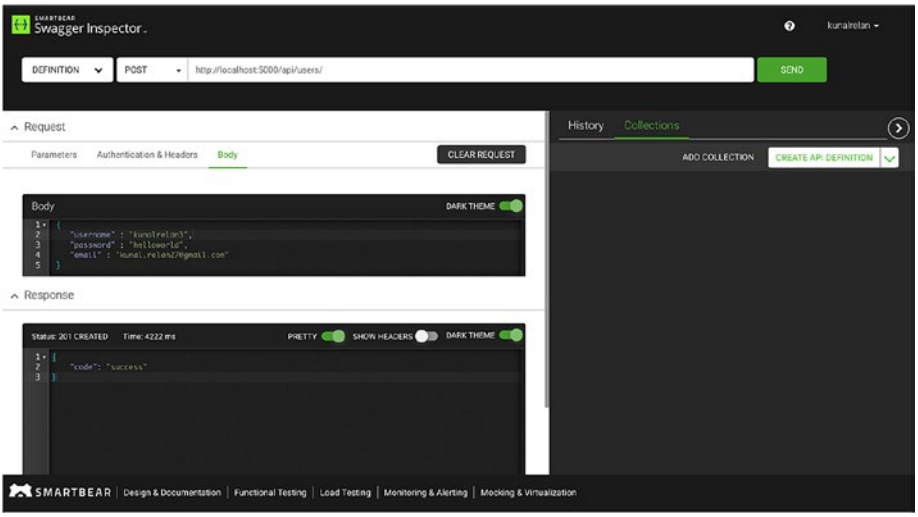

Figure 4-10. *Create user endpoint Swagger Inspector*

And similar to Postman, you should be able to check the API response in the response window as you see in the previous figure. Next you can verify the email and then access the login endpoint (Figure 4-11).

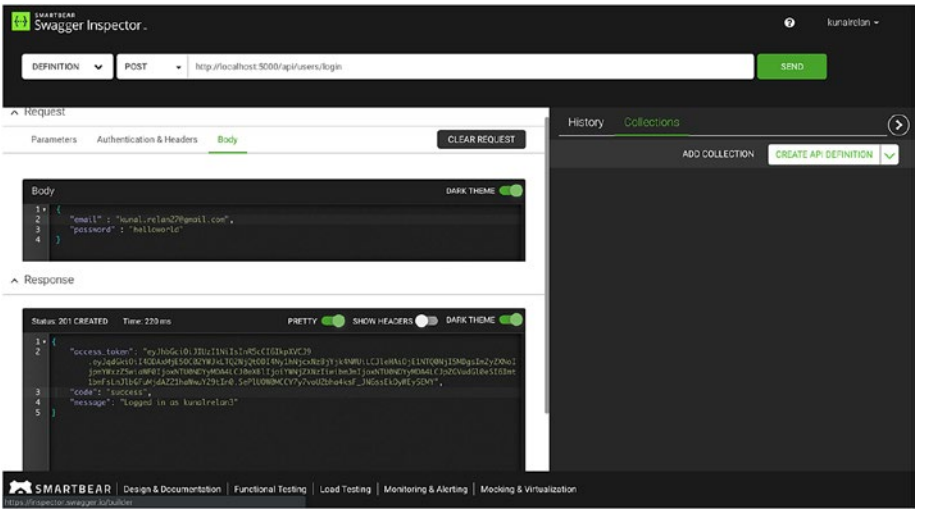

Figure 4-11. *Login endpoint*

Once you have requested all the endpoints you want the API documentation to generate, simply click the History tab and choose the endpoints you want the specification document to generate and pin them. Once you have them pinned, click the little arrow on the side of the Create API Definition button and select OAS 2.0 to use version 2.0 of the specification (Figure 4-12).

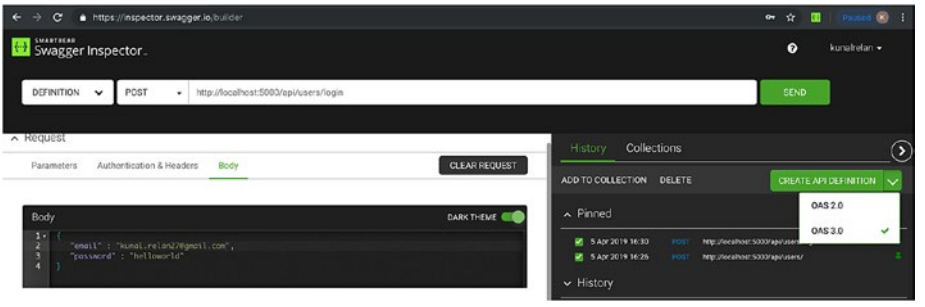

Figure 4-12. *Pinned requests*

Now click Create Definition which once completed shall open up a popup with link to open SwaggerHub where you can import the OpenAPI spec and view the API docs (Figure 4-13).

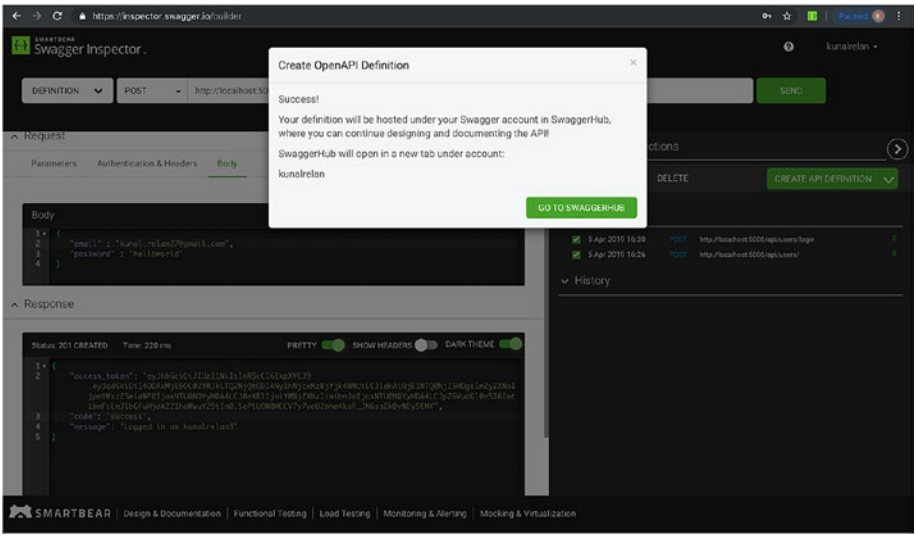

Figure 4-13. *OpenAPI spec generation*

Now follow the link and SwaggerHub shall open which will ask you to enter the title and version of your APIs. Here we'll add Author DB and let the version be default to 0.1, make visibility to private, and click Import API like in Figure 4-14.

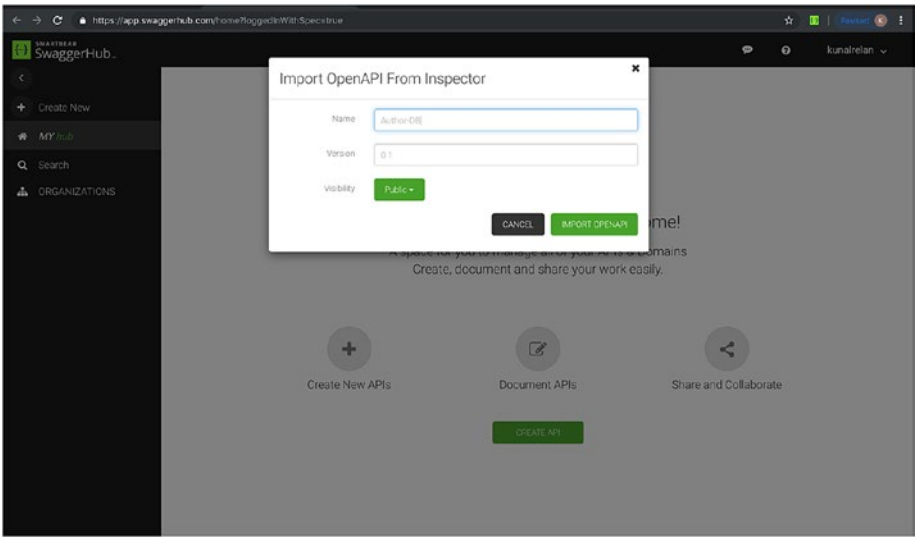

Figure 4-14. *Importing OpenAPI from Inspector*

Once done, you shall be able to check out the documentation for your APIs like in the following figure. Here for this tutorial, I have only selected two endpoints, but you can have all your endpoints documented here.

In Figure 4-15 you can see the selected server is the address of our local server, and then we have our selected endpoints.

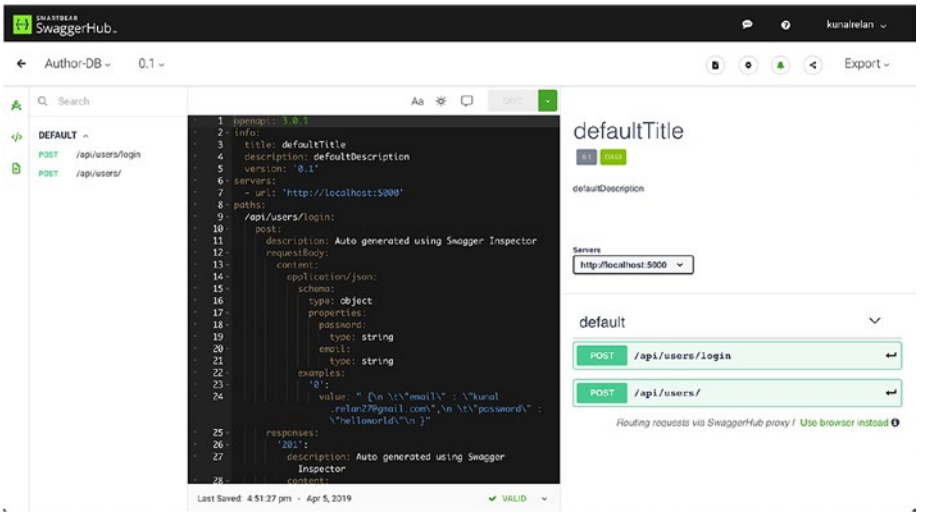

Figure 4-15. *SwaggerHub*

Next let's check out the API documentation by clicking the paper icon on the top bar like in Figures 4-16 and 4-17.

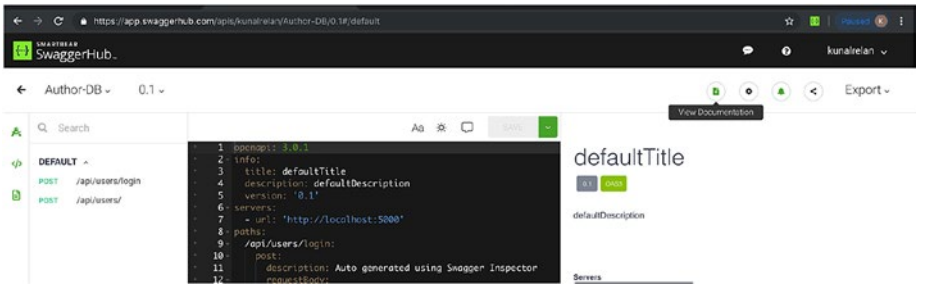

Figure 4-16. *View documentation*

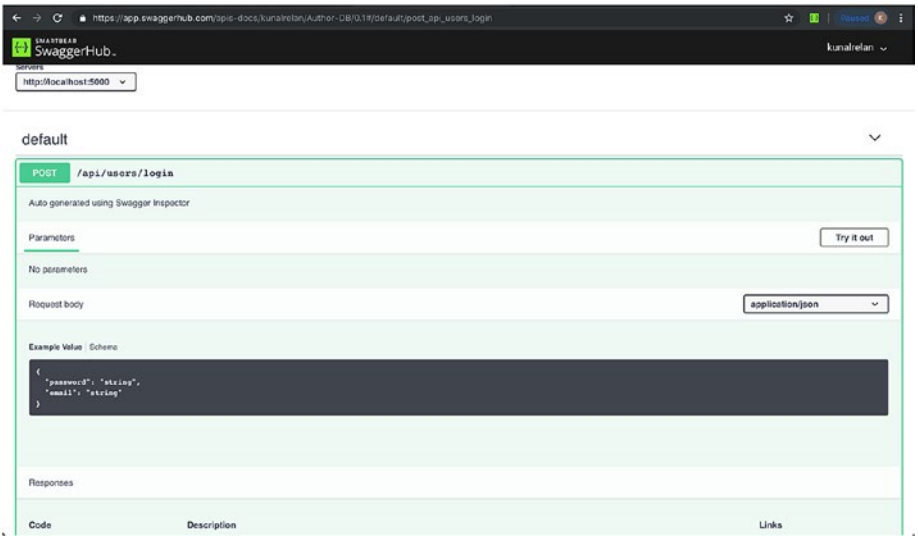

Figure 4-17. *View documentation page*

Once the page loads, you are now in an interactive mode of your API documentation where you can see the endpoints, parameters, sample request, and sample response. Next click Try It Out, and the Request body window shall become editable where you can fill the request body data like in Figure 4-18. Below that you can also see the responses and their formats.

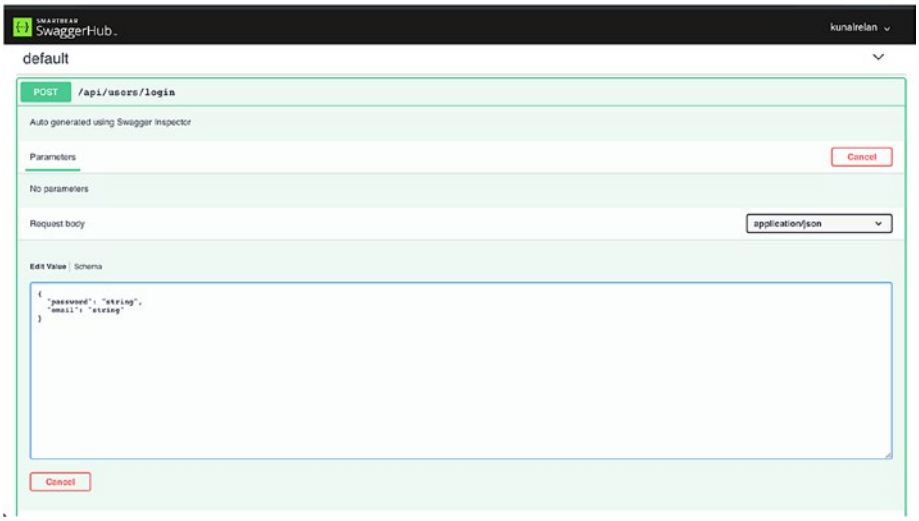

Figure 4-18. *API request mode*

So go ahead and edit the email and password and click execute to request to access the API.

Next you can also export the YAML/JSON version of the specification document to use it with your version of Swagger UI.

Moving on, we'll now integrate API documentation using our own installation of Swagger UI and build time specification.

For the same we'll use flask_swagger and flask_swagger_ui extension; let's go ahead and install both of them using PIP.

```
(venv)$ pip install flask_swagger flask_swagger_ui
```

Once installed let's integrate it in our application; to do so open main.py and import both the libraries using the following lines.

```
from flask_swagger import swagger
from flask_swagger_ui import get_swaggerui_blueprint
```

We'll serve Swagger UI on /api/docs endpoint.

Now we'll create an endpoint to serve our defined API specs using Swagger 2.0

So add the following code below errorhandler functions where we'll define /api/spec route and initiate our Swagger definition and return the generated JSON file.

```
@app.route("/api/spec")
    def spec():
        swag = swagger(app, prefix='/api')
        swag['info']['base'] = "http://localhost:5000"
        swag['info']['version'] = "1.0"
        swag['info']['title'] = "Flask Author DB"
        return jsonify(swag)
```

Now we'll initiate flask_swagger_ui to fetch this JSON file and render Swagger UI using it. Add the following code below the new route to initiate get_swagger_blueprint method we just imported from flask_swagger_ui, and here we'll supply the docs route, JSON file router, and app_name in config variable and then register the Blueprint.

```
swaggerui_blueprint = get_swaggerui_blueprint('/api/docs',
'/api/spec', config={'app_name': "Flask Author DB"})
app.register_blueprint(swaggerui_blueprint, url_
prefix=SWAGGER_URL)
```

And now when you try to access `htttp://localhost:5000/api/docs`, you should be able to see Swagger UI (Figure 4-19).

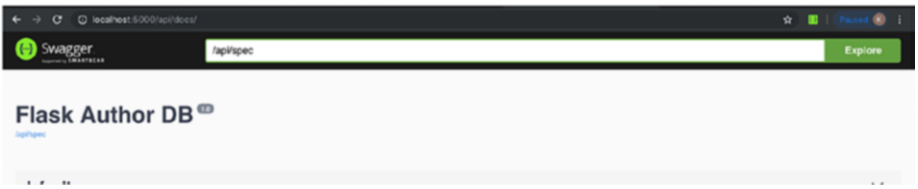

Figure 4-19. *Swagger UI*

In the preceding URL bar, you can also provide the URL to the JSON file exported from SwaggerHub to explore your APIs.

Build Time Documentation

Next, we'll document the APIs using build time documentation and generate the JSON documentation file; however, we'll use YAML while describing the endpoints.

Flask Swagger will automatically pick up YAML documentation from method definitions using ' ' " " ' under method followed by the description. We'll learn it using a sample definition in our Create user endpoint. So add the following lines after def create_user() in users.py routes.

```
    """
    Create user endpoint
    ---
    parameters:
        - in: body
          name: body
          schema:
            id: UserSignup
            required:
                - username
                - password
                - email
            properties:
                username:
                    type: string
                    description: Unique username of the user
                    default: "Johndoe"
                password:
                    type: string
                    description: Password of the user
```

```
                default: "somethingstrong"
            email:
                type: string
                description: email of the user
                default: "someemail@provider.com"
    responses:
            201:
                description: User successfully created
                schema:
                  id: UserSignUpSchema
                  properties:
                    code:
                      type: string
            422:
                description: Invalid input arguments
                schema:
                    id: invalidInput
                    properties:
                        code:
                            type: string
                        message:
                            type: string
    """
```

Here we are using YAML to define parameters and responses as you can see in the previous example; we define the kind of parameter it is, and in our case, it's a body parameter, and then we define the schema of the required parameters with sample data and field names. In responses we define the different types of expected responses and their schema (Figure 4-20).

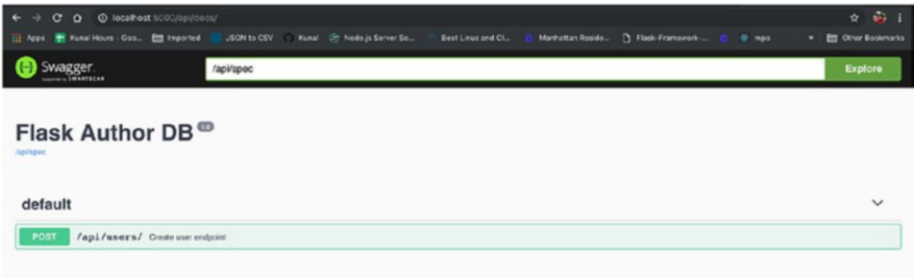

Figure 4-20. *Build time document generation*

Now if you reload your application and visit Swagger UI, you should be able to see your Create user endpoint and access it using Swagger UI.

Here notice how the description and parameters and responses were interpreted and placed in Swagger UI.

Next add this to login method to generate docs for login endpoint.

```
"""
User Login
---
parameters:
    - in: body
      name: body
      schema:
        id: UserLogin
        required:
            - password
            - email
        properties:
            email:
                type: string
                description: email of the user
                default: "someemail@provider.com"
            password:
                type: string
```

```
                description: Password of the user
                default: "somethingstrong"
responses:
        200:
            description: User successfully logged In
            schema:
              id: UserLoggedIn
              properties:
                code:
                  type: string
                message:
                  type: string
                value:
                  schema:
                    id: UserToken
                    properties:
                        access_token:
                            type: string
                        code:
                            type: string
                        message:
                            type: string
        401:
            description: Invalid input arguments
            schema:
                id: invalidInput
                properties:
                    code:
                        type: string
                    message:
                        type: string
"""
```

Next we'll move on to authors.py route file and create doc for Create author, and if you remember, this route needs the user to be logged in and here we'll add an extra header parameter which will accept authorization header.

```
"""
    Create author endpoint
    ---
    parameters:
        - in: body
          name: body
          schema:
            id: Author
            required:
                - first_name
                - last_name
                - books
            properties:
                first_name:
                    type: string
                    description: First name of the author
                    default: "John"
                last_name:
                    type: string
                    description: Last name of the author
                    default: "Doe"
        - in: header
          name: authorization
          type: string
          required: true
    security:
        - Bearer: []
    responses:
```

```
            200:
                description: Author successfully created
                schema:
                  id: AuthorCreated
                  properties:
                    code:
                      type: string
                    message:
                      type: string
                    value:
                      schema:
                        id: AuthorFull
                        properties:
                            first_name:
                                type: string
                            last_name:
                                type: string
                            books:
                                type: array
                                items:
                                    schema:
                                        id: BookSchema
            422:
                description: Invalid input arguments
                schema:
                    id: invalidInput
                    properties:
                        code:
                            type: string
                        message:
                            type: string
    """
```

Next add the following lines for Upsert author avatar endpoint; notice in this case we'll add a parameter for author ID to be a variable in path.

```
    """
    Upsert author avatar
    ---
    parameters:
        - in: body
          name: body
          schema:
            id: Author
            required:
                - avatar
            properties:
                avatar:
                    type: file
                    description: Image file
        - name: author_id
          in: path
          description: ID of the author
          required: true
          schema:
            type: integer
    responses:
            200:
                description: Author avatar successfully upserted
                schema:
                  id: AuthorCreated
                  properties:
                    code:
                      type: string
                    message:
```

```
                type: string
            value:
              schema:
                id: AuthorFull
                properties:
                    first_name:
                        type: string
                    last_name:
                        type: string
                    books:
                        type: array
                        items:
                            schema:
                                id: BookSchema
        422:
            description: Invalid input arguments
            schema:
                id: invalidInput
                properties:
                    code:
                        type: string
                    message:
                        type: string
    """
```

And now you can reload your Swagger UI, and you should be able to see all the endpoints (Figure 4-21) documented.

Figure 4-21. *Reload Swagger UI to see endpoints*

Conclusion

For this chapter, we'll only create documentation for the given endpoints, and you can build up on the top of it using the same methodologies, which will help you create full-fledged documentation for your REST endpoints. In the next chapter, we'll discuss testing our REST endpoints and cover topics including unit tests, mocks, code coverage, and so on.

CHAPTER 5

Testing in Flask

Something that is untested is broken.

This quote comes from an unknown source; however, it's not entirely true but most of it is right. Untested applications are always an unsafe bet to make. While the developers are confident about their work, in real world things work out differently; hence it's always a good idea to test the application throughout. Untested applications also make it hard to improve the existing code. However with automated tests, it's always easy to make changes and instantly know when something breaks. So testing not just only ensures if the application is behaving the way it is expected to, it also facilitates continuous development.

This chapter covers automated unit testing of REST APIs, and before we get into the actual implementation, we'll look into what unit testing is and the principles behind.

Introduction

Most software developers out there are usually already familiar with the term "unit testing," but for those who are not, unit testing revolves around the concept of breaking a large set of code into individual units to be tested in isolation. So typically in such a case, a larger set of code is software, and individual components are the units to be tested in isolation. Thus in our case, a single API request is a unit to be tested. Unit testing is the first level of software development and is usually done by software developers.

K. Relan, *Building REST APIs with Flask*, https://doi.org/10.1007/978-1-4842-5022-8_5

Let's look into some benefits of unit testing:

1. Unit tests are simple tests for a very narrow block of code, serving as a building block of the bigger spectrum of the application testing.
2. Being narrowly scoped, unit tests are the easiest to write and implement.
3. Unit tests increase confidence in modifying the code and are also the first point of failure if implemented correctly prompting the developer about parts of logic breaking the application.
4. Writing unit tests makes the development process faster, since it makes developers to do less of fuzzy testing and helps them catch the bugs sooner.
5. Catching and fixing bugs in development using unit tests is easier and less expensive than doing it after the code is deployed in production.
6. Unit tests are also a more reliable way of testing in contrast to manual fuzz tests.

Setting Up Unit Tests

So, in this section, we'll jump right into the action and start on implementing the tests; for the same we'll use a library called unittest2 which is an extension to the original unit testing framework of Python called unittest.

Let's go ahead and install the library first.

```
(venv)$ pip install unittest2
```

This shall install unittest2 for us; next we'll set up a base test class that we'll import in all our test files. This base class will set up the base for the tests and initiate the test client as the name suggests. So go ahead and create a file called test_base.py in utils folder.

Now let's configure our testing environment, so open up your config.py and add the following code to add testing config.

```
class TestingConfig(Config):
    TESTING = True
    SQLALCHEMY_ECHO = False
    JWT_SECRET_KEY = 'JWT-SECRET'
    SECRET_KEY= 'SECRET-KEY'
    SECURITY_PASSWORD_SALT= 'PASSWORD-SALT'
    MAIL_DEFAULT_SENDER= '
    MAIL_SERVER= 'smtp.gmail.com'
    MAIL_PORT= 465
    MAIL_USERNAME= "
    MAIL_PASSWORD= "
    MAIL_USE_TLS= False
    MAIL_USE_SSL= True
    UPLOAD_FOLDER= 'images'
```

Notice that we won't configure the SQLAlchemy URI here, which we'll do in test_base.py

Next, add the following lines to import the required dependencies in test_base.py

```
import unittest2 as unittest
from main import create_app
from api.utils.database import db
from api.config.config import TestingConfig
import tempfile
```

Next add the BaseTestCase class with the following code.

```
class BaseTestCase(unittest.TestCase):
    """A base test case"""
    def setUp(self):
        app = create_app(TestingConfig)
        self.test_db_file = tempfile.mkstemp()[1]
        app.config['SQLALCHEMY_DATABASE_URI'] = 'sqlite:///' +
        self.test_db_file
        with app.app_context():
            db.create_all()
        app.app_context().push()
        self.app = app.test_client()

    def tearDown(self):
        db.session.close_all()
        db.drop_all()
```

Here we are creating the SQLAlchemy sqlite database on the fly using tempfile.

What we just created previously is called a stub, which is a module that acts as a temporary replacement for a called module providing the same output as the actual product.

So the preceding method will run before every test is run and it spawns a new test client. We'll import this method in all the tests we create. A test is recognized by all the methods in the class which starts with test_ prefix. Here we'll have a unique database URL every time since we have configured tempfile, and we'll postfix it with a timestamp and then we have configured TESTING= True in app config which will disable error catching to enable better testing, and then finally we run db.create_all() to create the DB tables for the application.

Next we have defined another method tearDown which will remove the current database file and use a fresh database file for every test.

Unit Testing User Endpoints

So now we'll start writing the tests, and the first step to it is by creating a folder called tests in api directory where we'll create all our test files. So go ahead and create tests folder and create our first test file called test_users.py.

Now add the following imports in test_users.py

```
import json
from api.utils.test_base import BaseTestCase
from api.models.users import User
from datetime import datetime
import unittest2 as unittest
from api.utils.token import generate_verification_token,
confirm_verification_token
```

Once done, we'll define another method to create users using the SQLAlchemy model to facilitate testing.

Add this to the file next.

```
def create_users():
    user1 = User(email="kunal.relan12@gmail.com",
    username='kunalrelan12',
    password=User.generate_hash('helloworld'),
    isVerified=True).create()
    user2 = User(email="kunal.relan123@gmail.com",
    username='kunalrelan125',
    password=User.generate_hash('helloworld')).create()
```

Now we have our imports and the method to create users; next we'll define TestUsers class to hold all our tests.

```
class TestUsers(BaseTestCase):
    def setUp(self):
        super(TestUsers, self).setUp()
```

```
        create_users()

if __name__ == '__main__':
    unittest.main()
```

Add this code to the file which will import our base test class and set up the test client and call create_users() method to create the users. Notice that in create_users() method, we have created one verified and one unverified user so that we can cover up all the test cases. Now we can start writing our unit tests. Add the following code inside TestUsers() class.

We'll start by testing the login endpoint, and since we just created a verified user, we should be allowed to log in with a valid set of credentials.

```
    def test_login_user(self):
        user = {
          "email" : "kunal.relan12@gmail.com",
          "password" : "helloworld"
        }
        response = self.app.post(
            '/api/users/login',
            data=json.dumps(user),
            content_type='application/json'
        )
        data = json.loads(response.data)
        self.assertEqual(200, response.status_code)
        self.assertTrue('access_token' in data)
```

Add the following code inside the TestUsers class, and we should have our first unit test in which we create a user object and post the user to login endpoint. Once we receive the response, we'll use assertion to check if we got the expected status code and access_token in the response. An assertion is a boolean expression which will be true unless there is a bug or the conditional statement doesn't match. Unit test provides a list of assertion methods we can use to validate our tests.

But assertEqual(), assertNotEqual(), assertTrue(), and assertNotTrue() cover most of it.

Here assertEqual() and assertNotEqual() match for values, and assertTrue() and assertNotTrue() check if the value of passed variable being a boolean.

Now let's run our first test, so just open your terminal and activate your virtual environment.

In your terminal run the following command to run the tests.

```
(venv)$ python -m unittest discover api/tests
```

The preceding command will run all the test files inside the tests directory; since we have only one test for now, we can see the result of our tests in the following figure.

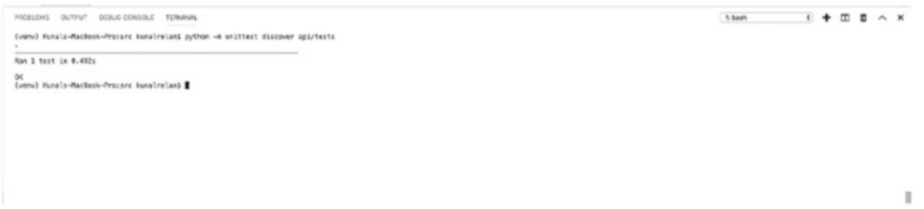

Figure 5-1. *Running unit tests*

So this was one way of running our unit tests, and before we process further with writing more tests, I'd like to introduce you to another extension to unittest library called nose which makes testing easier, so let's go ahead and install nose.

Use the following code to install nose.

```
(venv)$ pip install nose
```

And now once we have nose, let's see how we can use nose to run our tests since moving on we'll use nose to run all our tests.

By default nose will find all the test files using a (?:\b|_)[Tt]est regular expression; however, you can also specify the filename to test. Let's run the same test again by using nose.

```
(venv)$ nosetests
```

Figure 5-2. *Running unit tests with nose*

As you can see in the preceding figure, we can run our tests using a simple nosetest command. Next let's write unit tests for user model again.

So our goal here is to cover all the scenarios and check the application behavior in each of the scenarios; next we'll test login API when the user is not verified and when wrong credentials are submitted.

Add the following code for the respective tests.

```
def test_login_user_wrong_credentials(self):
    user = {
      "email" : "kunal.relan12@gmail.com",
      "password" : "helloworld12"
    }
    response = self.app.post(
        '/api/users/login',
        data=json.dumps(user),
        content_type='application/json'
    )
    data = json.loads(response.data)
    self.assertEqual(401, response.status_code)
```

```
def test_login_unverified_user(self):
    user = {
      "email" : "kunal.relan123@gmail.com",
      "password" : "helloworld"
    }
    response = self.app.post(
        '/api/users/login',
        data=json.dumps(user),
        content_type='application/json'
    )
    data = json.loads(response.data)
    self.assertEqual(400, response.status_code)
```

In the preceding code, in test_login_user_wrong_credentials method, we check for 401 status code in the response as we are supplying wrong credentials, and in test_login_unverified_user() method, we are trying to login with an unverified user which shall throw 400 error.

Next let's test the create_user endpoint and start by creating a test to create a user with correct fields to create a new user.

```
def test_create_user(self):
    user = {
      "username" : "kunalrelan2",
      "password" : "helloworld",
      "email" : "kunal.relan12@hotmail.com"
    }

    response = self.app.post(
        '/api/users/',
        data=json.dumps(user),
        content_type='application/json'
    )
```

```
        data = json.loads(response.data)
        self.assertEqual(201, response.status_code)
        self.assertTrue('success' in data['code'])
```

The preceding code will request the Create user endpoint with a new user object and shall be able to do so and respond with a 201 status code.

Next we'll add another test when username is not supplied to the Create user endpoint, and in this case, we shall get a 422 response. Here is the code for that.

```
    def test_create_user_without_username(self):
        user = {
          "password" : "helloworld",
          "email" : "kunal.relan12@hotmail.com"
        }

        response = self.app.post(
            '/api/users/',
            data=json.dumps(user),
            content_type='application/json'
        )
        data = json.loads(response.data)
        self.assertEqual(422, response.status_code)
```

Now we can move on to testing our confirm email endpoint, and here we'll first create a unit test with valid email, so you noticed we had an unverified user created in create_users() method, and here first we'll generate a validation token since we are not reading the email using the unit tests and then send the token to confirm email endpoint.

```
    def test_confirm_email(self):
        token = generate_verification_token('kunal.relan123@
        gmail.com')
```

```
        response = self.app.get(
            '/api/users/confirm/'+token
        )
        data = json.loads(response.data)
        self.assertEqual(200, response.status_code)
        self.assertTrue('success' in data['code'])
```

Next, we'll write another test with email of an already verified user to test if we get 422 in response status code.

```
    def test_confirm_email_for_verified_user(self):
        token = generate_verification_token('kunal.relan12@
        gmail.com')

        response = self.app.get(
            '/api/users/confirm/'+token
        )
        data = json.loads(response.data)
        self.assertEqual(422, response.status_code)
```

And the last one for this endpoint is we'll supply an incorrect email and should get a 404 response status code.

```
    def test_confirm_email_with_incorrect_email(self):
        token = generate_verification_token('kunal.relan43@
        gmail.com')

        response = self.app.get(
            '/api/users/confirm/'+token
        )
        data = json.loads(response.data)
        self.assertEqual(404, response.status_code)
```

Once we have our tests in place, it's time to test them all, so go ahead and use nosetests and run the tests.

Figure 5-3. *Nosetests on test_users.py*

So these are all the tests we want to cover with user model; next we can move on to authors and books.

Next let's create test_authors.py and we'll add the dependencies with a few changes, so add the following lines to import the required dependencies.

```
import json
from api.utils.test_base import BaseTestCase
from api.models.authors import Author
from api.models.books import Book
from datetime import datetime
from flask_jwt_extended import create_access_token
import unittest2 as unittest
import io
```

Next we'll define two helper methods, namely, create_authors and login, and add the following code for the same.

```
def create_authors():
    author1 = Author(first_name="John", last_name="Doe").create()
    author2 = Author(first_name="Jane", last_name="Doe").create()
```

We'll create two authors for the test using the method defined previously, and login method will generate a login token and return for authorized only routes.

```
def login():
    access_token = create_access_token(identity = 'kunal.relan@
    hotmail.com')
    return access_token
```

Next let's define our test class like we did earlier and initiate it.

```
class TestAuthors(BaseTestCase):
    def setUp(self):
        super(TestAuthors, self).setUp()
        create_authors()

if __name__ == '__main__':
    unittest.main()
```

Now we have the base of our author unit tests, and we can add the following test cases which should be self-explanatory.

Here we'll create a new author using POST author endpoint with the JWT token we generate using login method and expect author object with 201 status code in response.

```
    def test_create_author(self):
        token = login()
        author = {
            'first_name': 'Johny',
            'last_name': 'Doee'
        }
        response = self.app.post(
            '/api/authors/',
            data=json.dumps(author),
            content_type='application/json',
            headers= { 'Authorization': 'Bearer '+token }
        )
```

```
        data = json.loads(response.data)
        self.assertEqual(201, response.status_code)
        self.assertTrue('author' in data)
```

Here we'll try creating an author with authorization header, and it should return 401 in the response status code.

```
    def test_create_author_no_authorization(self):
        author = {
            'first_name': 'Johny',
            'last_name': 'Doee'
        }

        response = self.app.post(
            '/api/authors/',
            data=json.dumps(author),
            content_type='application/json',
        )
        data = json.loads(response.data)
        self.assertEqual(401, response.status_code)
```

In this test case, we'll try creating an author without last_name field, and it should respond back with 422 status code.

```
    def test_create_author_no_name(self):
        token = login()
        author = {
            'first_name': 'Johny'
        }

        response = self.app.post(
            '/api/authors/',
            data=json.dumps(author),
            content_type='application/json',
```

```
            headers= { 'Authorization': 'Bearer '+token }
        )
        data = json.loads(response.data)
        self.assertEqual(422, response.status_code)
```

In this one we'll test upload avatar endpoint and use io to create a temp image file and send it as multipart/form-data to upload the image.

```
    def test_upload_avatar(self):
        token = login()
        response = self.app.post(
            '/api/authors/avatar/2',
           data=dict(avatar=(io.BytesIO(b'test'),
           'test_file.jpg')),
            content_type='multipart/form-data',
            headers= { 'Authorization': 'Bearer '+ token }
        )
        self.assertEqual(200, response.status_code)
```

Here, we'll test the upload avatar by supplying a CSV file instead, and as expected it should not respond with 200 status code.

```
    def test_upload_avatar_with_csv_file(self):
        token = login()
        response = self.app.post(
            '/api/authors/avatar/2',
           data=dict(file=(io.BytesIO(b'test'), 'test_file.csv')),
            content_type='multipart/form-data',
            headers= { 'Authorization': 'Bearer '+ token }
        )
        self.assertEqual(422, response.status_code)
```

In this test, we'll get all the authors using GET all authors endpoint.

```
def test_get_authors(self):
    response = self.app.get(
        '/api/authors/',
        content_type='application/json'
    )
    data = json.loads(response.data)
    self.assertEqual(200, response.status_code)
    self.assertTrue('authors' in data)
```

Here we have a unit test for GET author by ID endpoint, and it'll return 200 response status code and author object.

```
def test_get_author_detail(self):
    response = self.app.get(
        '/api/authors/2',
        content_type='application/json'
        )
    data = json.loads(response.data)
    self.assertEqual(200, response.status_code)
    self.assertTrue('author' in data)
```

In this test we'll update the author object on the recently created author, and it shall also return 200 status code in the response.

```
def test_update_author(self):
    token = login()
    author = {
        'first_name': 'Joseph'
    }
    response = self.app.put(
        '/api/authors/2',
        data=json.dumps(author),
```

```
            content_type='application/json',
            headers= { 'Authorization': 'Bearer '+token }
        )
        self.assertEqual(200, response.status_code)
```

In this test we'll delete author object and expect 204 response status code.

```
    def test_delete_author(self):
        token = login()
        response = self.app.delete(
            '/api/authors/2',
            headers= { 'Authorization': 'Bearer '+token }
        )
        self.assertEqual(204, response.status_code)
```

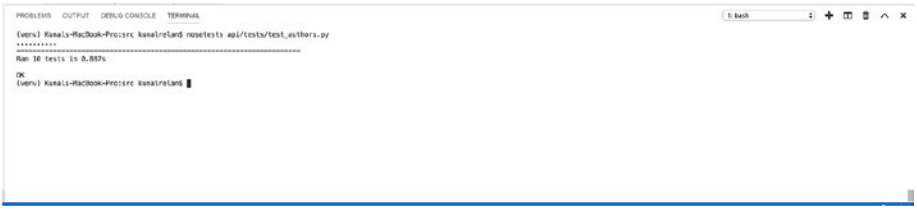

Figure 5-4. *Authors test*

So now you can run authors test like in the previous figure, and it should all pass like in that figure; next we'll move to books model test.

For books model tests, we can modify the author tests and set up unit tests for books in the same module, so let's update create_authors method to create some books as well; just go ahead and update the method with following code.

```
def create_authors():
    author1 = Author(first_name="John", last_name="Doe").
    create()
```

```
Book(title="Test Book 1", year=datetime(1976, 1, 1),
author_id=author1.id).create()
Book(title="Test Book 2", year=datetime(1992, 12, 1),
author_id=author1.id).create()

author2 = Author(first_name="Jane", last_name="Doe").
create()
Book(title="Test Book 3", year=datetime(1986, 1, 3),
author_id=author2.id).create()
Book(title="Test Book 4", year=datetime(1992, 12, 1),
author_id=author2.id).create()
```

And then here are the unit tests for book routes.

```
def test_create_book(self):
    token = login()
    author = {
        'title': 'Alice in wonderland',
        'year': 1982,
        'author_id': 2
    }

    response = self.app.post(
        '/api/books/',
        data=json.dumps(author),
        content_type='application/json',
        headers= { 'Authorization': 'Bearer '+token }
    )
    data = json.loads(response.data)
    self.assertEqual(201, response.status_code)
    self.assertTrue('book' in data)

def test_create_book_no_author(self):
    token = login()
```

```
        author = {
            'title': 'Alice in wonderland',
            'year': 1982
        }

        response = self.app.post(
            '/api/books/',
            data=json.dumps(author),
            content_type='application/json',
            headers= { 'Authorization': 'Bearer '+token }
        )
        data = json.loads(response.data)
        self.assertEqual(422, response.status_code)

    def test_create_book_no_authorization(self):
        author = {
            'title': 'Alice in wonderland',
            'year': 1982,
            'author_id': 2
        }

        response = self.app.post(
            '/api/books/',
            data=json.dumps(author),
            content_type='application/json'
        )
        data = json.loads(response.data)
        self.assertEqual(401, response.status_code)

    def test_get_books(self):
        response = self.app.get(
            '/api/books/',
            content_type='application/json'
        )
```

```
        data = json.loads(response.data)
        self.assertEqual(200, response.status_code)
        self.assertTrue('books' in data)

    def test_get_book_details(self):
        response = self.app.get(
            '/api/books/2',
            content_type='application/json'
            )
        data = json.loads(response.data)
        self.assertEqual(200, response.status_code)
        self.assertTrue('books' in data)

    def test_update_book(self):
        token = login()
        author = {
            'year': 1992,
            'title': 'Alice'
        }
        response = self.app.put(
            '/api/books/2',
            data=json.dumps(author),
            content_type='application/json',
            headers= { 'Authorization': 'Bearer '+token }
        )
        self.assertEqual(200, response.status_code)

    def test_delete_book(self):
        token = login()
        response = self.app.delete(
            '/api/books/2',
```

```
            headers= { 'Authorization': 'Bearer '+token }
        )
        self.assertEqual(204, response.status_code)
```

Test Coverage

So now we have learned to write test cases for our application, and the goal of the unit tests is to test as much code as possible, so we have to make sure every function with all its branches are covered, and the closer you get to 100%, the more comfortable you will be before making changes. Test coverage is an important tool to use in development; however, 100% coverage doesn't guarantee no bugs.

You can install coverage.py using PIP with the following command.

```
(venv)$ pip install coverage
```

Nose library has a built-in plugin that works with coverage module, so to run test coverage, you need to add two more parameters to the terminal while running nosetests.

Use the following command to run nosetests with the test coverage enabled.

```
(venv)$ nosetests  --with-coverage --cover-package=api.routes
```

So here we are enabling coverage using --with-coverage flag and specifying to only cover routes module, or else by default, it will also cover the installed modules.

Figure 5-5. *Test coverage*

As you can see, we have got a significant amount of code test coverage, and you can cover all other edge cases to achieve 100% test coverage.

Next you can also enable --cover-html flag to output information in HTML format which is more readable and presetable.

```
(venv)$ nosetests --with-coverage --cover-package=api.routes
--cover-html
```

The preceding command will generate the HTML format result of test coverage, and now you should see a folder called cover in your working directory; open the folder, and open index.html using your browser to see the test coverage report in HTML.

As you can see in the previous figure, we have got the HTML version of our test coverage report.

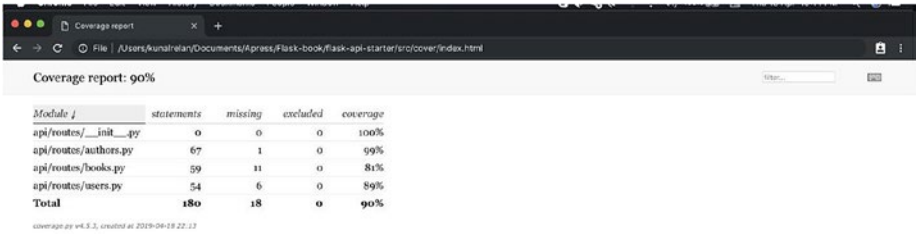

Figure 5-6. *Test coverage report in HTML*

Conclusion

So this is it for this chapter; we have learned the basics of unit testing, implemented test cases for our application, and covered unit tests for all our routes and integrated test coverage using nose testing library. This covers our development journey of this application. In the next chapter, we'll discuss about deployment and deploy our application on various cloud service providers.

CHAPTER 6

Deploying Flask Applications

So until now in this book, we focused entirely on developing the application, and in this chapter, we'll discuss about the next step which is deploying our application and managing the application post deployment which is a very crucial part of application development. In this chapter we'll primarily discuss various ways to deploy a Flask application securely. There can be various ways of deploying a Flask application, and each way has its pros and cons, so we'll weigh them out and discuss their cost effectiveness as well as security and perform ways to deploy our application. As I mentioned earlier, Flask's server is not suitable for production deployment and is only intended for development and debugging, so we'll be looking into various options out there.

In this chapter we'll cover the following topics:

1. Deploying Flask with uWSGI and Nginx on Alibaba Cloud ECS
2. Deploying Flask with Gunicorn on Alibaba Cloud ECS
3. Deploying Flask on Heroku
4. Deploying Flask on AWS Elastic Beanstalk
5. Deploying Flask on Google App Engine

K. Relan, *Building REST APIs with Flask*, https://doi.org/10.1007/978-1-4842-5022-8_6

So in this chapter, we'll entirely focus on deploying our application on all these platforms and discuss the pros and cons of each of them. While they all are great options, it's entirely the business use case and resources which define where we deploy the application.

Deploying Flask with uWSGI and Nginx on Alibaba Cloud ECS

Deploying applications this way is often called traditional hosting where the dependencies are installed manually or through a scripted installer, which involves manually installing the application and its dependencies and securing it. In this section we'll install and run our application in production using uWSGI and Nginx on a Linux OS hosted on Alibaba Cloud Elastic Compute Service.

uWSGI is a full-fledged HTTP server and a protocol capable of running production applications. uWSGI is a popular uwsgi (protocol) server, while Nginx is a free, open source, high-performing HTTP server and a reverse proxy. In our case we'll use Nginx to reverse proxy our HTTP calls to and from the uwsgi server which we'll deploy on Ubuntu OS.

So let's get straight into the business and deploy our application, but before we do that, we have to freeze our libraries in requirements.txt using pip freeze. Run the following commands to make sure the file has the list of all the required dependencies.

```
(venv)$ pip freeze > requirements.txt
```

So here pip freeze will output all the required installed packages in requirements format. Next we need to push our codebase to a version management system like GitHub which we'll pull later on our Linux instance. For this we'll create an Ubuntu instance on Alibaba Cloud for which you can signup at www.alibabacloud.com or you can use your Ubuntu instance on any other cloud provider or even use a virtual one.

So before we start deploying, we also need to have a MySQL server, and since this is about deploying the Flask app, we won't be covering deploying MySQL server. However, you can deploy one on the same instance or use a managed MySQL server service and edit the DB config details in config.py.

Once you have your cloud account setup, create an Ubuntu instance preferably version 16.04 or greater. Here we have Alibaba Cloud ECS (Elastic Compute Service), and once we have our instance, we'll SSH into using keypair or a password.

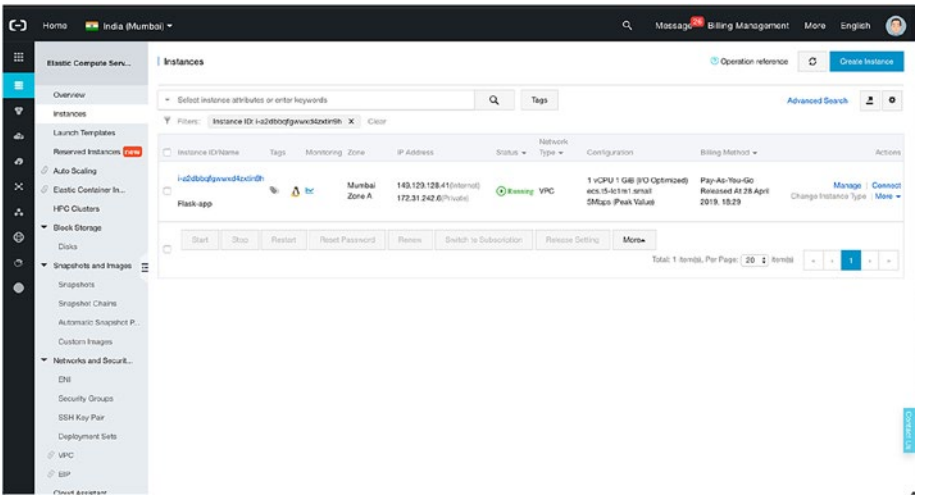

Figure 6-1. *Alibaba Cloud ECS Console*

Once you have your Ubuntu instance up and running, SSH into it and pull the codebase from your preferred version management system.

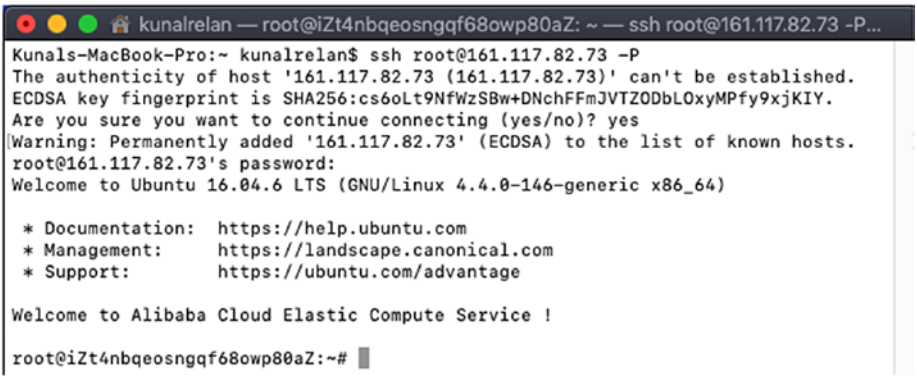

Figure 6-2. *SSH into Ubuntu instance*

As you can see by default, we have logged in as a root, so before moving on, we'll create another sudo user called Flask which is a good security measure. It is a good idea to run each app under its own user account, in order to limit the damage that security vulnerabilities in the app can do.

```
$ adduser flask
```

Next it'll prompt you to set a password for the new user and enter a few details; you can just enter the password and leave other fields empty if you wish to and then run the following command to add the user to sudoers list.

```
$ usermod -aG sudo flask
```

Now once we have our new user, let's login with that user in the shell using the following command.

```
$ su - flask
```

Next we'll pull our app from our GitHub repo, so make sure you have git client installed, and if you don't, use the following command to do so.

```
$ sudo apt-get install git
```

Use the following command to clone the app repository.

```
$ sudo git clone <repo_name>
```

Next change your current directory to the app source code and install virtualenv and uwsgi since we won't have those in our reqiurements.txt.

```
$ sudo pip install virtualenv uwsgi
```

Create a virtual env like we did in the previous chapter, and install the dependencies after activating the virtual environment with the following command.

```
$ pip install -r requirements.txt
```

We'll install all the dependencies needed to set up the application from Ubuntu repositories, and we'll start with installing python-pip which is a package manager for Python and python-dev which contains the header files needed to compile Python extensions.

```
$ sudo apt-get install python-pip python-dev
```

Once we have our dependencies installed, we'll create a uWSGI configuration file which will be called flask-app.ini, so go ahead and create a file called flask-app.ini in your current directory and add the following lines to it.

```
[uwsgi]
module = run:application

master = true
processes = 5

socket = flask-app.sock
chmod-socket = 660
vacuum = true

die-on-term = true
```

This file starts with [uwsgi] header so that WSGI knows to apply the settings. We also specify the module and the callable which is run.py in our case minus the extension and the callable which is application.

Then we instruct uwsgi to start the process as a master and spawn five worker processes to handle the requests.

Next we'll supply the Unix socket file for Nginx to follow the uWSGI requests for our application. Let's also change the permissions on the socket. We'll be giving the Nginx group ownership of the uWSGI process later on, so we need to make sure the group owner of the socket can read information from it and write to it. We will also clean up the socket when the process stops by adding the vacuum option.

The last thing we'll do is set the die-on-term option. This can help ensure that the init system and uWSGI have the same assumptions about what each process signal means.

Next, we'll create a systemd service unit file which will allow Ubuntu's init system to start our application automatically whenever the server boots.

```
This file will be called flask-app.service and will be placed
in /etc/systemd/system
Directory.
$ sudo nano /etc/systemd/system/flask-app.service
```

And paste the following lines in the file.

```
#Metadata and dependencies section
[Unit]
Description=Flask App service
After=network.target
#Define users and app working directory
[Service]
User=flask
Group=www-data
```

```
WorkingDirectory=/home/flask/flask-api-app/src
Environment="WORK_ENV=PROD"
ExecStart=/home/flask/flask-api-app/src/venv/bin/uwsgi --ini
flask-app.ini
#Link the service to start on multi-user system up
[Install]
WantedBy=multi-user.target
```

After this run the following command to enable and start our new service.

```
$ sudo systemctl start flask-app
$ sudo systemctl enable flask-app
```

Our uWSGI server should now be up and running waiting for requests in the socket file we made earlier. We'll now install and configure Nginx to pass and process the requests using the uwsgi protocol.

```
$ sudo apt-get install nginx
```

Now we should have an Nginx server up and running, and we'll begin by creating a new server block config file in /etc/nginx/sites-available , and we'll call it flask-app.

```
$ sudo nano /etc/nginx/sites-available/flask-app
```

We'll open a server block and instruct it to listen on port 80 and define the server name which should be the domain name of your service. Going ahead we'll define a location block inside the server block to define the base location and import uwsgi_params headers inside that specifies some general uWSGI parameters that need to be set. We'll then pass the requests to the socket we defined using the uwsgi_pass directive.

```
server {
    listen 80;
```

```
    server_name flaskapp;

    location / {
        include uwsgi_params;
        uwsgi_pass unix:/home/flask/flask-api-app/src/flask-
        app.sock;
    }
}
```

The preceding lines should configure our server block to listen to server requests on the socket. Once we have that all ready, next we'll create a symlink to sites-enabled directory.

```
$ sudo ln -s /etc/nginx/sites-available/flask-app /etc/nginx/
sites-enabled
```

With that in place, we can now test our changes for syntax errors using the following command.

```
$ sudo nginx -t
```

If there were no syntax errors, you should see this printed in your terminal.

```
$ nginx: the configuration file /etc/nginx/nginx.conf syntax is
ok
$ nginx: configuration file /etc/nginx/nginx.conf test is
successful
```

And now when you access your domain, it should be working. In case you don't have a domain and want to access the application, you should either edit the default server block in sites-enabled rather than creating a new one, or delete the default app and you can just access the application with the IP address.

Also make sure if you are running the Ubuntu server on a cloud service, port 80 is allowed on the firewall, and in our case, it's set using the security group.

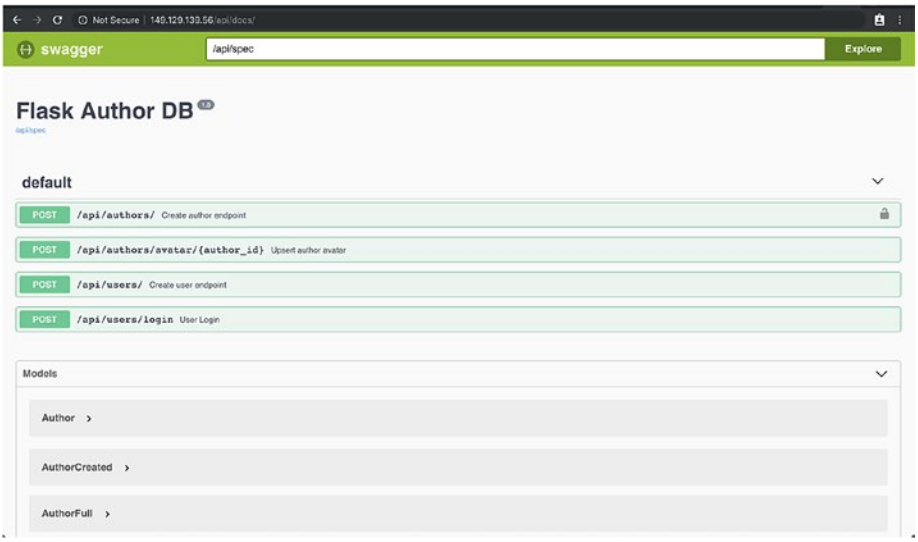

Figure 6-3. *Deployed application*

Deploying Flask on Gunicorn with Apache on Alibaba Cloud ECS

Now we'll install our Flask application using Gunicorn which is a Python WSGI HTTP server for Unix which will run our application, and then we'll reverse proxy the requests using Apache server.

To follow this section, you'll need the following:

1. Ubuntu server with a non-root user with sudo privileges
2. Apache server installed
3. A copy of our Flask app in home directory

As I mentioned, we'll use Gunicorn to run our application, so let's install Gunicorn using PIP.

```
$ pip install gunicorn
```

Next we'll create a system service just like we did in the earlier section, so go ahead and create our new service with the following command.

```
$ sudo nano /etc/systemd/system/flask-app.service
```

Next add the following lines in your nano editor.

```
[Unit]
Description= Flask App service
After=network.target

[Service]
User=flask
Group=www-data
Restart=on-failure
Environment="WORK_ENV=PROD"
WorkingDirectory=/home/flask/flask-api-app/src
ExecStart=/home/flask/flask-api-app/src/venv/bin/gunicorn -c
/home/flask/flask-api-app/src/gunicorn.conf -b 0.0.0.0:5000
wsgi:application

[Install]
WantedBy=multi-user.target
```

Now save the file and exit, and we should have our system service. Next we'll enable and start our service using the following command.

```
$ sudo systemctl start flask-app
$ sudo systemctl enable flask-app
```

So now our app should be running on Port 5000; next we need to configure Apache to reverse proxy our application.

By default reverse proxy module is disabled in Apache, and to enable it enter the following command.

```
$ a2enmod
```

And it will prompt for modules to activate; enter the following modules to be activated:

```
$ proxy proxy_ajp proxy_http rewrite deflate headers proxy_
balancer proxy_connect proxy_html
```

Now add our application to Apache web server config file. Add the following lines (inside VirtualHost block) to /etc/apache2/sites-available/000-default.conf

```
    <Proxy *>
        Order deny,allow
        Allow from all
    </Proxy>
    ProxyPreserveHost On
    <Location "/">
          ProxyPass "http://127.0.0.1:5000/"
          ProxyPassReverse "http://127.0.0.1:5000/"
    </Location>
```

Now it should be proxying our app on root route, and your final server block should look like this.

```
<VirtualHost *:80>
    # The ServerName directive sets the request scheme,
      hostname and port that
    # the server uses to identify itself. This is used when
      creating
    # redirection URLs. In the context of virtual hosts, the
      ServerName
```

```
    # specifies what hostname must appear in the request's
      Host: header to
    # match this virtual host. For the default virtual host
      (this file) this
    # value is not decisive as it is used as a last resort host
      regardless.
    # However, you must set it for any further virtual host
      explicitly.
    #ServerName www.example.com

    ServerAdmin webmaster@localhost
    DocumentRoot /var/www/html

    # Available loglevels: trace8, ..., trace1, debug, info,
      notice, warn,
    # error, crit, alert, emerg.
    # It is also possible to configure the loglevel for particular
    # modules, e.g.
    #LogLevel info ssl:warn

    ErrorLog ${APACHE_LOG_DIR}/error.log
    CustomLog ${APACHE_LOG_DIR}/access.log combined
     <Proxy *>
        Order deny,allow
        Allow from all
    </Proxy>
    ProxyPreserveHost On
    <Location "/">
          ProxyPass "http://127.0.0.1:5000/"
          ProxyPassReverse "http://127.0.0.1:5000/"
    </Location>
    # For most configuration files from conf-available/, which are
    # enabled or disabled at a global level, it is possible to
```

```
    # include a line for only one particular virtual host. For
      example the
    # following line enables the CGI configuration for this
      host only
    # after it has been globally disabled with "a2disconf".
    #Include conf-available/serve-cgi-bin.conf
</VirtualHost>

# vim: syntax=apache ts=4 sw=4 sts=4 sr noet
```

Save the file and exit, and we have covered it all. Just restart the server with the following command.

```
$ sudo service apache2 restart
```

Now visit the application in your browser using the IP address.

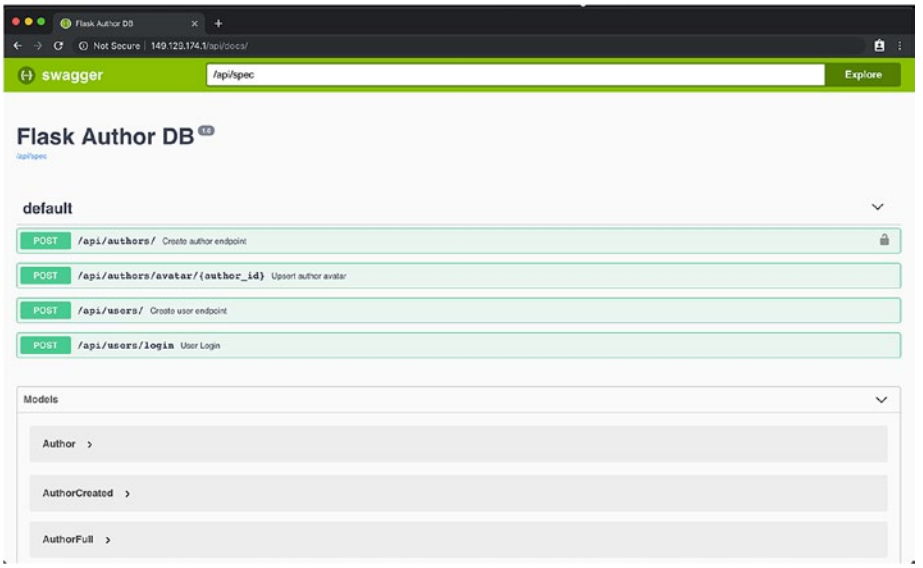

Figure 6-4. *Deployed Flask app on Gunicorn*

Deploying Flask on AWS Elastic Beanstalk

In this section we'll deploy our Flask application using AWS Elastic Beanstalk. AWS Elastic Beanstalk is an easy-to-use service for deploying and scaling web applications and services.

We'll assume that you already have an active AWS account and AWS CLI setup in your development machine or else you can use AWS docs on that.

To create the application environment and deploy the application, initialize your EB CLI repository with the eb init command.

```
$ eb init -p python-2.7 flask-app --region <your_region>
```

Note For the list of regions, refer to this guide: https://docs.aws.amazon.com/general/latest/gr/rande.html

---

You should see the following response in your terminal.

```
$ Application flask-app has been created.
```

The preceding command creates a new application named flask-app and configures your local repository to create environments with the latest Python 2.7.

Next run eb init again to configure a keypair for SSH login.

Next we'll create an environment and deploy your application to it with eb create.

```
$ eb create
```

Next enter the environment name, DNS prefix, and load balancer type which will eliminate the need to expose the web server to the world.

Figure 6-5. *eb create*

Now it shall take around 5 minutes to be deployed. Once it is deployed, we just need to configure a few more details, which we'll directly do in the AWS web console.

Figure 6-6. *eb create success*

Once the application finishes deploying, you should see a similar output like in the preceding figure. Next log on to the AWS web console, and open Elastic Beanstalk Configuration tab.

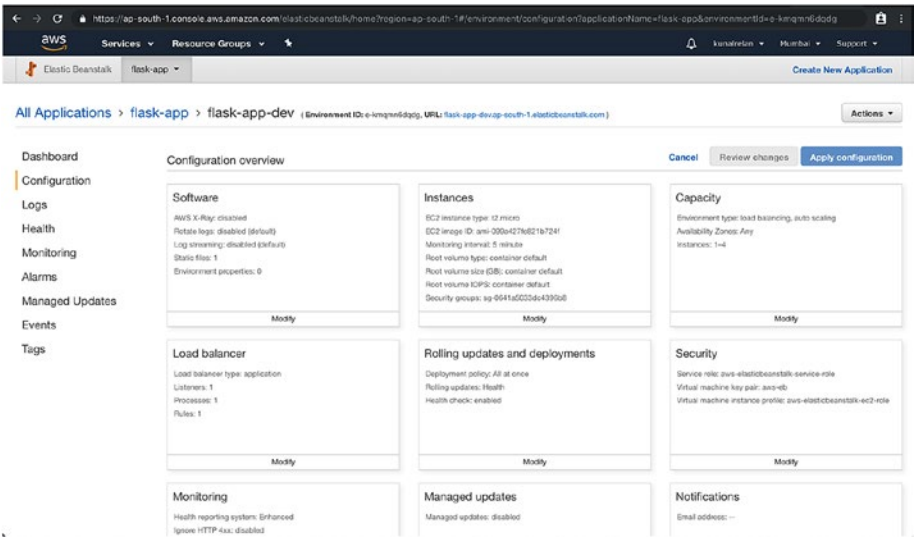

Figure 6-7. *Elastic Beanstalk Application Configuration*

Next click on modify; on the software tab and inside container options, update the WSGIPath to run.py.

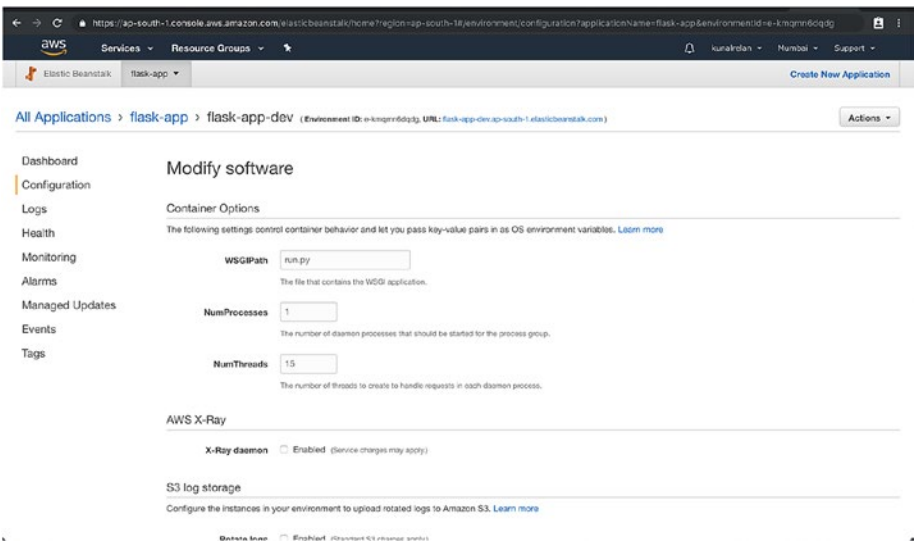

Figure 6-8. *WSGIpath set*

Now scroll down, and in environment variable, supply WORK_ENV and set it to Prod so that our application runs in production mode. Next click on apply and the application should reload and start working.

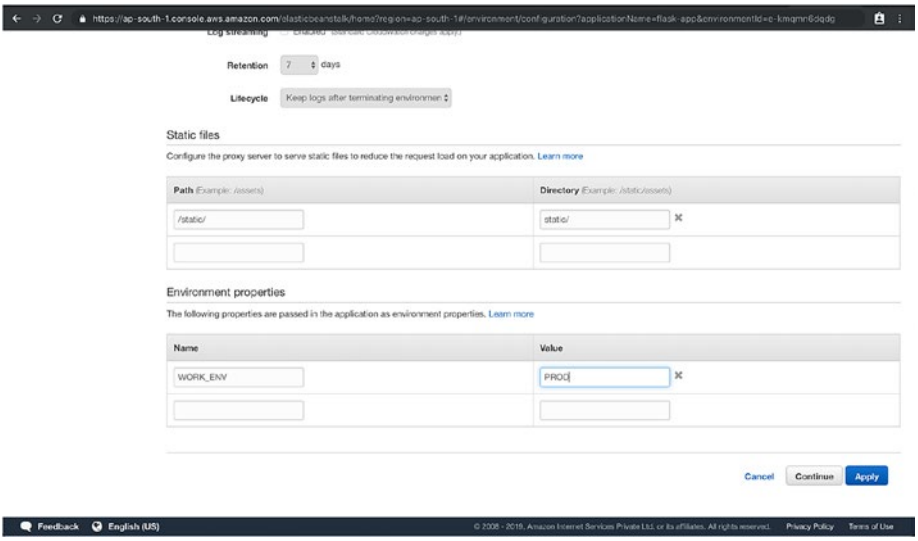

Figure 6-9. *Elastic Beanstalk Environment variables*

Now you can go back to dashboard to find the URL of the application, and it should be up and running.

Note In Elastic Beanstalk you can also configure and start a MySQL RDS server attached to the environment to run with the application, but it is out of the scope of this book.

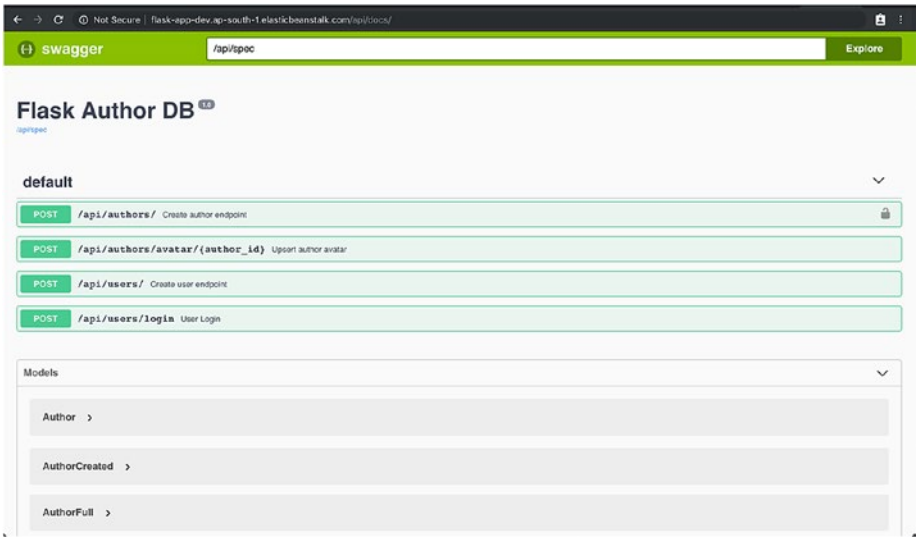

Figure 6-10. *Deployed Flask app on Elastic Beanstalk*

Deploying Flask App on Heroku

Heroku is a Platform as a Service (PaaS) which supports a variety of modern applications providing a container-based environment for deploying and managing apps at scale in the cloud. Deploying applications on Heroku is quite straightforward and instant. You can either use Heroku git, connect with your current GitHub account, or use container registry. Here we'll deploy our application using Heroku CLI; hence make sure you have a working Heroku account at `https://signup.heroku.com/` which lets you deploy up to five applications for free.

You'll also need Heroku CLI which is available to download at `https://devcenter.heroku.com/articles/heroku-command-line`. Once you have the CLI, login to Heroku CLI using the following command which will then prompt you to provide your login credentials.

```
$ heroku login
```

Adding a Procfile

In order for us to successfully deploy our application on Heroku, we'll have to add Procfile to that application which defines the command to be executed for the application to run.

With Heroku we'll use a web server called Gunicorn, so before we create Procfile, install Gunicorn using the following command.

```
(venv)$ pip install gunicorn
```

Now update your requirements.txt file using pip freeze command.

```
(venv)$ pip freeze > requirements.txt
```

Now let's first test if Gunicorn is working fine with our application; run the following command to locally start a Gunicorn server.

```
(venv)$ gunicorn run:application
```

Upon running, you should get the following output on your terminal which implies that the server is working fine.

```
[2019-04-29 22:54:41 +0530] [37191] [INFO] Starting gunicorn
19.9.0
[2019-04-29 22:54:41 +0530] [37191] [INFO] Listening at:
http://127.0.0.1:8000 (37191)
[2019-04-29 22:54:41 +0530] [37191] [INFO] Using worker: sync
[2019-04-29 22:54:41 +0530] [37194] [INFO] Booting worker with
pid: 37194
```

Note By default Gunicorn starts on Port 8000.

So next, create a file called Procfile inside src directory and add the following line in it.

```
web: gunicorn run:application
```

Here Web is specified for Heroku to start a web server for the application. Now there is just one more thing needed before we create and deploy our application on Heroku. Since Heroku by default uses Python 3.6 runtime, we'll have to create another file called runtime.txt and add the following line so that Heroku uses the right Python version for our application.

```
python-2.7.16
```

Now we are ready to deploy our application; in src directory of your application, run the following command to create a new Heroku app.

```
$ heroku create <app_name>
```

It should take a few seconds and you shall see a similar output in your terminal.

```
Creating flask-app-2019... done
https://flask-app-2019.herokuapp.com/ | https://git.heroku.com/
flask-app-2019.git
```

Next initialize a new Heroku git repo with the following command.

```
$ git init
$ heroku git:remote -a flask-app-2019
```

Now add all the files and commit the code with the following command.

```
$ git add .
$ git commiti -m "init"
```

Before pushing and deploying the code, one last thing we need to do is set the WORK_ENV environment variable, so use the following command to do so.

```
$ heroku config:set WORK_ENV=PROD
```

Next we need to push the code to Heroku git and it'll be automatically deployed.

```
$ git push heroku master
```

In a few minutes, your application should be deployed and running. The URL of your application is `htttps://<app_name>.herokuapp.com`

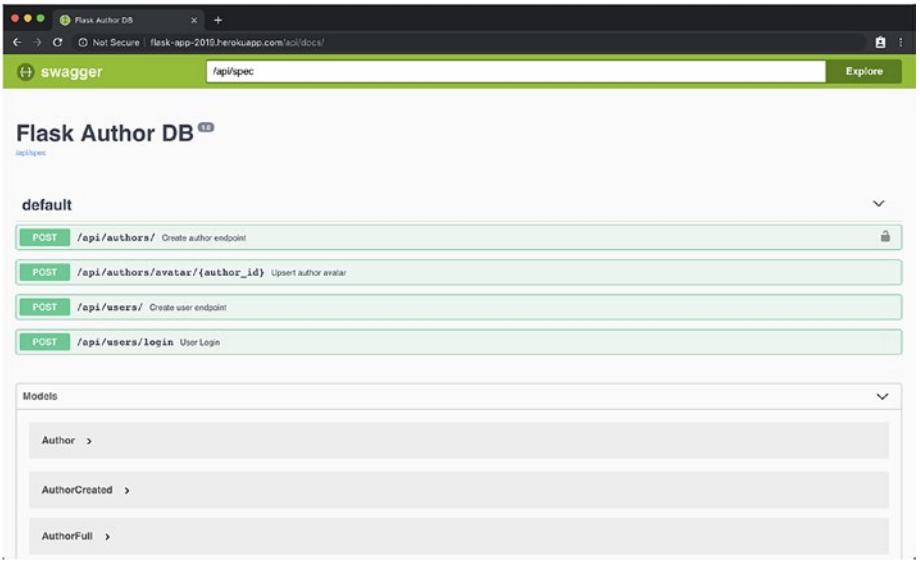

Figure 6-11. *Flask App on Heroku*

So this was it for deploying our application on Heroku; you can learn more about Heroku on https://devcenter.heroku.com

Deploying Flask App on Google App Engine

In this section, we'll deploy our application on Google Cloud App Engine, which is a fully managed serverless platform for deploying and scaling applications on the cloud. App Engine supports a variety of platforms including Python and provides a fully managed service for deploying backend services. So before we start, make sure you have an active Google Cloud Account or you can signup at https://cloud.google.com/products/search/apply/. Google Cloud provides $300 credits for a year as well.

Next install Google Cloud CLI using the following guide: https://cloud.google.com/sdk/docs/quickstarts. Once it's setup run the following command to login to your Google Cloud Account.

```
$ gcloud auth login
```

Once successful, we can start creating our Google App Engine application, but before we do that, we need to create a couple of config files.

First create app.yaml in src directory with the following code to configure the app basics for Google App Engine.

```
runtime: python27
api_version: 1
threadsafe: true
handlers:
- url: /avatar
  static_dir: images
- url: /.*
  script: wsgi.application

libraries:
  - name: ssl
    version: latest
env_variables:
  WORK_ENV: PROD
```

Next create appengine_config.py which will get the installed modules from our virtual environment for the app engine to know where the third-party modules are installed.

```
from google.appengine.ext import vendor

vendor.add('venv/lib/python2.7/site-packages/')
```

Now we are ready to initialize our app; run the following command for the same:

```
$ gcloud init
```

which will prompt you to create the application, name, and project and select the region, so enter appropriately.

Once done, run the following command to deploy your application on Google Cloud App Engine.

Within a couple of minutes, it should be deployed and running. Now you can run the following command in your terminal to open the application in your default browser.

```
$ gcloud app browse
```

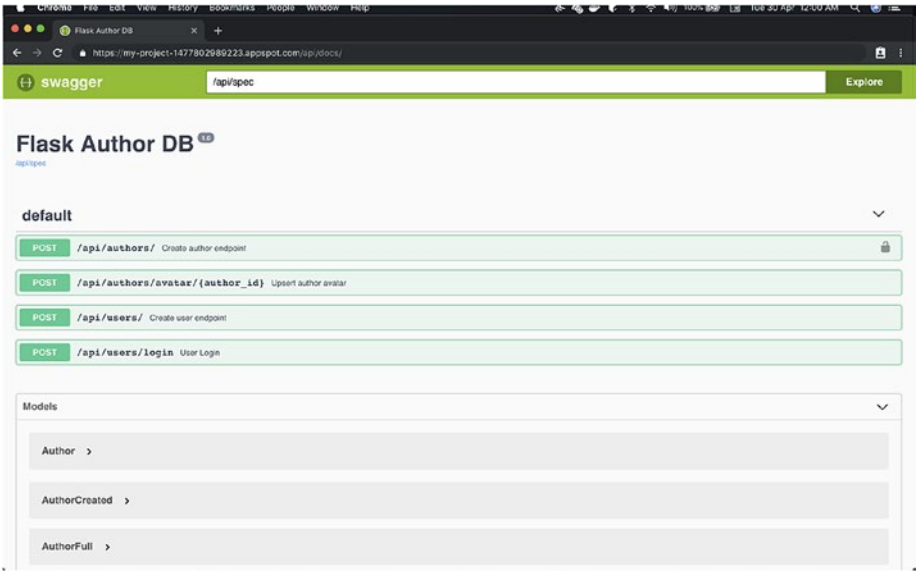

Figure 6-12. *Flask App on Google Cloud App Engine*

Conclusion

So in this chapter, we deployed our application on various cloud platforms using different methodologies, which should have given you a primer, or various deployment and scaling options for deploying your Flask applications. In the next chapter, we'll discuss about post-deployment steps for managing and debugging your deployed application.

CHAPTER 7

Monitoring Flask Applications

Up until now, we have covered developing, testing, and deploying our flask application. In this chapter, we'll discuss about some add-ons to manage and support your Flask application and steps forward from here.

Application Monitoring

Even after performing various kinds of tests on our application, in real world there are always some exceptional scenarios and bottlenecks which we are unaware of while development, and they shoot up as bugs and errors in production, as people start using the application. That's when we need application monitoring which monitors the behavior of your application in production including downtime check, endpoint errors, crashes, exceptions, and performance-related issues. Monitoring is crucial for applications, since raw log files are hard to interpret, and they get bulky overtime for developers to make sense of. Log files can detect functional errors most of the time, but it doesn't tell much about the performance-related issues which is also crucial to your application since the business is dependent upon the application being able to serve its customers in a timely fashion. Thus proactive application monitoring is critical to deal with stability, performance, and errors in your application.

K. Relan, *Building REST APIs with Flask*, https://doi.org/10.1007/978-1-4842-5022-8_7

All major Cloud service providers support features for monitoring virtual machines. We deploy our application on, for CPU utilization, memory utilization and network on the operating system level. However, application monitoring usually encompasses the following things:

1. Application errors and warnings
2. Application performance of every transaction
3. Database and third-party integration querying performance
4. Basic server monitoring and metrics
5. Application log data

There are a lot of great application monitoring tools in the market, and here in this chapter, we'll cover integrating a few of them as they all come with different sets of features, payment options, and so on.

Here is a list of few open-source monitoring projects:

1. Sentry
2. Sensu
3. Service canary
4. Flask monitoring dashboard

There are a couple of monitoring services available in the market as well like New Relic, Sentry.io, Scout, and so on which takes the burden of deploying the monitoring software away but comes at a price. We'll examine the types of application monitoring tools.

Sentry

Sentry is an open source application monitoring system developed in Python but is available for all major platforms. Sentry also has a Cloud-hosted service which has different subscription models ranging from a free version for developers to business versions which costs around $80 per month. In this we'll be checking out the free version and integrate it with ours which is pretty straightforward.

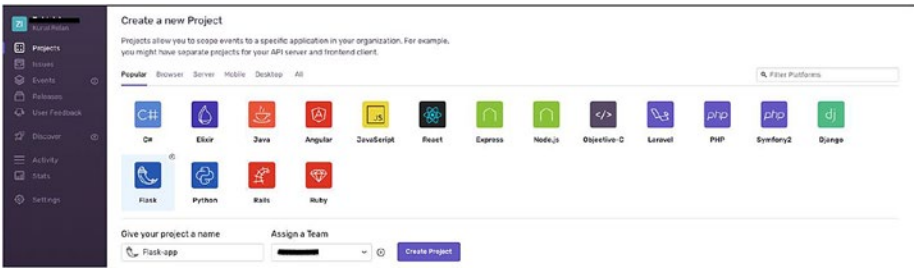

Figure 7-1. *Create new project*

To begin with, signup for sentry on https://sentry.io/signup/, and once you have successfully signed up, login to your dashboard. Once done, click add project button and select Flask as the framework, input the name, and submit on create project.

Once done, it will take us to the next page which has integration details, so just install the sentry SDK using PIP with the given command and copy paste the integration code in your main.py.

```
(venv)$pip install sentry-sdk[flask]
```

Next add the following code before app = Flask(__name__).

```
sentry_sdk.init(
    dsn="<your_dsn_here>"
    integrations=[FlaskIntegration()]
)
```

Once done, you can deploy the application and sentry will take care of the rest. Let's test it out by hitting a 404 endpoint making an event in sentry dashboard.

In your browser, request any endpoint which doesn't exist, and sentry SDK will fire off an event from the application like in the following screenshot.

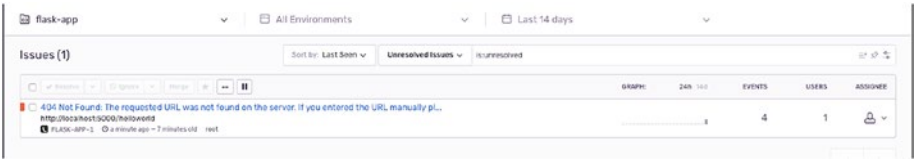

Figure 7-2. *Sentry issues listing*

Clicking on the issue will give you insights into the issue and details to help you resolve the issue like in the following screenshot.

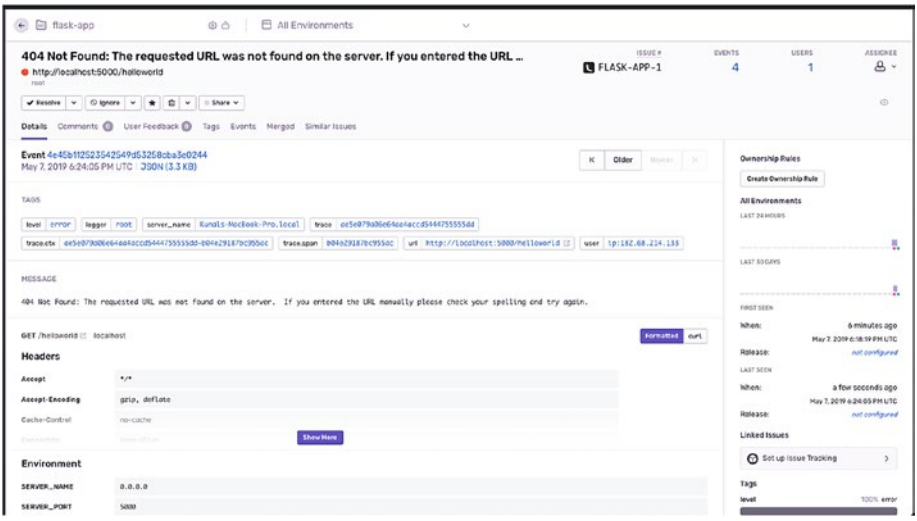

Figure 7-3. *Sentry issue details*

Sentry has a lot more features for you to explore and helo your application stable and error free.

Flask Monitoring Dashboard

Flask Monitoring Dashboard is an extension for Flask applications. It outrightly monitors the application performance and utilization, profiles the requests, and can also be configured to run specific jobs to manage your application. It is open source and free, so let's get started on it.

Install Flask Monitoring Dashboard using PIP with the following code.

```
(venv)$pip install flask_monitoringdashboard
```

Next in your main.py file, import the extension using the following code, where we have other library imports.

```
import flask_monitoringdashboard as dashboard
```

Now right below where we have initiated our app object, add the following code.

```
dashboard.bind(app)
```

And that's pretty much it; now restart your application and visit http://<host>:<port>/dashboard, and it will open the login page. The default credentials are admin and admin which you should change right after.

Figure 7-4. *Flask Monitoring Dashboard*

Once you login, you'll be redirected to the dashboard which will have an overview of your endpoints, and you can click each of them to get a deeper insight and can also set the monitoring level for each one of them as per your preferences.

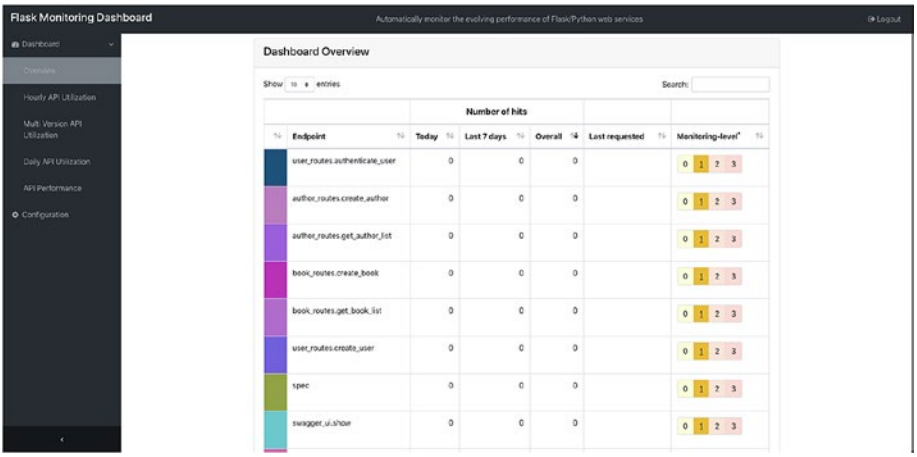

Figure 7-5. *Flask Monitoring Dashboard overview*

Clicking upon endpoints will redirect you to the insights page for each endpoint where you can churn out graph data for each requests and get more in-depth information about the endpoint usage.

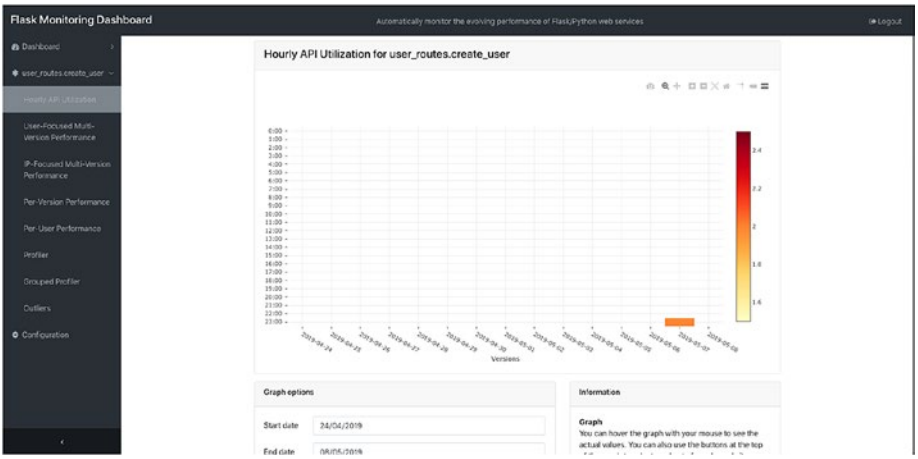

Figure 7-6. *API utilization insights*

New Relic

New Relic is one of the most reliable and competitive application monitoring tools in the market; they provide a comprehensive database with real-time monitoring services. New Relic is a paid subscription-based service, but they have a 14-day trial which we'll use to check it out. So go ahead and sign up for the same on `https://newrelic.com/signup`

Once you sign up, you'll be asked to choose the platform; go ahead and select Python as the platform.

Figure 7-7. *New Relic setup*

In your application directory, go ahead and install the New Relic agent using the following command.

```
(venv)$ pip install newrelic
```

Next we need to generate the configuration using our New Relic key, so click Reveal license key button on the screen which will display your private key.

Now execute the following command with your key.

```
(venv)$ newrelic-admin generate-config <your-key-goes-here>
newrelic.ini
```

So now our application should be configured; next use the following command to run your application and test the configuration.

```
(venv)$ NEW_RELIC_CONFIG_FILE=newrelic.ini newrelic-admin run-
program python run.py
```

Once you do, click Listen for my application button like in the following screenshot, which will start listening to requests from your application to configure your dashboard, and once it successfully receives the data, you'll see a button to redirect to your New Relic dashboard.

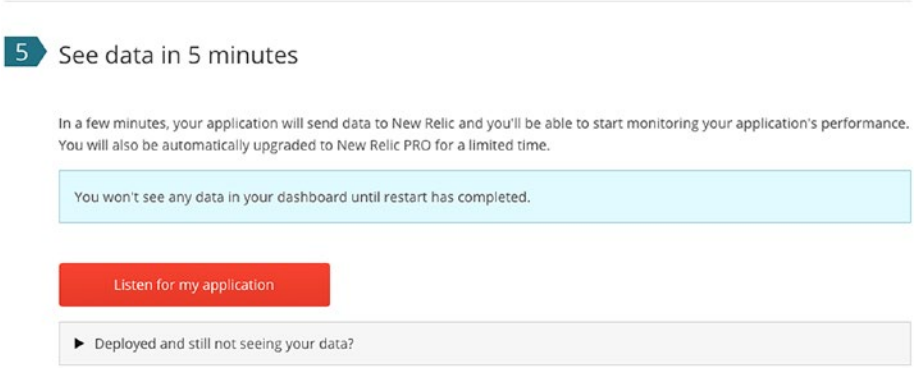

Figure 7-8. *New Relic Listen for application*

Now you'll see the application dashboard which lists your applications; click Python Application since we only have one application here.

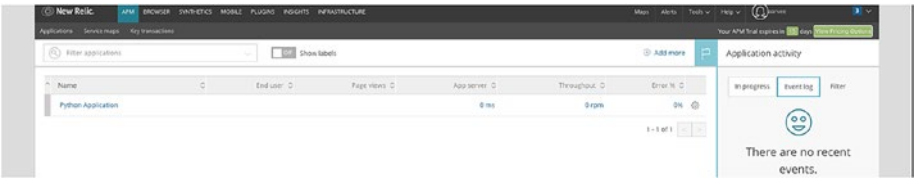

Figure 7-9. *New Relic Application dashboard*

After clicking, you'll be redirected to your application dashboard which looks quite comprehensive but provides a lot of insights about the application state. Refer to the following screenshot as an example.

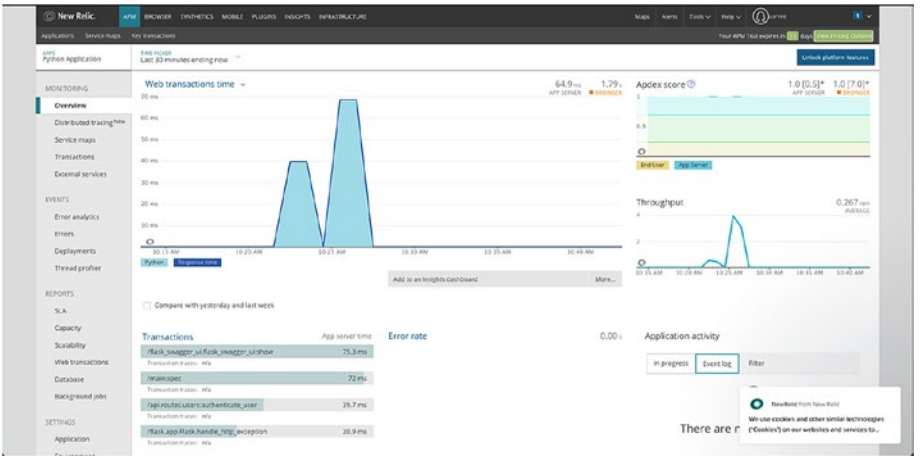

Figure 7-10. *Python Application dashboard*

As you can see, we can check out the latest transactions and check out the transaction time graph, and then we have throughput graph and apdex score which scores the application on the basis of a set value of 0.5 seconds response time. Under events, you can check out error analytics and errors which provide an in-depth details of errors raised in the system.

You can learn more about New Relic in their official documentation at https://docs.newrelic.com/docs/apm/new-relic-apm/guides.

Bonus Services

So we have covered all the topics to get you started with developing REST applications using Flask. However, this is just a beginner's guide, and there are a lot more things to cover for real business use cases including integrating third-party services like search, caching, pub-sub, real-time communication, and so on. This book covers the basics of Flask REST API development which can be used as a base to build your REST applications. In this module we'll cover the basics of some additional libraries and tools that could add value to your application.

Full Text Search with Flask

Flask is compatible with a couple of libraries that provide integration with full text search applications like Elasticsearch.

Pyelasticsearch

Pyelasticsearch is a clean library to integrate Elasticsearch which is a very popular and powerful search engine in your flask application. However, Elasticsearch provides REST endpoints to connect with the search engine, but pyelasticsearch makes it easier to communicate with the endpoints. You can learn more about pyelasticsearch at https://pyelasticsearch.readthedocs.io and check this link out to understand more about elasticsearch www.elastic.co/guide/en/elasticsearch/reference/current/getting-started.html

Flask-WhooshAlchemy

Whoosh is a fast, search engine library built in Python and is highly flexible and supports complex data searching based on free-form or structured text. Flask-WhooshAlchemy is a Flask extension to integrate the Whoosh search engine library with SQLAlchemy in Flask. It's pretty straightforward to integrate and get your full text search up without any third-party application unlike pyelasticsearch. You can learn more about it at https://pythonhosted.org/Flask-WhooshAlchemy/

Email

We used Flask mail for verifying user emails. Here is a list of other libraries you can use for efficient email integration in your application.

Flask-SendGrid

Flask-SendGrid is a Flask extension to simplify sending email using sendgrid which is a renowned email service; you can sign up for SendGrid at https://sendgrid.com/; they provide a free subscription which includes 40,000 emails for first 30 days and 100/day forever. You can check out Flask-SendGrid at https://github.com/frankv/flask-sendgrid which makes sending email a piece of cake.

AWS SNS Using Boto3

Boto3 is an AWS SDK for Python, and you can use AWS' SNS (Simple Notification Service) to send email and text message using Boto. Here is a guide to sending email using Python with Boto https://docs.aws.amazon.com/ses/latest/DeveloperGuide/send-using-sdk-python.html. You'll need an active AWS account for this and Boto installed from https://boto3.readthedocs.io/en/latest/guide/quickstart.html#installation.

File Storage

File storage is an important aspect of an application; we stored user avatars in an application server file system which is not a good approach for production applications, and in such cases you'd like to store and access your files using a file storage service. Here are a handful of suggestions for the same.

AWS S3 Using Boto3

You can leverage Boto3 to manage your files on Amazon AWS S3, which is a powerful file management system. This guide will provide you with everything you need to manage your files using Flask https://boto3.amazonaws.com/v1/documentation/api/latest/reference/services/s3.html

Alibaba Cloud OSS

Alibaba Cloud provides a sophisticated file storage platform called Object Storage Service; you can use their Python SDK from https://github.com/aliyun/aliyun-oss-python-sdk and easily setup file management using their OSS guide which is available at https://help.aliyun.com/document_detail/32026.html

Conclusion

This marks the end of this chapter and the book. There is a lot more to explore in optimizing and upgrading your application, but this will serve as the right base to grow from; if you have issues in integrating any of the mentioned services, check out their official docs, reach out to support, or reach out on Stack Overflow to solve them. You can also use this link to ask or read queries regarding Flask https://stackoverflow.com/search?q=flask.

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K. Relan, *Building REST APIs with Flask*, https://doi.org/10.1007/978-1-4842-5022-8

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