3RD EDITION

Flask Framework Cookbook

Enhance your Flask skills with advanced techniques and build dynamic, responsive web applications

SHALABH AGGARWAL

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Third Edition

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Shalabh Aggarwal

BIRMINGHAM—MUMBAI

Flask Framework Cookbook

Third Edition

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To my late father, Videsh, who will always be there in my thoughts for the love and encouragement he gave me to explore new things in life.

– Shalabh Aggarwal

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Shalabh Aggarwal is a seasoned engineering leader who develops and manages enterprise systems and web and mobile applications for small- and large-scale organizations. He started his career working with Python, and although he now works on multiple technologies, he remains a Python developer at heart. He is passionate about open source technologies and writes highly readable and high-quality code. Throughout his career, he has built software products and engineering teams for companies moving from 0 to 1, 1 to 10, and 10 to 100 levels.

He is also active in voluntary training for engineering students and young engineers on non-conventional and open source topics. When not working with full-time assignments, he consults for start-ups on starting or scaling up while leveraging different technologies. When not writing code, he dedicates his time to his young kid and occasional travels.

I would like to thank my family, my wife, and my mother for putting up with me during my long writing and research sessions. Special thanks to my three-year-old son, Krishiv, for it was his time that was sacrificed the most. Thanks also to the Pocoo and Pallets teams, Armin Ronacher, and the complete Flask community for developing and maintaining the framework that made this series of books possible.

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Thank you, Packt Publishing, for giving me the opportunity to do the technical review for this book. A special thanks to the editorial team and coordinator for their constant support and patience. I would also like to thank my family, who have been my unwavering source of support and motivation. Finally, I would like to acknowledge the author of this book for his dedication and hard work. His expertise and passion for the subject matter are evident in every chapter, and it has been an honor to work with him..

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Preface

Flask, the lightweight Python web framework, is popular due to its powerful modular design that lets you build scalable web apps. With this recipe-based guide, you'll explore modern solutions and the best practices to build web applications using Flask.

Updated to the latest version of Flask 2.2.x and Python 3.11.x, this third edition of *Flask Framework Cookbook* moves away from some of the old and obsolete libraries and introduces recipes on bleeding-edge technologies. You'll discover different ways of using Flask to create, deploy, and manage microservices.

This book takes you through a number of recipes that will help you understand the power of Flask and its extensions. You will start by exploring the different configurations that a Flask application can make use of. From here, you will learn how to work with templates, before learning about the ORM and view layers, which act as the foundation of web applications. Then, you will learn how to write RESTful APIs with Flask, after learning various authentication techniques.

As you move ahead, you will learn how to write an admin interface, followed by debugging and logging errors in Flask. You will also learn how to make your applications multilingual and gain insight into the various testing techniques. You will learn about the different deployment and post-deployment techniques on platforms such as Apache, Tornado, NGINX, Gunicorn, Sentry, New Relic, and Datadog. Finally, you will learn about popular microservices tools, such as Docker, Kubernetes, Google Cloud Run, and GitHub Actions, that can be used to build highly scalable services.

A new chapter has been added on the latest technology that is making waves nowadays – that is, GPT. Here, you will learn about some simple and basic yet powerful implementations of GPT to build automated text completion fields, chatbots, and AI-powered image generations. Before you complete the book, you will learn about some additional tips and tricks that will be helpful to handle specific use cases, such as full-text searching, caching, email, and asynchronous operations.

By the end of this book, you will have all the information required to make the best use of this incredible microframework, writing small and big applications and scaling them with industry-standard practices.

Who this book is for

If you are a web developer who wants to learn more about developing scalable and production-ready applications in Flask, this is the book for you. You'll also find this book useful even if you are already aware of Flask's major extensions and want to use them for better application development. This book can also come in handy if you quickly want to refer to any specific topic on Flask, any of its popular extensions, or some specific use cases. Basic Python programming experience along with some understanding of web development and its related terminology is assumed.

What this book covers

Chapter 1, *Flask Configurations*, explains the different ways in which Flask can be configured to suit the various needs of any project. It starts by telling us how to set up a development environment and moves on to the different configuration techniques.

Chapter 2, *Templating with Jinja*, covers the basics of Jinja2 templating from the perspective of Flask and explains how to make applications with modular and extensible templates.

Chapter 3, *Data Modeling in Flask*, deals with one of the most important parts of any application – that is, its interaction with database systems. We will see how Flask can connect to different database systems, define models, and query databases to retrieve and feed data.

Chapter 4, *Working with Views*, deals with the core of web frameworks. It talks about how to interact with web requests and the proper responses to these requests. It covers various methods of handling requests properly and designing them in the best way.

Chapter 5, *Web Forms with WTForms*, covers form handling, which is an important part of any web application. As much as forms are important, their validation holds equal importance, if not more. Presenting this information to users in an interactive fashion adds a lot of value to an application.

Chapter 6, *Authenticating in Flask*, talks about authentication, which acts as the red line between an application being secure and insecure. It deals with multiple social and enterprise login techniques in detail. Authentication is an important part of any application, be it web-based, desktop, or mobile.

Chapter 7, *RESTful API Building*, explains REST as a protocol and then discusses writing RESTful APIs for Flask applications using libraries, as well as completely customized APIs. An API can be summarized as a developer's interface to an application.

Chapter 8, *Admin Interface for Flask Apps*, focuses on writing admin views for Flask applications. First, we will write completely custom-made views and then write them with the help of an extension. As opposed to the very popular Python-based web framework Django, Flask does not provide an admin interface by default. Although this can be seen as a shortcoming by many, this gives developers the flexibility to create an admin interface as per their requirements and have complete control over an application.

Chapter 9, *Internationalization and Localization*, expands the scope of Flask applications and covers the basics of how to enable support for multiple languages. Web applications usually are not limited to one geographical region or to serving people from one linguistic domain. For example, a web application intended for users in Europe will be expected to support other European languages, such as German, French, Italian, Spanish, and so on, apart from English.

Chapter 10, *Debugging, Error Handling, and Testing*, moves on from being completely development-oriented to testing our application. With better error handling and tests, the robustness of the application increases manifold, and debugging makes the lives of developers easier. It is very important to know how robust our application is and to keep track of how it has worked and performed. This, in turn, gives rise to the need to be informed when something goes wrong in the application. Testing in itself is a very huge topic and has several books devoted to it.

Chapter 11, *Deployment and Post-Deployment*, covers the various ways and tools with which an application can be deployed. Then, you will learn about application monitoring, which helps us to keep track of the performance of the application. Deployment of an application and managing the application post-deployment is as important as developing it. There can be various ways of deploying an application, and choosing the best way depends on the requirements.

Chapter 12, *Microservices and Container*, explores how to package Flask applications with Docker and deploy them with Kubernetes. We will also see how to serve applications in a serverless fashion by leveraging Google Cloud Run and GitHub Actions. *Microservices* is one of the biggest buzzwords in modern software technology. These are as useful as they are popular and make the lives of developers easier. They allows people to focus on development rather than investing that time in thinking about the deployment of applications.

Chapter 13, *GPT with Flask*, implements some of the most popular and common yet powerful APIs of GPT to build AI-powered apps with Flask. We will see how easy it is to automate text completions using GPT to build highly user-intuitive search fields. Then, a simple chatbot implementation using ChatGPT is demonstrated, followed by AI-powered image generation.

Chapter 14, *Additional Tips and Tricks*, covers some additional recipes that can be used to add value to an application, if necessary.

To get the most out of this book

You will need *Python* installed on your computer as a prerequisite. All the code in the book has been written and tested on *Python 3.11.x* on a *UNIX-based OS*, either *macOS* or *Ubuntu*. The book uses *Flask 2.2.x*, and not all the code will work for earlier versions of Flask and/or Python. However, most code should work for future versions unless a breaking change is introduced. For other relevant packages or libraries, the versions are mentioned directly in the recipes wherever relevant.

Software/hardware covered in the book	**Operating system requirements**
Python 3.11.x	Windows, macOS, or Linux
Flask 2.2.x	Windows, macOS, or Linux

There are a few recipes that focus on some paid SaaS software, such as *Sentry*, *New Relic*, *Datadog*, **Amazon Web Services** (**AWS**), **Google Cloud Platform** (**GCP**), *GitHub*, and *OpenAI (GPT)*. Although a trial or free version exists for all of them, you might need to purchase them if you exceed the free limit.

If you are using the digital version of this book, we advise you to type the code yourself or access the code from the book's GitHub repository (a link is available in the next section). Doing so will help you avoid any potential errors related to the copying and pasting of code.

Download the example code files

You can download the example code files for this book from GitHub at `https://github.com/PacktPublishing/Flask-Framework-Cookbook-Third-Edition`. If there's an update to the code, it will be updated in the GitHub repository.

We also have other code bundles from our rich catalog of books and videos available at `https://github.com/PacktPublishing/`. Check them out!

Download the color images

We also provide a PDF file that has color images of the screenshots and diagrams used in this book. You can download it here: `https://packt.link/KWUib`.

Conventions used

There are a number of text conventions used throughout this book.

`Code in text`: Indicates code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles. Here is an example: "In the preceding code, first, the instance folder is loaded from the given path; then, the configuration file is loaded from the config.cfg file in the given instance folder."

A block of code is set as follows:

```
PRODUCTS = {
    'iphone': {
        'name': 'iPhone 5S',
        'category': 'Phones',
        'price': 699,
},
```

When we wish to draw your attention to a particular part of a code block, the relevant lines or items are set in bold:

```
from flask_wtf.file import FileField, FileRequired

class Product(db.Model):
    image_path = db.Column(db.String(255))
    def __init__(self, name, price, category, image_path):
        self.image_path = image_path
```

Any command-line input or output is written as follows:

```
$ sudo apt update
$ sudo apt install python3-dev
$ sudo apt install apache2 apache2-dev
```

Bold: Indicates a new term, an important word, or words that you see on screen. For instance, words in menus or dialog boxes appear in **bold**. Here is an example: "It can also handle the **Remember me** feature, account recovery features, and so on."

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Part 1: Flask Fundamentals

As the name suggests, this part of the book focuses on the basic fundamental building blocks of any Flask web application. A clear understanding of these topics is essential to building scalable, configurable, and extensible web applications with Flask as we move to more complex topics.

Developers usually struggle with how to set up their Flask application configurations to suit different environments, such as development and production. At times, they might find it difficult to choose the best way to structure their Flask applications. The first chapter helps in answering such questions and many more.

The next three chapters focus on creating the foundational pillars of any web application – that is, models, views, and templates. A very important concept covered in these chapters concerns connecting multiple types of databases with your application.

The content in these chapters will be basic- to mid-level in complexity, and it will act as the groundwork to address more complex use cases in the next two parts of the book.

At the end of this first part of the book, you will be able to create a full-fledged Flask application that will be functional and capable of basic functionalities.

This part of the book comprises the following chapters:

- *Chapter 1, Flask Configurations*
- *Chapter 2, Templating with Jinja*
- *Chapter 3, Data Modeling in Flask*
- *Chapter 4, Working with Views*

1
Flask Configurations

This introductory chapter will help us understand the different ways **Flask** can be configured to suit the various needs of a project. Flask is "*The Python micro framework for building web applications*" (pallets/Flask, `https://github.com/pallets/flask`).

So, why is Flask called a **microframework**? Does this mean Flask lacks functionality, or that it's mandatory for the complete code of your web application to be contained in a single file? Not really! The term microframework simply refers to the fact that Flask aims to keep the core of its framework small but highly extensible. This makes writing applications or extensions both easy and flexible and gives developers the power to choose the configurations they want for their application without imposing any restrictions on the choice of database, templating engine, admin interface, and so on. In this chapter, you will learn several ways to set up and configure Flask.

> **Important information**
>
> This whole book uses *Python 3* as the default version of Python. Python 2 lost its support on December 31, 2019, and is therefore not supported in this book. It is recommended that you use Python 3 while learning from this book, as many of the recipes might not work on Python 2.
>
> Likewise, while writing this book, Flask 2.2.x was the latest version. Although a lot of code in this book can work on earlier versions of Flask, it is recommended that you use versions 2.2.x and above.

Getting started with Flask takes just a couple of minutes. Setting up a simple *Hello World* application is as easy as pie. Simply create a file, such as `app.py`, in any location on your computer that can access `python` or `python3` that contains the following script:

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

@app.route('/')
def hello_world():
```

```
    return 'Hello to the World of Flask!'

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

Now, Flask needs to be installed; this can be done via `pip` or `pip3`. You may have to use `sudo` on a Unix-based machine if you run into access issues:

```
$ pip3 install Flask
```

> **Important**
>
> The code and Flask installation example here is just intended to demonstrate the ease with which Flask can be used. To set up a proper development environment, follow the recipes in this chapter.

The preceding snippet is a complete Flask-based web application. Here, an instance of the imported `Flask` class is a **Web Server Gateway Interface** (**WSGI**) (`http://legacy.python.org/dev/peps/pep-0333/`) application. So, `app` in this code becomes our WSGI application, and as this is a standalone module, we set the `__name__` string to `'__main__'`. If we save this in a file called `app.py`, then the application can simply be run using the following command:

```
$ python3 app.py
* Running on http://127.0.0.1:5000 (Press CTRL+C to quit)
```

Now, if we head over to our browser and type `http://127.0.0.1:5000/`, we can see our application running.

Alternatively, the application can be run by using `flask run` or Python's `-m` switch with Flask. While following this approach, the last two lines of `app.py` can be skipped. Note that the following commands work only if there is a file named `app.py` or `wsgi.py` in the current directory. If not, then the file containing the `app` object should be exported as an environment variable, namely `FLASK_APP`. As a best practice, this should be done in either case:

```
$ export FLASK_APP=app.py
$ flask run
* Running on http://127.0.0.1:5000/
```

Alternatively, if you decide to use the `-m` switch, it will look as follows:

```
$ export FLASK_APP=app.py
$ python3 -m flask run
* Running on http://127.0.0.1:5000/
```

> **Tip**
> Never save your application file as `flask.py`; if you do, it will conflict with Flask itself while importing.

In this chapter, we will cover the following recipes:

- Setting up our environment with `virtualenv`
- Handling basic configurations
- Configuring class-based settings
- Organizing static files
- Being deployment-specific with the `instance` folder
- Compositions of views and models
- Creating a modular web app with blueprints
- Making a Flask app installable using `setuptools`

Technical requirements

Working with Flask and **Python** in general is pretty easy and does not require a lot of dependencies and configurations. For most of the chapters in this book, all the required packages shall be mentioned in the relevant recipes. I will mention more specific requirements in relevant chapters. In general, you will need the following:

- A decent computer, preferably with a *UNIX*-based OS such as *Linux* or *macOS*. You can also use Windows, which would require some additional setup, but that is out of the scope of this book.
- A code editor of choice as the IDE. I use *Vim* and *Visual Studio Code* but anything will work, so long as it supports *Python*.
- A good internet connection as you will be downloading the packages and their dependencies.

All the code is freely available on GitHub at `https://github.com/PacktPublishing/Flask-Framework-Cookbook-Third-Edition`. This repository on GitHub contains the code for all the chapters in this book, segregated into corresponding folders.

Setting up a virtual environment

Flask can be simply installed using `pip`/`pip3` or `easy_install` globally, but it's preferable to set up an application environment using **venv**. This prevents the global Python installation from being affected by a custom installation as it creates a separate environment for the application. This separate environment is helpful as it allows you to have multiple versions of the same library for multiple applications; some packages might also have different versions of the same libraries as dependencies. `venv` manages this in separate environments and does not let the incorrect version of any library affect any application. In this recipe, we will learn how to create and manage these environments.

How to do it...

Python3 comes bundled with a `venv` module to create virtual environments. So, simply create a new environment called `my_flask_env` (or any other name of your choice) inside the folder of your choice where you want your development environment to live. This will create a new folder with the same name, as follows:

```
$ python3 -m venv my_flask_env
```

Run the following commands from inside the `my_flask_env` folder:

```
$ source my_flask_env/bin/activate
$ pip3 install flask
```

This will activate our environment and install `flask` inside it. Now, we can do anything with our application within this environment, without affecting any other Python environment.

How it works...

So far, we have used `pip3 install flask` multiple times. As its name suggests, the command refers to the installation of Flask, just like any Python package. If we look a bit deeper into the process of installing Flask via `pip3`, we will see that several packages are installed. The following is an outline of the package installation process of Flask:

```
$ pip3 install flask
Collecting Flask
...........
...........
Many more lines.........
...........
Installing collected packages: zipp, Werkzeug, MarkupSafe,
itsdangerous, click, Jinja2, importlib-metadata, Flask
Successfully installed Flask-2.1.2 Jinja2-3.1.2 MarkupSafe-2.1.1
Werkzeug-2.1.2 click-8.1.3 importlib-metadata-4.11.4
itsdangerous-2.1.2 zipp-3.8.0
```

If we look carefully at the preceding snippet, we will see that multiple packages have been installed. Of these, five packages, namely, `Werkzeug`, `Jinja2`, `click`, `itsdangerous`, and `markupsafe`, are the packages on which Flask depends, and it will not work if any of them are missing. Others are sub-dependencies that are needed for the dependencies of Flask to work.

There's more...

Before `venv` was introduced in *Python 3.3*, `virtualenv` was the standard library used to create and manage virtual environments. `venv` is a subset of `virtualenv` and misses out on the advanced features that `virtualenv` provides. For the sake of simplicity and to stay in the context of this book, I will use `venv`, but you are free to explore `virtualenv` and `virtualenvwrapper`.

See also

The references relating to this section are as follows:

- `https://pypi.python.org/pypi/Flask`
- `https://pypi.python.org/pypi/Werkzeug`
- `https://pypi.python.org/pypi/Jinja2`
- `https://pypi.python.org/pypi/itsdangerous`
- `https://pypi.python.org/pypi/MarkupSafe`
- `https://pypi.python.org/pypi/click`

Read more about `virtualenv` and `virtualenvwrapper` at `https://virtualenv.pypa.io/en/latest/` and `https://pypi.org/project/virtualenvwrapper/`.

Handling basic configurations

One of the beauties of Flask is that it is very easy to configure a Flask application according to the needs of the project. In this recipe, we will try to understand the different ways in which a Flask application can be configured, including how to load a configuration from environment variables, Python files, or even a `config` object.

Getting ready

In Flask, configuration variables are stored on a dictionary-like attribute named `config` of the `Flask` object. The `config` attribute is a subclass of the Python dictionary, and we can modify it just like any dictionary.

How to do it...

To run our application in debug mode, for instance, we can write the following:

```
app = Flask(__name__)
app.config['DEBUG'] = True
```

Tip

The `debug` Boolean can also be set at the Flask `object` level rather than at the `config` level, as follows:

`app.debug = True`

Alternatively, we can pass `debug` as a named argument to `app.run`, as follows:

`app.run(debug=True)`

In new versions of Flask, the debug mode can also be set on an environment variable, `FLASK_DEBUG=1`. Then, we can run the app using `flask run` or Python's `-m` switch:

```
$ export FLASK_DEBUG=1
```

Enabling debug mode will make the server reload itself in the event of any code changes, and it also provides the very helpful *Werkzeug* debugger when something goes wrong.

There are a bunch of configuration values provided by Flask. We will come across them in relevant recipes throughout this chapter.

As an application becomes larger, there is a need to manage the application's configuration in a separate file, as shown in the following example. In most operating systems and development environments that you use, it is unlikely that this file will be a part of the version control system. Thus, Flask provides us with multiple ways to fetch configurations. The most frequently used methods are as follows:

- From a Python configuration file (`*.cfg`), where the configuration can be fetched using the following statement:

  ```
  app.config.from_pyfile('myconfig.cfg')
  ```

- From an object, where the configuration can be fetched using the following statement:

  ```
  app.config.from_object('myapplication.default_settings')
  ```

- Alternatively, to load from the same file from which this command is run, we can use the following statement:

  ```
  app.config.from_object(__name__)
  ```

- From an environment variable, the configuration can be fetched using the following statement:

  ```
  app.config.from_envvar('PATH_TO_CONFIG_FILE')
  ```

- New in Flask version *2.0* is a capability to load from generic configuration file formats such as **JSON** or **TOML**:

  ```
  app.config.from_file('config.json', load=json.load)
  ```

  Alternatively, we can do the following:

  ```
  app.config.from_file('config.toml', load=toml.load)
  ```

How it works...

Flask is designed to only pick up configuration variables that are written in uppercase. This allows us to define any local variables in our configuration files and objects and leave the rest to Flask.

The best practice when using configurations is to have a bunch of default settings in `app.py`, or via any object in the application itself, and then override the same by loading it from the configuration file. So, the code will look as follows:

```
app = Flask(__name__)
DEBUG = True
TESTING = True
app.config.from_object(__name__)
app.config.from_pyfile('/path/to/config/file')
```

Configuring using class-based settings

An effective way of laying out configurations for different deployment modes, such as production, testing, staging, and so on, can be cleanly done using the inheritance pattern of classes. As your project gets bigger, you can have different deployment modes, and each mode can have several different configuration settings or some settings that will remain the same. In this recipe, we will learn how to use class-based settings to achieve such a pattern.

How to do it...

We can have a base class with default settings; then, other classes can simply inherit from the base class and override or add deployment-specific configuration variables to it, as shown in the following example:

```
class BaseConfig(object):
    'Base config class'
    SECRET_KEY = 'A random secret key'
    DEBUG = True
    TESTING = False
    NEW_CONFIG_VARIABLE = 'my value'

class ProductionConfig(BaseConfig):
    'Production specific config'
```

```
    DEBUG = False
    SECRET_KEY = open('/path/to/secret/file').read()

class StagingConfig(BaseConfig):
    'Staging specific config'
    DEBUG = True

class DevelopmentConfig(BaseConfig):
    'Development environment specific config'
    DEBUG = True
    TESTING = True
    SECRET_KEY = 'Another random secret key'
```

Important information

In a production configuration, the secret key is generally stored in a separate file because, for security reasons, it should not be a part of your version control system. This should be kept in the local filesystem on the machine itself, whether it is your machine or a server.

How it works...

Now, we can use any of the preceding classes while loading the application's configuration via `from_object()`. Let's say that we save the preceding class-based configuration in a file named `configuration.py`, as follows:

```
app.config.from_object('configuration.DevelopmentConfig')
```

Overall, this makes managing configurations for different deployment environments more flexible and easier.

Organizing static files

Organizing static files such as JavaScript, stylesheets, images, and so on efficiently is always a matter of concern for all web frameworks. In this recipe, we'll learn how to achieve this in Flask.

How to do it...

Flask recommends a specific way of organizing static files in an application, as follows:

```
my_app/
    app.py
    config.py
    __init__.py
    static/
```

```
        css/
        js/
        images/
            logo.png
```

While rendering this in templates (say, the `logo.png` file), we can refer to the static files using the following code:

```
<img src='/static/images/logo.png'>
```

How it works...

If a folder named `static` exists at the application's root level – that is, at the same level as `app.py` – then Flask will automatically read the contents of the folder without any extra configuration.

There's more...

Alternatively, we can provide a parameter named `static_folder` to the application object while defining the application in `app.py`, as follows:

```
app = Flask(__name__,
    static_folder='/path/to/static/folder')
```

In the preceding line of code, `static` refers to the value of `static_folder` on the application object. This can be modified as follows by providing a URL prefix by supplying `static_url_path`:

```
app = Flask(
    _name_, static_url_path='/differentstatic',
    static_folder='/path/to/static/folder'
)
```

Now, to render the static file, we can use the following code:

```
<img src='/differentstatic/logo.png'>
```

It is always a good practice to use `url_for` to create URLs for static files rather than explicitly defining them, as follows:

```
<img src="{{ url_for('static', filename='logo.png') }}">
```

Being deployment-specific with the instance folder

Flask provides yet another method for configuration, where we can efficiently manage deployment-specific parts. Instance folders allow us to segregate deployment-specific files from our version-controlled application. We know that configuration files can be separate for different deployment environments, such as development and production, but there are also many more files, such as database files, session files, cache files, and other runtime files. In this recipe, we will create an instance folder that will act like a holder container for such kinds of files. By design, the instance folder will not be a part of the version control system.

How to do it...

By default, the instance folder is picked up from the application automatically if we have a folder named `instance` in our application at the application level, as follows:

```
my_app/
    app.py
    instance/
        config.cfg
```

We can also explicitly define the absolute path of the instance folder by using the `instance_path` parameter on our application object, as follows:

```
app = Flask(
    __name__,
    instance_path='/absolute/path/to/instance/folder')
```

To load the configuration file from the instance folder, we can use the `instance_relative_config` parameter on the application object, as follows:

```
app = Flask(__name__, instance_relative_config=True)
```

This tells the application to load the configuration file from the instance folder. The following example shows how to configure this:

```
app = Flask(
    __name__, instance_path='path/to/instance/folder',
    instance_relative_config=True
)
app.config.from_pyfile('config.cfg', silent=True)
```

How it works...

In the preceding code, first, the instance folder is loaded from the given path; then, the configuration file is loaded from the `config.cfg` file in the given instance folder. Here, `silent=True` is optional and is used to suppress the error if `config.cfg` is not found in the instance folder. If `silent=True` is not given and the file is not found, then the application will fail, giving the following error:

```
IOError: [Errno 2] Unable to load configuration file (No such file or
directory): '/absolute/path/to/config/file'
```

Information

It might seem that loading the configuration from the instance folder using `instance_relative_config` is redundant work and could be moved to one of the configuration methods itself. However, the beauty of this process lies in the fact that the instance folder concept is completely independent of configuration, and `instance_relative_config` just complements the configuration object.

Composition of views and models

As our application becomes bigger, we might want to structure it in a modular manner. In this recipe, we will do this by restructuring our *Hello World* application.

How to do it...

First, create a new folder in the application and move all the files inside this new folder. Then, create `__init__.py` in the folders, which are to be used as modules.

After that, create a new file called `run.py` in the topmost folder. As its name implies, this file will be used to run the application.

Finally, create separate folders to act as modules.

Refer to the following file structure to get a better understanding:

```
flask_app/
    run.py
    my_app/
        __init__.py
        hello/
            __init__.py
            models.py
            views.py
```

Let's see how each of the preceding files will look.

The `flask_app/run.py` file will look something like the following lines of code:

```
from my_app import app
app.run(debug=True)
```

The `flask_app/my_app/__init__.py` file will look something like the following lines of code:

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

import my_app.hello.views
```

Next, we have an empty file just to make the enclosing folder a Python package, `flask_app/my_app/hello/__init__.py`:

```
# No content.
# We need this file just to make this folder a python module.
```

The models file, `flask_app/my_app/hello/models.py`, has a non-persistent key-value store, as follows:

```
MESSAGES = {
    'default': 'Hello to the World of Flask!',
}
```

Finally, the following is the views file, `flask_app/my_app/hello/views.py`. Here, we fetch the message corresponding to the requested key and can also create or update a message:

```
from my_app import app
from my_app.hello.models import MESSAGES

@app.route('/')
@app.route('/hello')
def hello_world():
    return MESSAGES['default']


@app.route('/show/<key>')
def get_message(key):
    return MESSAGES.get(key) or "%s not found!" % key


@app.route('/add/<key>/<message>')
def add_or_update_message(key, message):
    MESSAGES[key] = message
    return "%s Added/Updated" % key
```

How it works...

In this recipe, we have a circular import between `my_app/__init__.py` and `my_app/hello/views.py`, where, in the former, we import `views` from the latter, and in the latter, we import `app` from the former. Although this makes the two modules dependent on each other, there is no issue, as we won't be using views in `my_app/__init__.py`. Note that it is best to import the views at the bottom of the file so that they are not used in this file. This ensures that when you refer to the `app` object inside the view, it does not lead to null-pointer exceptions.

In this recipe, we used a very simple non-persistent in-memory key-value store to demonstrate the model's layout structure. We could have written the dictionary for the `MESSAGES` hash map in `views.py` itself, but it is best practice to keep the model and view layers separate.

So, we can run this app using just `run.py`, as follows:

```
$ python run.py
Serving Flask app "my_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: 111-111-111
```

Tip

Note the preceding `WARNING` in the block. This warning occurs because we did not specify the application environment, and by default, `production` is assumed. To run the application in the `development` environment, modify the `run.py` file with the following:

```
from my_app import app
app.env="development"
app.run(debug=True)
```

Information

The reloader indicates that the application is being run in debug mode and that the application will reload whenever a change is made in the code.

As we can see, we have already defined a default message in `MESSAGES`. We can view that by opening `http://127.0.0.1:5000/show/default`. To add a new message, we can type `http://127.0.0.1:5000/add/great/Flask%20is%20greatgreat!!`. This will update the `MESSAGES` key-value store so that it looks like this:

```
MESSAGES = {
    'default': 'Hello to the World of Flask!',
    'great': 'Flask is great!!',
}
```

Now, if we open `http://127.0.0.1:5000/show/great` in a browser, we will see our message, which would have otherwise appeared as a not found message.

See also

The next recipe, *Creating a modular web app with blueprints*, provides a much better way of organizing your Flask applications and is a ready-made solution for circular imports.

Creating a modular web app with blueprints

A **blueprint** is a feature in Flask that helps make large applications modular. This keeps application dispatching simple by providing a central place to register all components in an application. A blueprint looks like an application object but is not an application. It also looks like a pluggable app or a smaller part of a bigger app, but it is not. A blueprint is a set of operations that can be registered on an application and represents how to construct or build an application. Another benefit is that it allows us to create reusable components between multiple applications.

Getting ready

In this recipe, we'll take the application from the previous recipe, *Composition of views and models*, as a reference and modify it so that it works using blueprints.

How to do it...

The following is an example of a simple *Hello World* application using `Blueprint`. It will work like it did in the previous recipe but will be much more modular and extensible.

First, we will start with the following `flask_app/my_app/__init__.py` file:

```
from flask import Flask
from my_app.hello.views import hello

app = Flask(__name__)
app.register_blueprint(hello)
```

Next, we will add some code to the views file, `my_app/hello/views.py`, which should look as follows:

```
from flask import Blueprint
from my_app.hello.models import MESSAGES

hello = Blueprint('hello', __name__)

@hello.route('/')
@hello.route('/hello')
def hello_world():
    return MESSAGES['default']


@hello.route('/show/<key>')
def get_message(key):
    return MESSAGES.get(key) or "%s not found!" % key


@hello.route('/add/<key>/<message>')
def add_or_update_message(key, message):
    MESSAGES[key] = message
    return "%s Added/Updated" % key
```

We have now defined a blueprint in the `flask_app/my_app/hello/views.py` file. We no longer need the application object in this file, and our complete routing is defined on a blueprint named `hello`. Instead of `@app.route`, we use `@hello.route`. The same blueprint is imported into `flask_app/my_app/__init__.py` and registered on the application object.

We can create any number of blueprints in our application and complete most of the activities that we would usually do, such as providing different template paths or different static paths. We can even have different URL prefixes or subdomains for our blueprints.

How it works...

This application will work in just the same way as the last application. The only difference is in the way the code is organized.

Making a Flask app installable using setuptools

We now have a Flask app, but how do we install it like any **Python package?** It is possible that another application might depend on our application, or that our application is an extension of Flask and would need to be installed in a Python environment so it can be used by other applications. In this recipe, we will see how `setuptools` can be used to create an installable Python package.

What is a Python package?

A Python package can simply be thought of as a program that can be imported using Python's `import` statement in a virtual environment or globally based on its installation scope.

How to do it...

Installing a Flask app can be easily achieved using the `setuptools` Python library. To achieve this, create a file called `setup.py` in your application's folder and configure it to run a setup script for the application. This will take care of any dependencies, descriptions, loading test packages, and so on.

The following is an example of a simple `setup.py` script for the *Hello World* application from the previous recipe:

```
#!/usr/bin/env python
# -*- coding: UTF-8 -*-
import os
from setuptools import setup

setup(
    name = 'my_app',
    version='1.0',
    license='GNU General Public License v3',
    author='Shalabh Aggarwal',
    author_email='contact@shalabhaggarwal.com',

    description='Hello world application for Flask',
    packages=['my_app'],
    platforms='any',
    install_requires=[
        'Flask',
    ],
    classifiers=[
        'Development Status :: 4 - Beta',
        'Environment :: Web Environment',
        'Intended Audience :: Developers',
        'License :: OSI Approved :: GNU General Public
          License v3',
        'Operating System :: OS Independent',
        'Programming Language :: Python',
        'Topic :: Internet :: WWW/HTTP :: Dynamic Content',
        'Topic :: Software Development :: Libraries ::
          Python Modules'
],
)
```

How it works...

In the preceding script, most of the configuration is self-explanatory. The classifiers are used when the application is made available on **PyPI**. These will help other users search the application using the relevant classifiers.

Now, we can run this file with the `install` keyword, as follows:

```
$ python setup.py install
```

The preceding command will install the application along with all the dependencies mentioned in `install_requires` – that is, Flask and all of Flask's dependencies. Now, the app can be used just like any Python package in a Python environment.

To verify the successful installation of your package, import it inside a Python environment:

```
$ python
Python 3.8.13 (default, May  8 2022, 17:52:27)
>>> import my_app
>>>
```

See also

The list of valid trove classifiers can be found at `https://pypi.python.org/pypi?%3Aaction=list_classifiers`.

2
Templating with Jinja

This chapter will cover the basics of **Jinja** templating from the perspective of Flask. We will also learn how to design and develop applications with modular and extensible templates.

> **Information**
>
> If you have followed Flask or Jinja or this book's previous editions, you might have noticed that, previously, this templating library was called *Jinja2*. The latest version of Jinja at the time of writing is version 3, and the authors/community have decided to call it just *Jinja* instead of confusingly continuing with Jinja2, Jinja3, and so on.

In Flask, we can write a complete web application without the need for a third-party templating engine. For example, have a look at the following code; this is a standalone, simple Hello World application with a bit of HTML styling included:

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

@app.route('/')
@app.route('/hello')
@app.route('/hello/<user>')
def hello_world(user=None):
    user = user or 'Shalabh'
    return '''
<html>
    <head>
        <title>Flask Framework Cookbook</title>
    </head>
    <body>
        <h1>Hello %s!</h1>
        <p>Welcome to the world of Flask!</p>
    </body>
```

```
</html>''' % user

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

Is the preceding pattern of application writing feasible in the case of large applications that involve thousands of lines of HTML, JS, and CSS code? In my opinion, no!

Fortunately, templating offers a solution because it allows us to structure our views code by keeping our templates extensible and separate. Flask provides default support for Jinja, although we can use any templating engine that suits us. Furthermore, Jinja provides many additional features that make templates very powerful and modular.

In this chapter, we will cover the following recipes:

- Bootstrapping the standard layout
- Implementing block composition and layout inheritance
- Creating a custom context processor
- Creating a custom Jinja filter
- Creating a custom macro for forms
- Advanced date and time formatting

Technical requirements

Jinja is installed as a part of the standard Flask installation. There is no need to install it separately. For more details, refer to the *Setting up a virtual environment* section in *Chapter 1*.

Bootstrapping the standard layout

Most of the applications in Flask follow a specific pattern of laying out templates. In this recipe, we will implement the recommended way of structuring the layout of templates in a Flask application.

Getting ready

By default, Flask expects templates to be placed inside a folder named `templates` at the application root level. If this folder is present, then Flask will automatically read the contents by making the contents of this folder available for use with the `render_template()` method, which we will use extensively throughout this book.

How to do it...

Let's demonstrate this with a small application. This application is very similar to the one we developed in *Chapter 1*, *Flask Configurations*.

The first thing to do is to add a new folder named `templates` under `my_app`. The application structure should look like the following directory structure:

```
flask_app/
    run.py
    my_app/
        __init__.py
        hello/
            __init__.py
            views.py
        templates
```

We now need to make some changes to the application. The `hello_world()` method in the `views` file, `my_app/hello/views.py`, should look like the following lines of code:

```
from flask import render_template, request

@hello.route('/')
@hello.route('/hello')
def hello_world():
    user = request.args.get('user', 'Shalabh')
    return render_template('index.html', user=user)
```

In the preceding method, we look for a URL query argument, `user`. If it is found, we use it, and if not, we use the default argument, `Shalabh`. Then, this value is passed to the context of the template to be rendered – that is, `index.html` – and the resulting template is rendered.

The `my_app/templates/index.html` template can simply be the following:

```
<html>
  <head>
    <title>Flask Framework Cookbook</title>
  </head>
  <body>
    <h1>Hello {{ user }}!</h1>
    <p>Welcome to the world of Flask!</p>
  </body>
</html>
```

How it works...

Now, if we open the `http://127.0.0.1:5000/hello` URL in a browser, we should see a response similar to the one shown in the following screenshot:

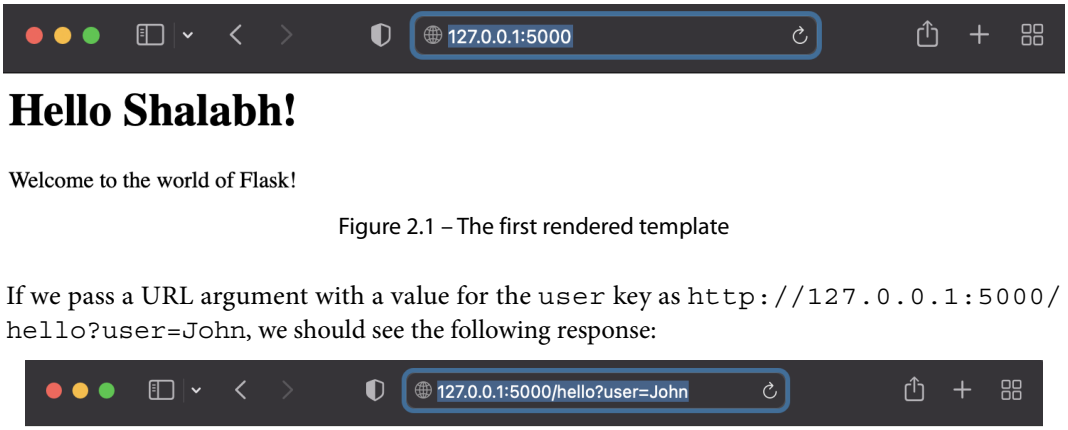


Figure 2.1 – The first rendered template

If we pass a URL argument with a value for the `user` key as `http://127.0.0.1:5000/hello?user=John`, we should see the following response:

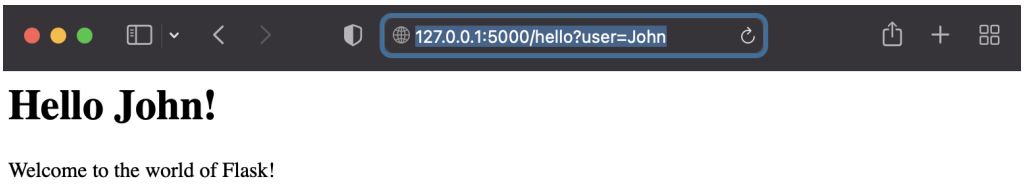


Figure 2.2 – Serving custom content in the template

As we can see in `views.py`, the argument passed in the URL is fetched from the `request` object using `request.args.get('user')` and then passed to the context of the template being rendered, using `render_template`. The argument is then parsed using the Jinja placeholder, `{{ user }}`, to fetch the contents from the current value of the `user` variable from the template context. This placeholder evaluates all of the expressions placed inside it, depending on the template context.

> **Information**
>
> The Jinja documentation can be found at `http://jinja.pocoo.org/`. This will come in handy when writing templates.

Implementing block composition and layout inheritance

Usually, any web application will have a number of web pages that are different from each other. However, code blocks such as headers and footers will appear the same on almost all pages throughout the site; likewise, the menu will remain the same. In fact, it is usually just the center container block that changes. For this, Jinja provides a great way of ensuring inheritance among templates.

With this in mind, it's a good practice to have a base template where the basic layout of the site, along with the header and footer, can be structured.

Getting ready

In this recipe, we will create a small application that will have a home page and a product page (such as the ones we see on e-commerce stores). We will use the Bootstrap framework to give a minimalistic design and theme to our template. Bootstrap v5 can be downloaded from `http://getbootstrap.com/`.

> **Information**
>
> The latest version of Bootstrap at the time of writing is v5. Different versions of Bootstrap might cause the UI of an application to behave in different ways, but the core essence of Bootstrap remains the same.

For the sake of simplicity and focus on the topic at hand, we have created a hardcoded data store of a few products, which can be found in the `models.py` file. These are imported and read in `views.py` and are sent over to the template as template context variables, via the `render_template()` method. The rest of the parsing and display is handled by the templating language, which in our case is Jinja.

How to do it...

Have a look at the following layout:

```
flask_app/
    - run.py
    - my_app/
        - __init__.py
        - product/
            - __init__.py
            - views.py
            - models.py
        - templates/
            - base.html
            - home.html
            - product.html
        - static/
            - js/
                - bootstrap.bundle.min.js
                - jquery.min.js
            - css/
                - bootstrap.min.css
                - main.css
```

In the preceding layout, `static/css/bootstrap.min.css` and `static/js/bootstrap.bundle.min.js` are standard files that can be downloaded from the Bootstrap website mentioned in the *Getting ready* section. The `run.py` file remains the same, as always. The rest of the application-building process is as follows.

First, define the models in `my_app/product/models.py`. In this chapter, we will work on a simple, non-persistent key-value store. We will start with a few hardcoded product records made well in advance, as follows:

```
PRODUCTS = {
    'iphone': {
        'name': 'iPhone 5S',
        'category': 'Phones',
        'price': 699,
    },
    'galaxy': {
        'name': 'Samsung Galaxy 5',
        'category': 'Phones',
        'price': 649,
    },
    'ipad-air': {
        'name': 'iPad Air',
        'category': 'Tablets',
        'price': 649,
    },
    'ipad-mini': {
        'name': 'iPad Mini',
        'category': 'Tablets',
        'price': 549
    }
}
```

Next comes the views – that is, `my_app/product/views.py`. Here, we will follow the blueprint style to write the application, as follows:

```
from werkzeug.exceptions import abort
from flask import render_template
from flask import Blueprint
from my_app.product.models import PRODUCTS

product_blueprint = Blueprint('product', __name__)

@product_blueprint.route('/')
@product_blueprint.route('/home')
def home():
    return render_template('home.html', products=PRODUCTS)
```

```
@product_blueprint.route('/product/<key>')
def product(key):
    product = PRODUCTS.get(key)
    if not product:
        abort(404)
    return render_template('product.html', product=product)
```

Information

The `abort()` method comes in handy when you want to abort a request with a specific error message. Flask provides basic error message pages, which can be customized as needed. We will look at them in the *Creating custom 404 and 500 handlers* recipe in *Chapter 4*, *Working with Views*.

The name of the blueprint (`product`) that is passed in the `Blueprint` constructor will be appended to the endpoints defined in this blueprint. Do have a look at the `base.html` code for clarity.

Now, create the application's configuration file, `my_app/__init__.py`, which should look like the following lines of code:

```
from flask import Flask
from my_app.product.views import product_blueprint

app = Flask(__name__)
app.register_blueprint(product_blueprint)
```

It is always possible to create your own custom CSS, which can add more flavor to the standard CSS provided by Bootstrap. To do this, add a bit of custom CSS code in `my_app/static/css/main.css`, as follows:

```
body {
  padding-top: 50px;
}
.top-pad {
  padding: 10px 15px;
  text-align: center;
}
```

When considering templates, it is always a good practice to create a base template to house the common code that can be inherited by all the other templates. Name this template `base.html` and place it in `my_app/templates/base.html`, as follows:

```
<!DOCTYPE html>
<html lang="en">
  <head>
```

```
    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width,
      initial-scale=1">
    <title>Flask Framework Cookbook</title>
    <link href="{{ url_for('static',
      filename='css/bootstrap.min.css') }}"
      rel="stylesheet">
    <link href="{{ url_for('static',
      filename='css/main.css') }}" rel="stylesheet">
    <script src="{{ url_for('static',
      filename='js/moment.min.js') }}"></script>
  </head>
  <body>
    <nav class="navbar navbar-dark bg-dark fixed-top"
      role="navigation">
      <div class="container">
        <div class="navbar-header">
          <a class="navbar-brand" href="{{
            url_for('product.home') }}">Flask Cookbook</a>
        </div>
      </nav>
    </div>
    <div class="container">
    {% block container %}{% endblock %}
    </div>

    <script src="{{ url_for('static',
      filename='js/jquery.min.js') }}"></script>
    <script src="{{ url_for('static',
      filename='js/bootstrap.bundle.min.js') }}"></script>
  </body>
</html>
```

Most of the preceding code contains normal HTML and Jinja evaluation placeholders, which we introduced in the previous recipe, *Bootstrapping the recommended layout*. An important point to note, however, is how the `url_for()` method is used for blueprint URLs. The blueprint name is appended to all endpoints. This becomes very useful when there are multiple blueprints inside one application, as some of them may have similar-looking URLs.

On the home page, `my_app/templates/home.html`, iterate over all the products and display them, as follows:

```
{% extends 'base.html' %}
```

```
{% block container %}
  <div class="top-pad">
    {% for id, product in products.items() %}
    <div class="top-pad offset-1 col-sm-10">
      <div class="card text-center">
        <div class="card-body">
          <h2>
            <a href="{{ url_for('product.product', key=id)
              }}">{{ product['name'] }}</a>
            <small>$ {{ product['price'] }}</small>
          </h2>
        </div>
      </div>
    </div>
    {% endfor %}
  </div>
{% endblock %}
```

Then, create the individual product page, `my_app/templates/product.html`, which should look like the following lines of code:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <h1>{{ product['name'] }}</h1>
    <h3><small>{{ product['category'] }}</small></h3>
    <h5>$ {{ product['price'] }}</h5>
  </div>
{% endblock %}
```

How it works...

In the preceding template structure, there is an inheritance pattern being followed. The `base.html` file acts as the base template for all other templates. The `home.html` file inherits from `base.html`, and `product.html` inherits from `home.html`. In `product.html`, the `container` block is overwritten, which was first populated in `home.html`. When this app is run, we should see output similar to that shown in the following screenshot:

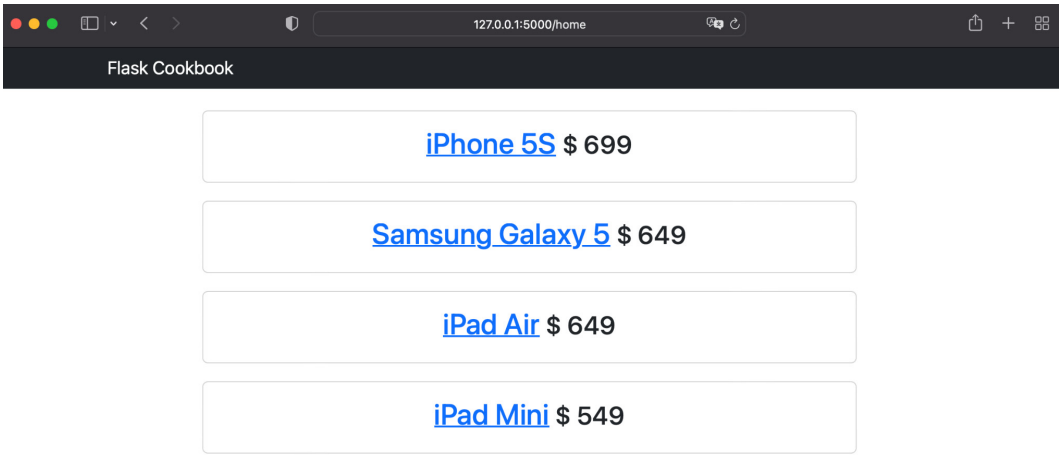


Figure 2.3 – Iterating over blocks to create reusable content

The preceding screenshot shows how the home page will look. Note the URL in the browser. The product page should appear as follows:

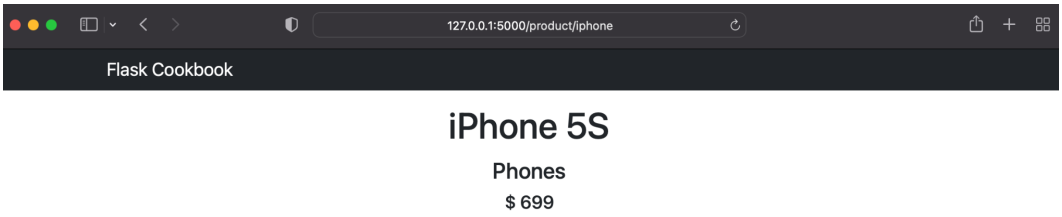


Figure 2.4 – Inheriting template blocks to create clean code

Creating a custom context processor

Sometimes, we might want to calculate or process a value directly in templates. Jinja maintains the notion that the processing of logic should be handled in views and not in templates, thereby keeping templates clean. A context processor becomes a handy tool in this case. With a context processor, we can pass our values to a method, which will then be processed in a Python method, and our resultant value will be returned. This is done by simply adding a function to the template context, thanks to Python allowing its users to pass functions like any other object. In this recipe, we'll see how to write a custom context processor.

How to do it...

To write a custom context processor, follow the steps described as follows.

Let's first display the descriptive name of the product in the `Category / Product-name` format. Afterward, add the method to `my_app/product/views.py`, as follows:

```
@product_blueprint.context_processor
def some_processor():
    def full_name(product):
        return '{0} / {1}'.format(product['category'],
          product['name'])
    return {'full_name': full_name}
```

A context is simply a dictionary that can be modified to add or remove values. Any method decorated with `@product_blueprint.context_processor` should return a dictionary that updates the actual context. We can use the preceding context processor as follows:

```
{{ full_name(product) }}
```

We can add the preceding code to our app for the product listing (in the `flask_app/my_app/templates/product.html` file) in the following manner:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <h4>{{ full_name(product) }}</h4>
    <h1>{{ product['name'] }}</h1>
    <h3><small>{{ product['category'] }}</small></h3>
    <h5>$ {{ product['price'] }}</h5>
  </div>
{% endblock %}
```

The resulting parsed HTML page should look like the following screenshot:

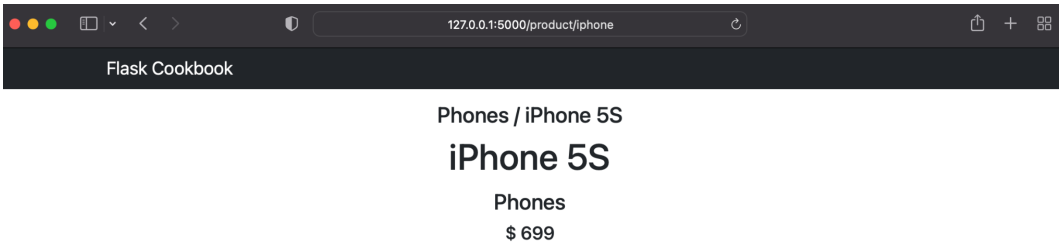


Figure 2.5 – A custom context processor for the product name

Information

Have a look at the *Implementing block composition and layout inheritance* recipe earlier in this chapter to understand the context of this recipe better regarding the product and category logic.

Creating a custom Jinja filter

After looking at the previous recipe, experienced developers might wonder why we used a context processor for the purpose of creating a well-formatted product name. Well, we can also write a filter for the same purpose, which will make things much cleaner. A filter can be written to display the descriptive name of a product, as shown in the following example:

```
@product_blueprint.app_template_filter('full_name')
def full_name_filter(product):
    return '{0} / {1}'.format(product['category'],
      product['name'])
```

This can also be used as follows:

```
{{ product|full_name }}
```

The preceding code will yield a similar result as in the previous recipe. Moving on, let's now take things to a higher level by using external libraries to format currency.

How to do it...

First, let's create a filter to format a currency based on the current local language. Add the following code to `my_app/__init__.py`:

```
import ccy
from flask import request

@app.template_filter('format_currency')
def format_currency_filter(amount):
    currency_code =
     ccy.countryccy(request.accept_languages.best[-2:])
    return '{0} {1}'.format(currency_code, amount)
```

> **Information**
>
> `request.accept_languages` might not work in cases where a request does not have the `ACCEPT-LANGUAGES` header.

The preceding snippet will require the installation of a new package, `ccy`, as follows:

```
$ pip install ccy
```

The filter created in this example takes the language that best matches the current browser locale (which, in my case, is `en-US`), takes the last two characters from the locale string, and then generates the currency as per the ISO country code, which is represented by two characters.

Tip

An interesting point to note in this recipe is that the Jinja filter can be created at the blueprint level as well as at the application level. If the filter is at the blueprint level, the decorator would be `app_template_filter`; otherwise, at the application level, the decorator would be `template_filter`.

How it works...

The filter can be used in our template for the product as follows:

```
<h3>{{ product['price']|format_currency }}</h3>
```

The preceding code will yield the result shown in the following screenshot:

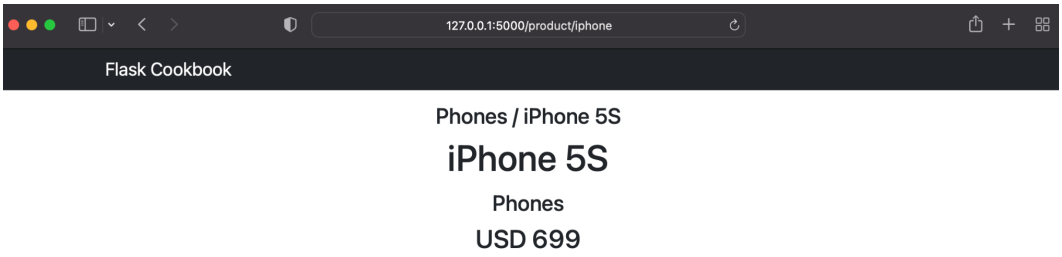


Figure 2.6 – A custom Jinja filter for the display of currency

See also

The *Implementing block composition and layout inheritance* recipe earlier in this chapter will aid your understanding of the context of this recipe regarding product and category logic.

Creating a custom macro for forms

Macros allow us to write reusable pieces of HTML blocks. They are analogous to functions in regular programming languages. We can pass arguments to macros as we do with functions in Python, and we can then use them to process an HTML block. Macros can be called any number of times, and the output will vary as per the logic inside them. In this recipe, let's understand how to write a macro in Jinja.

Getting ready

Macros in Jinja are a very common topic and have a lot of use cases. Here, we will just take a look at how a macro can be created and then used after importing it.

How to do it...

One of the most redundant pieces of code in HTML is that which defines input fields in forms. This is because most fields have similar code with maybe some style modifications.

The following snippet is a macro that creates input fields when invoked. The best practice is to create the macro in a separate file for better reusability – for example, `_helpers.html`:

```
{% macro render_field(name, class='', value='',
  type='text') -%}
<input type="{{ type }}" name="{{ name }}" class="{{ class
  }}" value="{{ value }}"/>
{%- endmacro %}
```

> **Information**
>
> The minus sign (`-`) before and after `%` will strip the whitespace before and after these blocks, making the HTML code cleaner to read.

Now, the macro should be imported into the file to be used, as follows:

```
{% from '_helpers.html' import render_field %}
```

It can now be called using the following code:

```
<fieldset>
{{ render_field('username', 'icon-user') }}
{{ render_field('password', 'icon-key', type='password') }}
</fieldset>
```

It is always good practice to define macros in a different file to keep the code clean and increase code readability.

> **Tip**
>
> If you need to write a private macro that cannot be accessed from outside its current file, name the macro with an underscore preceding the name.

Advanced date and time formatting

Date and time formatting is a painful thing to handle in web applications. Such formatting in Python, using the `datetime` library, often increases overhead and is pretty complex when it comes to the correct handling of time zones. It is a best practice to standardize timestamps to UTC when they are stored in a database, but this means that the timestamp needs to be processed every time it is presented to users around the world.

Instead, it is smarter to defer this processing to the client side – that is, the browser. The browser always knows the current time zone of its user and will, therefore, be able to manipulate the date and time information correctly. This approach also reduces any unnecessary overhead from the application servers. In this recipe, we will understand how to achieve this. We will use `Moment.js` for this purpose.

Getting ready

`Moment.js` can be included in our app just like any JS library. We just have to download and place the JS file, `moment.min.js`, in the `static/js` folder. The `Moment.js` file can be downloaded from `http://momentjs.com/`. This file can then be used in an HTML file by adding the following statement along with other JavaScript libraries:

```
<script src="{{ url_for('static',
  filename='js/moment.min.js') }}"></script>
```

The basic usage of `Moment.js` is shown in the following code. This can be done in the browser console for JavaScript:

```
>>> moment().calendar(); "Today at 11:09 AM"
>>> moment().endOf('day').fromNow(); "in 13 hours"
>>> moment().format('LLLL'); "Sunday, July 24, 2022 11:10
  AM"
```

How to do it...

To use `Moment.js` in an application, please follow the required steps.

First, write a wrapper in Python and use it via the Jinja environment variables, as follows:

```
from markupsafe import Markup

class momentjs(object):
    def __init__(self, timestamp):
        self.timestamp = timestamp

    # Wrapper to call moment.js method
    def render(self, format):
        return Markup(
            "<script>\ndocument
              .write(moment(\"%s\").%s);\n</script>" % (
              self.timestamp.strftime("%Y-%m-%dT%H:%M:%S"),
              format
            )
        )
```

```
    # Format time
    def format(self, fmt):
        return self.render("format(\"%s\")" % fmt)

    def calendar(self):
        return self.render("calendar()")

    def fromNow(self):
        return self.render("fromNow()")
```

You can add as many `Moment.js` methods as you want to parse to the preceding class, as and when they're needed. Now, in your `app.py` file, set the following created class to the Jinja environment variables:

```
# Set jinja template global
app.jinja_env.globals['momentjs'] = momentjs
```

You can now use the class in templates, as shown in the following example. Make sure that `timestamp` is an instance of a JavaScript `date` object:

```
<p>Current time: {{ momentjs(timestamp).calendar() }}</p>
<br/>
<p>Time: {{momentjs(timestamp).format('YYYY-MM-DD
  HH:mm:ss')}}</p>
<br/>
<p>From now: {{momentjs(timestamp).fromNow()}}</p>
```

How it works...

The output of the preceding HTML is shown in the following screenshot. Note how the formatting varies for each statement.

Current time: Today at 12:02 PM

Time: 2023-03-28 12:02:40

From now: a few seconds ago

Figure 2.7 – Datetime formatting using momentjs

There's more...

You can read more about the `Moment.js` library at `http://momentjs.com/`.

3
Data Modeling in Flask

This chapter covers one of the most important aspects of any application, which is the interaction with the database systems. In this chapter, you will see how Flask can connect to database systems, define models, and query the databases for the retrieval and feeding of data. Flask has been designed to be flexible enough to support any database. The simplest way would be to use the direct `SQLite3` package, which is a *DB-API 2.0* interface and does not give an actual **object-relational mapping** (**ORM**). Here, we need to write SQL queries to talk with the database. This approach is not recommended for large projects, as it can eventually become a nightmare to maintain the application. Also, with this approach, the models are virtually non-existent and everything happens in the view functions, and it is not a good practice to write database queries in your view functions.

In this chapter, we will talk about creating an ORM layer for our Flask applications with SQLAlchemy for relational database systems, which is recommended and widely used for applications of any size. Also, we will have a glance over how to write a Flask app with a NoSQL database system.

> **Information**
> ORM implies how our application's data models store and deal with data at a conceptual level. A powerful ORM makes the designing and querying of business logic easy and streamlined.

In this chapter, we will cover the following recipes:

- Creating an SQLAlchemy DB instance
- Creating a basic product model
- Creating a relational category model
- Migrating databases using Alembic and Flask-Migrate
- Indexing model data with Redis
- Opting for the NoSQL way with MongoDB

Creating an SQLAlchemy DB instance

SQLAlchemy is a Python SQL toolkit and provides ORM, which combines the flexibility and power of SQL with the feel of Python's object-oriented nature. In this recipe, we will understand how to create an SQLAlchemy database instance that can be used to perform any database operation that shall be covered in future recipes.

Getting ready

Flask-SQLAlchemy is the extension that provides the SQLAlchemy interface for Flask. This extension can simply be installed by using `pip` as follows:

```
$ pip install flask-sqlalchemy
```

The first thing to keep in mind with Flask-SQLAlchemy is the application configuration parameter, which tells SQLAlchemy about the location of the database to be used:

```
app.config['SQLALCHEMY_DATABASE_URI'] =
  os.environ('DATABASE_URI')
```

`SQLALCHEMY_DATABASE_URI` is a combination of the database protocol, any authentication needed, and also the name of the database. In the case of SQLite, this would look something like the following:

```
sqlite:////tmp/test.db
```

In the case of PostgreSQL, it would look like the following:

```
postgresql://yourusername:yourpassword@localhost/yournewdb
```

This extension then provides a class named `Model`, which helps define models for our application. Read more about database URLs at `https://docs.sqlalchemy.org/en/14/core/engines.html#database-urls`.

> **Tip**
>
> The SQLite database URI is OS-specific, meaning the URI would be different for Unix/macOS/Linux and Windows. Please refer to the documentation at `https://docs.sqlalchemy.org/en/14/core/engines.html#sqlite` for more details.

> **Information**
>
> For all database systems other than SQLite, separate libraries are needed. For example, for using PostgreSQL, you need `psycopg2`.

How to do it...

Let's create a small application in this recipe to understand the basic database connection with Flask. We will build over this application in the next few recipes. Here, we will just see how to create a `db` instance and validate its existence. The file's structure would look like the following:

```
    flask_catalog/
        run.py
        my_app/
            __init__.py
```

First, we start with `flask_app/run.py`. This is the usual `run` file that we have read about previously in this book in multiple recipes:

```
from my_app import app
app.run(debug=True)
```

Then, we configure our application configuration file, `flask_app/my_app/__init__.py`:

```
from flask import Flask
from flask_sqlalchemy import SQLAlchemy

app = Flask(__name__)
app.config['SQLALCHEMY_DATABASE_URI'] =
  'sqlite:////tmp/test.db'
db = SQLAlchemy(app)

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

Here, we first configure our application to point `SQLALCHEMY_DATABASE_URI` to a specific location. Then, we create an object of `SQLAlchemy` with the name `db`. As the name suggests, this is the object that will handle all our ORM-related activities. As mentioned earlier, this object has a class named `Model`, which provides the base for creating models in Flask. Any class can just subclass or inherit the `Model` class to create models, which will act as database tables.

Now, if we open the `http://127.0.0.1:5000` URL in a browser, we will see nothing. This is because we have just configured the database connection for this application and there is nothing to be seen on the browser. However, you can always head to the location specified in `app.config` for the database location to see the newly created `test.db` file.

There's more...

Sometimes, you may want a single SQLAlchemy `db` instance to be used across multiple applications, or to create an application dynamically. In such cases, it is not preferable to bind the `db` instance to a single application. Here, you will have to work with the application context to achieve the desired outcome.

In this case, register the application with SQLAlchemy differently, as follows:

```
from flask import Flask
from flask_sqlalchemy import SQLAlchemy

db = SQLAlchemy()

def create_app():
    app = Flask(__name__)
    db.init_app(app)
    return app
```

> **Tip**
> The preceding approach can be taken up while initializing the app with any Flask extension and is very common when dealing with real-life applications.

Now, all the operations that were earlier possible globally with the `db` instance will require a Flask application context at all times.

The Flask application context is as follows:

```
>>> from my_app import create_app
>>> app = create_app()
>>> app.test_request_context().push()
>>> # Do whatever needs to be done
>>> app.test_request_context().pop()
```

Or, you can use context manager, as follows:

```
with app():
# We have flask application context now till we are inside the with
block
```

See also

The next couple of recipes will extend the current application to make a complete application, which will help us to understand the ORM layer better.

Creating a basic product model

In this recipe, we will create an application that will help us to store products to be displayed on the catalog section of a website. It should be possible to add products to the catalog and then delete them as and when required. As you saw in the last chapter, this is possible to do using non-persistent storage as well. Here, however, we will store data in a database to have persistent storage.

How to do it...

The new directory layout would appear as follows:

```
    flask_catalog/
        run.py
        my_app/
            __init__.py
            catalog/
                __init__.py
                views.py
                models.py
```

First of all, start by modifying the application configuration file, `flask_catalog/my_app/__init__.py`:

```
from flask import Flask
from flask_sqlalchemy import SQLAlchemy

app = Flask(__name__)
app.config['SQLALCHEMY_DATABASE_URI'] =
    'sqlite:////tmp/test.db'
db = SQLAlchemy(app)

from my_app.catalog.views import catalog
app.register_blueprint(catalog)

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

The last statement in the file is `db.create_all()`, which tells the application to create all the tables in the database specified. So, as soon as the application runs, all the tables will be created if they are not already there. Since you are not in an application request at this point, create a context manually using `with app.app_context():`.

Now is the time to create models that are placed in `flask_catalog/my_app/catalog/models.py`:

```
from my_app import db

class Product(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(255))
    price = db.Column(db.Float)

    def __init__(self, name, price):
```

```
        self.name = name
        self.price = price

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

In this file, we have created a model named `Product`, which has three fields, namely `id`, `name`, and `price`. `id` is a self-generated field in the database, which will store the ID of the record and is the primary key. `name` is a field of the `string` type, and `price` is a field of the `float` type.

Now, add a new file for views, which is `lask_catalog/my_app/catalog/views.py`. In this file, we have multiple view methods, which control how we deal with the product model and the web application in general.

```
from flask import request, jsonify, Blueprint
from my_app import db
from my_app.catalog.models import Product

catalog = Blueprint('catalog', __name__)

@catalog.route('/')
@catalog.route('/home')
def home():
    return "Welcome to the Catalog Home."
```

The preceding method handles how the home page or the application landing page looks or responds to users. You would most probably want to use a template for rendering this in your applications. We will cover this in the next chapter.

Have a look at the following code:

```
@catalog.route('/product/<id>')
def product(id):
    product = Product.query.get_or_404(id)
    return 'Product - %s, $%s' % (product.name,
      product.price)
```

The preceding method controls the output to be shown when a user looks for a specific product using its ID. We filter for the product using the ID and then return its information if a product is found, or else abort with a `404` error.

Consider the following code:

```
@catalog.route('/products')
def products():
    products = Product.query.all()
    res = {}
```

```
    for product in products:
        res[product.id] = {
            'name': product.name,
            'price': str(product.price)
        }
    return jsonify(res)
```

The preceding method returns a list of all products in the database in JSON format. If no product is found, it simply returns an empty JSON: { }.

Consider the following code:

```
@catalog.route('/product-create', methods=['POST',])
def create_product():
    name = request.form.get('name')
    price = request.form.get('price')
    product = Product(name, price)
    db.session.add(product)
    db.session.commit()
    return 'Product created.'
```

The preceding method controls the creation of a product in the database. We first get the information from the `request` object and then create a `Product` instance from this information.

Then, we add this `Product` instance to the database session and finally, use `commit` to save the record to the database.

How it works...

In the beginning, the database is empty and has no products. This can be confirmed by opening `http://127.0.0.1:5000/products` in a browser. This would result in an empty JSON response, or { }.

Now, first, we would want to create a product. For this, we need to send a `POST` request, which can easily be sent from the Python prompt using the `requests` library:

```
>>> import requests
>>> requests.post('http://127.0.0.1:5000/product-create',
data={'name': 'iPhone 5S', 'price': '549.0'})
```

To confirm whether the product is now in the database, we can again open `http://127.0.0.1:5000/products` in the browser. This time, it will show a JSON dump of the product details, which will look like this:

```
{
  "1": {
    "name": "iPhone 5S",
```

```
    "price": "549."
  }
}
```

Creating a relational category model

In our previous recipe, we created a simple product model, which had a couple of fields. In practice, however, applications are much more complex and have various relationships between their tables. These relationships can be one-to-one, one-to-many, many-to-one, or many-to-many. In this recipe, we will try to understand some of these relationships with the help of an example.

How to do it...

Let's say we want to have product categories where each category can have multiple products, but each product should have only one category. Let's do this by modifying some files from the application in the last recipe. We will make modifications to both models and views. In models, we will add a `Category` model, and, in views, we will add new methods to handle category-related calls and also modify the existing methods to accommodate the newly added feature.

First, modify the `models.py` file to add the `Category` model and make some modifications to the `Product` model:

```
from my_app import db

class Product(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(255))
    price = db.Column(db.Float)
    category_id = db.Column(db.Integer,
      db.ForeignKey('category.id'))
    category = db.relationship(
        'Category', backref=db.backref('products',
          lazy='dynamic')
    )

    def __init__(self, name, price, category):
        self.name = name
        self.price = price
        self.category = category

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

In the preceding `Product` model, check the newly added fields for `category_id` and `category`. `category_id` is the foreign key to the `Category` model, and `category` represents the relationship table. As evident from the definitions themselves, one of them is a relationship, and the other uses this relationship to store the foreign key value in the database. This is a simple many-to-one relationship from `product` to `category`. Also, notice the `backref` argument in the `category` field; this argument allows us to access products from the `Category` model by writing something as simple as `category.products` in our views. This acts like a one-to-many relationship from the other end.

> **Important information**
>
> Just adding the field to the model would not get reflected in the database right away. You might need to drop the whole database and then run the application again or run migrations, which shall be covered in the next recipe, *Migrating databases using Alembic and Flask-Migrate*.
>
> For SQLite, you can simply delete the database file that was created while initializing the application.

Create a `Category` model that has just one field called `name`:

```
class Category(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(100))

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

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

Now, modify `views.py` to accommodate the change in the models. Make the first change in the `products()` method:

```
from my_app.catalog.models import Product, Category

@catalog.route('/products')
def products():
    products = Product.query.all()
    res = {}
    for product in products:
        res[product.id] = {
            'name': product.name,
            'price': product.price,
            'category': product.category.name
        }
    return jsonify(res)
```

Here, we have just one change where we send the `category` name in the product's JSON data, which is being generated to be returned as a response when a request is made to the preceding endpoint.

Change the `create_product()` method to look for the category before creating the product:

```
@catalog.route('/product-create', methods=['POST',])
def create_product():
    name = request.form.get('name')
    price = request.form.get('price')
    categ_name = request.form.get('category')
    category =
      Category.query.filter_by(name=categ_name).first()
    if not category:
        category = Category(categ_name)
    product = Product(name, price, category)
    db.session.add(product)
    db.session.commit()
    return 'Product created.'
```

Here, we will first search for an existing category with the category name in the request. If an existing category is found, we will use the same in the product creation; otherwise, we will create a new category.

Create a new method, `create_category()`, to handle the creation of a category:

```
@catalog.route('/category-create', methods=['POST',])
def create_category():
    name = request.form.get('name')
    category = Category(name)
    db.session.add(category)
    db.session.commit()
    return 'Category created.'
```

The preceding code is a relatively simple method for creating a category using the name provided in the request.

Create a new method, `categories()`, to handle the listing of all categories and corresponding products:

```
@catalog.route('/categories')
def categories():
    categories = Category.query.all()
    res = {}
    for category in categories:
        res[category.id] = {
            'name': category.name
        }
        for product in category.products:
            res[category.id]['products'] = {
```

```
                'id': product.id,
                'name': product.name,
                'price': product.price
            }
    return jsonify(res)
```

The preceding method does a bit of tricky stuff. Here, we fetched all the categories from the database and then, for each category, we fetched all the products and then returned all the data as a JSON dump.

How it works...

This recipe works very similarly to the preceding recipe, *Creating a basic product model*.

To create a product with a category, make a `POST` request to the `/product-create` endpoint:

```
>>> import requests
>>> requests.post('http://127.0.0.1:5000/product-create',
data={'name': 'iPhone 5S', 'price': '549.0', 'category': 'Phones'})
```

To view how the data now looks when fetched from the database, open `http://127.0.0.1:5000/categories` in your browser:

```
{
  "1": {
    "name": "Phones",
    "products": {
      "id": 1,
      "name": "iPhone 5S",
      "price": 549.0
    }
  }
}
```

See also

Refer to the *Creating a basic product model* recipe to understand the context of this recipe and how this recipe works for a browser, given that its workings are very similar to the previous one.

Migrating databases using Alembic and Flask-Migrate

Updating database schema is an important use case for all applications, as it involves adding or removing tables and/or columns or changing column types. One way is to drop the database and then create a new one using `db.drop_all()` and `db.create_all()`. However, this approach cannot be followed for applications in production or even in staging. We would like to migrate our database to match the newly updated model with all the data intact.

For this, we have **Alembic**, a Python-based tool for managing database migrations, which uses SQLAlchemy as the underlying engine. Alembic provides automatic migrations to a great extent with some limitations (of course, we cannot expect any tool to be seamless). As the icing on the cake, we have a Flask extension called **Flask-Migrate**, which eases the process of migrations even more. In this recipe, we will cover the basics of database migration techniques using Alembic and Flask-Migrate.

Getting ready

First of all, run the following command to install `Flask-Migrate`:

```
$ pip install Flask-Migrate
```

This will also install Alembic, among a number of other dependencies.

How to do it...

To enable migrations, we need to modify our app definition a bit. Let's understand how such a config appears if we modify the same for our `catalog` application:

The following lines of code show how `my_app/__init__.py` appears:

```
from flask import Flask
from flask_sqlalchemy import SQLAlchemy
from flask_migrate import Migrate

app = Flask(__name__)
app.config['SQLALCHEMY_DATABASE_URI'] =
  'sqlite:////tmp/test.db'
db = SQLAlchemy(app)
migrate = Migrate(app, db)

from my_app.catalog.views import catalog
app.register_blueprint(catalog)

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

If we pass `--help` to the `flask` command while running it as a script, the terminal will show all the available options, as shown in the following screenshot:

```
Usage: flask [OPTIONS] COMMAND [ARGS]...

  A general utility script for Flask applications.

  An application to load must be given with the '--app' option, 'FLASK_APP'
  environment variable, or with a 'wsgi.py' or 'app.py' file in the current
  directory.

Options:
  -e, --env-file FILE   Load environment variables from this file. python-
                        dotenv must be installed.
  -A, --app IMPORT      The Flask application or factory function to load, in
                        the form 'module:name'. Module can be a dotted import
                        or file path. Name is not required if it is 'app',
                        'application', 'create_app', or 'make_app', and can be
                        'name(args)' to pass arguments.
  --debug / --no-debug  Set debug mode.
  --version             Show the Flask version.
  --help                Show this message and exit.

Commands:
  db      Perform database migrations.
  routes  Show the routes for the app.
  run     Run a development server.
  shell   Run a shell in the app context.
```

Figure 3.1 – Database migration option

To initialize migrations, run the `init` command:

```
$ flask db init
```

Important information

For the migration commands to work, the Flask application should be locatable; otherwise, you will get the following error:

```
Error: Could not locate a Flask application. Use the 'flask
--app' option, 'FLASK_APP' environment variable, or a 'wsgi.
py' or 'app.py' file in the current directory.
```

In our case, simply export the Flask application to the environment variable:

```
export FLASK_APP="my_app.__init__.py"
```

Or, simply with the following:

```
export FLASK_APP=my_app
```

Once changes are made to the models, call the `migrate` command:

```
$ flask db migrate
```

To make the changes reflect on the database, call the `upgrade` command:

```
$ flask db upgrade
```

How it works...

Now, let's say we modify the model of our `product` table to add a new field called

`company`, as shown here:

```
class Product(db.Model):
    # Same Product model as last recipe
    # ...
    company = db.Column(db.String(100))
```

The result of `migrate` will be something like the following snippet:

```
$ flask db migrate
INFO  [alembic.runtime.migration] Context impl SQLiteImpl.
INFO  [alembic.runtime.migration] Will assume non-transactional DDL.
INFO  [alembic.autogenerate.compare] Detected added column 'product.
company'
Generating
<path/to/application>/flask_catalog/migrations/versions/2c08f71f9253_.
py
... done
```

In the preceding code, we can see that Alembic compares the new model with the database table and detects a newly added column for `company` in the `product` table (created by the `Product` model).

Similarly, the output of `upgrade` will be something like the following snippet:

```
$ flask db upgrade
INFO  [alembic.runtime.migration] Context impl SQLiteImpl.
INFO  [alembic.runtime.migration] Will assume non-transactional DDL.
INFO  [alembic.runtime.migration] Running upgrade None ->
2c08f71f9253, empty message
```

Here, Alembic performs the upgrade of the database for the migration detected earlier. We can see a hex code in the preceding output. This represents the revision of the migration performed. This is for internal use by Alembic to track the changes to database tables.

See also

Refer to the *Creating a basic product model* recipe for the context of this recipe around the catalog models for `product`.

Indexing model data with Redis

There may be some features we want to implement but do not want to have persistent storage for them. In such a use case, it is a good approach to have these stored in cache-like storage temporarily – for example, when we want to show a list of recently viewed products to visitors on a website. In this recipe, we will understand how to use Redis as an effective cache to store non-persistent data that can be accessed at a high speed.

Getting ready

We will do this with the help of Redis, which can be installed using the following command:

```
$ pip install redis
```

Make sure that you run the Redis server for the connection to happen. To install and run a Redis server, refer to `http://redis.io/topics/quickstart`.

Then, we need to have the connection open to Redis. This can be done by adding the following lines of code to `my_app/__init__.py`:

```
from redis import Redis
redis = Redis()
```

We can do this in our application file, where we will define the app, or in the views file, where we will use it. It is preferred that you do this in the application file because then, the connection will be open throughout the application, and the `redis` object can be used by just importing it where required.

How to do it...

We will maintain a `set` in Redis, which will store the products visited recently. This will be populated whenever a product is visited. The entry will expire in 10 minutes. This change goes in `views.py`:

```
@catalog.route('/product/<id>')
def product(id):
    product = Product.query.get_or_404(id)
    product_key = 'product-%s' % product.id
    redis.set(product_key, product.name)
    redis.expire(product_key, 600)
    return 'Product - %s, $%s' % (product.name,
      product.price)
```

In the preceding method, note the `set()` and `expire()` methods on the `redis` object. First, set the product ID using the `product_key` value in the Redis store. Then, set the `expire` time of the key to `600` seconds.

> **Tip**
>
> It would be a good practice to fetch the `expire` time – that is, `600` – from a configuration value. This can be set on the application object in `my_app/__init__.py`, and can then be fetched from there.

Now, we will look for the keys that are still alive in the cache and then fetch the products corresponding to these keys and return them:

```
@catalog.route('/recent-products')
def recent_products():
    keys_alive = redis.keys('product-*')
    products = [redis.get(k).decode('utf-8') for k in
      keys_alive]
    return jsonify({'products': products})
```

How it works...

An entry is added to the store whenever a user visits a product, and the entry is kept there for 600 seconds (10 minutes). Now, this product will be listed in the recent products list for the next 10 minutes unless it is visited again, which will reset the time to 10 minutes again.

To test this, add a few products to your database:

```
>>> requests.post('http://127.0.0.1:5000/product-create',
data={'name': 'iPhone 5S', 'price': '549.0', 'category': 'Phones'})
>>> requests.post('http://127.0.0.1:5000/product-create',
data={'name': 'iPhone 13', 'price': '799.0', 'category': 'Phones'})
>>> requests.post('http://127.0.0.1:5000/product-create',
data={'name': 'iPad Pro', 'price': '999.0', 'category': 'Tablets'})
>>> requests.post('http://127.0.0.1:5000/product-create',
data={'name': 'iPhone 5S', 'price': '549.0', 'category': 'Phones'})
```

Then, visit some products by simply opening the product URLs in the browser – for example, `http://127.0.0.1:5000/product/1` and `http://127.0.0.1:5000/product/3`.

Now, open `http://127.0.0.1:5000/recent-products` in the browser to view the list of recent products:

```
{
  "products": [
    "iPad Pro",
    "iPhone 5S"
  ]
}
```

Opting for the NoSQL way with MongoDB

Sometimes, the data to be used in the application we are building may not be structured at all; it may be semi-structured, or there may be some data whose schema changes frequently over time. In such cases, we would refrain from using an RDBMS, as it adds to the pain and is difficult to scale and maintain. For such cases, it would be desirable to use a NoSQL database.

Also, as a result of fast and quick development in the currently prevalent development environment, it is not always possible to design the perfect schema the first time. NoSQL provides the flexibility to modify the schema without much hassle.

In production environments, the database usually grows to a huge size over a period of time. This drastically affects the performance of the overall system. Vertical and horizontal scaling techniques are available, but they can be very costly at times. In such cases, a NoSQL database can be considered, as it is designed from scratch for similar purposes. The ability of NoSQL databases to run on large multiple clusters and handle huge volumes of data generated with high velocity makes them a good choice when looking to handle scaling issues with traditional RDBMSes.

In this recipe, we will use MongoDB to learn how to integrate NoSQL with Flask.

Getting ready

There are many extensions available for using Flask with MongoDB. We will use `Flask-MongoEngine`, as it provides a good level of abstraction, which makes it easy to understand. It can be installed using the following command:

```
$ pip install flask-mongoengine
```

Remember to run the MongoDB server for the connection to happen. For more details on installing and running MongoDB, refer to `http://docs.mongodb.org/manual/installation/`.

How to do it...

First, manually create a database in MongoDB using the command line. Let's name this database `my_catalog`:

```
>>> mongosh
Current Mongosh Log ID:  62fa8dtfd435df654150997b
Connecting to:  mongodb://127.0.0.1:27017/?directConnection
=true&serverSelectionTimeoutMS=2000&appName=mongosh+1.5.4
Using MongoDB:    6.0.0
Using Mongosh:    1.5.4

test> use my_catalog
switched to db my_catalog
```

The following is a rewrite of our catalog application using MongoDB. The first change comes to our configuration file, `my_app/__init__.py`:

```
from flask import Flask
from flask_mongoengine import MongoEngine


app = Flask(__name__)
app.config['MONGODB_SETTINGS'] = {'DB': 'my_catalog'}
app.debug = True
db = MongoEngine(app)


from my_app.catalog.views import catalog
app.register_blueprint(catalog)
```

> **Information**
>
> Note that instead of the usual SQLAlchemy-centric settings, we now have `MONGODB_SETTINGS`. Here, we just specify the name of the database to use, which, in our case, is `my_catalog`.

Next, we will create a `Product` model using MongoDB fields. This happens as usual in the models file, `my_app/catalog/models.py`:

```
import datetime
from my_app import db


class Product(db.Document):
    created_at = db.DateTimeField(
        default=datetime.datetime.now, required=True
```

```
    )
    key = db.StringField(max_length=255, required=True)
    name = db.StringField(max_length=255, required=True)
    price = db.DecimalField()

    def __repr__(self):
        return '<Product %r>' % self.id
```

Important information

Now would be a good time to look at the MongoDB fields used to create the preceding model and their similarity to the SQLAlchemy fields used in the previous recipes. Here, instead of an `ID` field, we have a `key`, which stores the unique identifier that will be used to uniquely identify a record. Also, note the class that is inherited by `Product` while creating the model. In the case of SQLAlchemy, it is `db.Model`, and in the case of MongoDB, it is `db.Document`. This is in accordance with how these database systems work. SQLAlchemy works with conventional RDBMSes, but MongoDB is a NoSQL document database system.

The following is the views file, namely, `my_app/catalog/views.py`:

```
from decimal import Decimal
from flask import request, Blueprint, jsonify
from my_app.catalog.models import Product

catalog = Blueprint('catalog', __name__)

@catalog.route('/')
@catalog.route('/home')
def home():
    return "Welcome to the Catalog Home."

@catalog.route('/product/<key>')
def product(key):
    product = Product.objects.get_or_404(key=key)
    return 'Product - %s, $%s' % (product.name,
      product.price)

@catalog.route('/products')
def products():
    products = Product.objects.all()
    res = {}
    for product in products:
        res[product.key] = {
            'name': product.name,
            'price': str(product.price),
```

```
        }
    return jsonify(res)

@catalog.route('/product-create', methods=['POST',])
def create_product():
    name = request.form.get('name')
    key = request.form.get('key')
    price = request.form.get('price')
    product = Product(
        name=name,
        key=key,
        price=Decimal(price)
    )
    product.save()
    return 'Product created.'
```

You will notice that it is very similar to the views created for the SQLAlchemy-based models. There are just a few differences in the methods that are called from the MongoEngine extension, and these should be easy to understand.

How it works...

First, add products to the database by using the `/product-create` endpoint:

```
>>> res = requests.post('http://127.0.0.1:5000/product-create',
data={'key': 'iphone-5s', 'name': 'iPhone 5S', 'price': '549.0'})
```

Now, validate the product addition by visiting the `http://127.0.0.1:5000/products` endpoint in the browser. The following is the resultant JSON value:

```
{
  "iphone-5s": {
    "name": "iPhone 5S",
    "price": "549.00"
  }
}
```

See also

Refer to the *Creating a basic product model* recipe to understand how this application is structured.

4
Working with Views

With any web application, it is very important to control how you interact with web requests and the proper responses to cater to these requests. This chapter takes us through the various methods of handling requests properly and designing them in the best way.

Flask offers several ways of designing and laying out URL routing for our applications. Also, it gives us the flexibility to keep the architecture of our views as just functions or to create classes, which can be inherited and modified as required. In earlier versions, Flask just had function-based views. Later, however, in Version 0.7, inspired by Django, Flask introduced the concept of pluggable views, which allows us to have classes and then write methods in these classes. This also makes the process of building a RESTful API pretty straightforward, with every HTTP method being handled by the corresponding class method. Also, we can always go a level deeper into the Werkzeug library and use the more flexible, but slightly complex, concept of URL maps. In fact, large applications and frameworks prefer using URL maps.

In this chapter, we will cover the following recipes:

- Writing function-based views and URL routes
- Writing class-based views
- Implementing URL routing and product-based pagination
- Rendering to templates
- Dealing with XHR requests
- Using decorators to handle requests beautifully
- Creating custom 4xx and 5xx error handlers
- Flashing messages for better user feedback
- Implementing SQL-based searching

Writing function-based views and URL routes

This is the simplest way of writing views and URL routes in Flask. We can just write a method and decorate it with the endpoint. In this recipe, we will write a few URL routes for `GET` and `POST` requests.

Getting ready

To go through this recipe, we can start with any Flask application. The app can be a new, empty, or complex app. We just need to understand the methods outlined in this recipe.

How to do it...

The following section explains the three most widely used different kinds of requests, demonstrated by means of small examples.

A simple GET request

The following is a simple example of what a `GET` request looks like:

```
@app.route('/a-get-request')
def get_request():
    bar = request.args.get('foo', 'bar')
    return 'A simple Flask request where foo is %s' % bar
```

Here, we just check whether the URL query has an argument called `foo`. If yes, we display this in the response; otherwise, the default is `bar`.

A simple POST request

`POST` is similar to the `GET` request, but with a few differences:

```
@app.route('/a-post-request', methods=['POST'])
def post_request():
    bar = request.form.get('foo', 'bar')
    return 'A simple Flask request where foo is %s' % bar
```

The route now contains an extra argument called `methods`. Also, instead of `request.args`, we now use `request.form`, as `POST` assumes that the data is submitted in a form.

A simple GET/POST request

An amalgamation of both `GET` and `POST` into a single `view` function can be written as shown here:

```
@app.route('/a-request', methods=['GET', 'POST'])
def some_request():
    if request.method == 'GET':
```

```
        bar = request.args.get('foo', 'bar')
    else:
        bar = request.form.get('foo', 'bar')
    return 'A simple Flask request where foo is %s' % bar
```

How it works...

Let's try to understand how the preceding play of methods works.

By default, any Flask `view` function supports only `GET` requests. In order to support or handle any other kind of request, we have to specifically tell our `route()` decorator about the methods we want to support. This is precisely what we did in our last two methods for `POST` and `GET/POST`.

For `GET` requests, the `request` object will look for `args` – that is, `request.args.get()` – and for `POST`, it will look for `form` – that is, `request.form.get()`.

Also, if we try to make a `GET` request to a method that supports only `POST`, the request will fail with a `405` HTTP error. The same holds true for all the methods. Refer to the following screenshot:

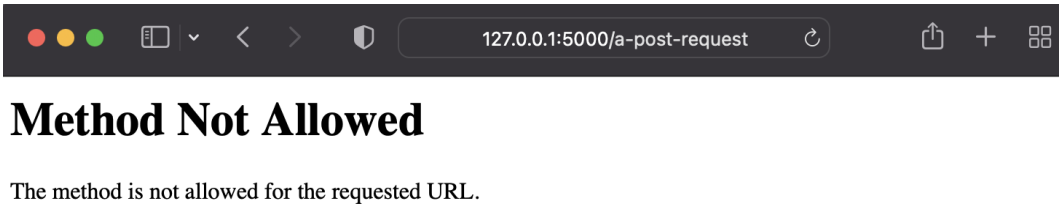


Figure 4.1 – The Method Not Allowed error page

There's more...

Sometimes, we might want to have a URL map kind of a pattern, where we prefer to define all the URL rules with endpoints in a single place, rather than them being scattered all around an application. For this, we will need to define our methods without the `route()` decorator and define the route on our application object, as shown here:

```
def get_request():
    bar = request.args.get('foo', 'bar')
    return 'A simple Flask request where foo is %s' % bar

app = Flask(__name__)
app.add_url_rule('/a-get-request', view_func=get_request)
```

Make sure that you give the correct relative path to the method assigned to `view_func`.

Writing class-based views

Flask introduced the concept of pluggable views in *Version 0.7*; this added a lot of flexibility to the existing implementation. We can write views in the form of classes; these views can be written in a generic fashion and allow for easy and understandable inheritance. In this recipe, we will look at how to create such class-based views.

Getting ready

Refer to the previous recipe, *Writing function-based views and URL routes*, to see the basic function-based views first.

How to do it...

Flask provides a class named `View`, which can be inherited to add our custom behavior. The following is an example of a simple `GET` request:

```
from flask.views import View

class GetRequest(View):
    def dispatch_request(self):
        bar = request.args.get('foo', 'bar')
        return 'A simple Flask request where foo is %s' %
          bar

app.add_url_rule(
    '/a-get-request',
      view_func=GetRequest.as_view('get_request')
)
```

The name of the view provided in `as_view` (i.e., `get_request`) signifies the name that will be used when referring to this endpoint in `url_for()`.

To accommodate both the `GET` and `POST` requests, we can write the following code:

```
class GetPostRequest(View):
    methods = ['GET', 'POST']
    def dispatch_request(self):
        if request.method == 'GET':
            bar = request.args.get('foo', 'bar')
        if request.method == 'POST':
            bar = request.form.get('foo', 'bar')
        return 'A simple Flask request where foo is %s' %
          bar
```

```
app.add_url_rule(
    '/a-request',
    view_func=GetPostRequest.as_view('a_request')
)
```

How it works...

We know that by default, any Flask `view` function supports only `GET` requests. The same applies to class-based views. In order to support or handle any other kind of request, we have to specifically tell our class, via a class attribute called `methods`, about the `HTTP` methods we want to support. This is exactly what we did in our last example of `GET/POST` requests.

For `GET` requests, the `request` object will look for `args` – that is, `request.args.get()` – and for `POST`, it will look for `form` – that is, `request.form.get()`.

Also, if we try to make a `GET` request to a method that supports only `POST`, the request will fail with a `405` HTTP error. The same holds true for all the methods.

There's more...

Now, many of you may be considering whether it would be possible to just declare the `GET` and `POST` methods inside a `View` class and let Flask handle the rest of the stuff. The answer to this question is `MethodView`. Let's write our previous snippet using `MethodView`:

```
from flask.views import MethodView

class GetPostRequest(MethodView):

    def get(self):
        bar = request.args.get('foo', 'bar')
        return 'A simple Flask request where foo is %s' %
          bar

    def post(self):
        bar = request.form.get('foo', 'bar')
        return 'A simple Flask request where foo is %s' %
          bar

app.add_url_rule(
    '/a-request',
    view_func=GetPostRequest.as_view('a_request')
)
```

See also

Refer to the previous recipe, *Writing function-based views and URL routes*, to understand the contrast between class- and function-based views.

Implementing URL routing and product-based pagination

At times, we may encounter a problem where there is a need to parse the various parts of a URL differently. For example, a URL can have an integer part, a string part, a string part of a specific length, and slashes in the URL. We can parse all these combinations in our URLs using URL converters. In this recipe, we will see how to do this. Also, we will learn how to implement pagination using the `Flask-SQLAlchemy` extension.

Getting ready

We have already seen several instances of basic URL converters in this book. In this recipe, we will look at some advanced URL converters and learn how to use them.

How to do it...

Let's say we have a URL route defined as follows:

```
@app.route('/test/<name>')
def get_name(name):
    return name
```

Here, the URL, `http://127.0.0.1:5000/test/Shalabh`, will result in `Shalabh` being parsed and passed in the `name` argument of the `get_name` method. This is a Unicode or string converter, which is the default one and need not be specified explicitly.

We can also have strings with specific lengths. Let's say we want to parse a URL that may contain a country code or currency code. Country codes are usually two characters long, and currency codes are three characters long. This can be done as follows:

```
@app.route('/test/<string(minlength=2,maxlength=3):code>')
def get_name(code):
    return code
```

This will match both `US` and `USD` in the URL – that is, `http://127.0.0.1:5000/test/USD` and `http://127.0.0.1:5000/test/US` will be treated similarly. We can also match the exact length using the `length` parameter instead of `minlength` and `maxlength`.

We can also parse integer values in a similar fashion:

```
@app.route('/test/<int:age>')
def get_age(age):
    return str(age)
```

We can also specify the minimum and maximum values that can be accepted. For example, to limit the acceptable age between 18 and 99, the URL can be structured as `@app.route('/test/<int(min=18,max=99):age>')`. We can also parse float values using `float` in place of `int` in the preceding example.

Let's understand the concept of **pagination** next. In the *Creating a basic product model* recipe in *Chapter 3*, *Data Modeling in Flask*, we created a handler to list all the products in our database. If we have thousands of products, then generating a list of all of these products in one go can take a lot of time. Also, if we have to render these products in a template, then we would not want to show more than 10–20 products on a page in one go. Pagination proves to be a big help in building great applications.

Let's modify the `products()` method to list products to support pagination:

```
@catalog.route('/products')
@catalog.route('/products/<int:page>')
def products(page=1):
    products = Product.query.paginate(page, 10).items
    res = {}
    for product in products:
        res[product.id] = {
            'name': product.name,
            'price': product.price,
            'category': product.category.name
        }
    return jsonify(res)
```

In the preceding handler, we added a new URL route that adds a `page` parameter to the URL. Now, the `http://127.0.0.1:5000/products` URL will be the same as `http://127.0.0.1:5000/products/1`, and both will return a list of the first 10 products from the database. The `http://127.0.0.1:5000/products/2` URL will return the next 10 products, and so on.

Information

The `paginate()` method takes four arguments and returns an object of the `Pagination` class. These four arguments are as follows:

- `page`: This is the current page to be listed.
- `per_page`: This is the number of items to be listed per page.
- `error_out`: If no items are found for the page, then this aborts with a `404` error. To prevent this behavior, set this parameter to `False`, and then it will just return an empty list.
- `max_per_page`: If this value is specified, then `per_page` will be limited to the same.

See also

Refer to the *Creating a basic product model* recipe in *Chapter 3*, *Data Modeling in Flask*, to understand the context of this recipe for pagination, as this recipe builds on top of it.

Rendering to templates

After writing the views, we will surely want to render the content in a template and get information from the underlying database.

Getting ready

To render templates, we will use `Jinja` as the templating language. Refer to *Chapter 2*, *Templating with Jinja2*, to understand templating in depth.

How to do it...

We will again work in reference to our existing catalog application from the previous recipe. Let's modify our views to render templates and then display data from the database in these templates.

The following is the modified `views.py` code and the templates. The complete app can be downloaded from the code bundle provided with this book or from the GitHub repository.

We will start by modifying our views – that is, `flask_catalog_template/my_app/catalog/views.py` – to render templates on specific handlers:

```
from flask import request, Blueprint, render_template
from my_app import db
from my_app.catalog.models import Product, Category

catalog = Blueprint('catalog', __name__)

@catalog.route('/')
@catalog.route('/home')
def home():
    return render_template('home.html')
```

Note the `render_template()` method. This method will render `home.html` when the `home` handler is called.

The following method handles the rendering of `product.html` with the `product` object in the template context:

```
@catalog.route('/product/<id>')
def product(id):
```

```
    product = Product.query.get_or_404(id)
    return render_template('product.html', product=product)
```

To get the paginated list of all products, see the following method:

```
@catalog.route('/products')
@catalog.route('/products/<int:page>')
def products(page=1):
    products = Product.query.paginate(page, 10)
    return render_template('products.html',
      products=products)
```

Here, the `products.html` template will be rendered with the list of paginated `product` objects in the context.

To render the product template on the creation of a new product, the `create_product()` method can be modified, as shown here:

```
@catalog.route('/product-create', methods=['POST',])
def create_product():
    # ...Same code as before ...
    return render_template('product.html', product=product)
```

This can also be done using `redirect()`, but we will cover this at a later stage. Have a look at the following code:

```
@catalog.route('/category-create', methods=['POST',])
def create_category():
    # ...Same code as before ...
    return render_template('category.html',
      category=category)

@catalog.route('/category/<id>')
def category(id):
    category = Category.query.get_or_404(id)
    return render_template('category.html',
      category=category)

@catalog.route('/categories')
def categories():
    categories = Category.query.all()
    return render_template(
        'categories.html', categories=categories)
```

All three handlers in the preceding code work in a similar way, as discussed earlier when rendering the product-related templates.

The following are all the templates created and rendered as part of the application. For more information on how these templates are written and how they work, refer to *Chapter 2*, *Templating with Jinja2*.

The first template file is `flask_catalog_template/my_app/templates/base.html`, as follows:

```
<!DOCTYPE html>
<html lang="en">
  <head>
    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width,
      initial-scale=1">
    <title>Flask Framework Cookbook</title>
    <link href="{{ url_for('static', filename
      ='css/bootstrap.min.css') }}" rel="stylesheet">
    <link href="{{ url_for('static', filename
      ='css/main.css') }}" rel="stylesheet">
  </head>
  <body>
    <div class="navbar navbar-inverse navbar-fixed-top"
      role="navigation">
      <div class="container">
        <div class="navbar-header">
          <a class="navbar-brand" href="{{ url_for
            ('catalog.home') }}">Flask Cookbook</a>
        </div>
      </div>
    </div>
    <div class="container">
    {% block container %}{% endblock %}
    </div>

    <!-- jQuery (necessary for Bootstrap's JavaScript
      plugins) -->
    <script src="https://ajax.googleapis.com/ajax/libs
      /jquery/2.0.0/jquery.min.js"></script>
    <script src="{{ url_for('static', filename
      ='js/bootstrap.min.js') }}"></script>
  </body>
</html>
```

The `flask_catalog_template/my_app/templates/home.html` file appears as follows:

```
{% extends 'base.html' %}

{% block container %}
  <h1>Welcome to the Catalog Home</h1>
  <a href="{{ url_for('catalog.products') }}">Click here to
    see the catalog</a>
{% endblock %}
```

The `flask_catalog_template/my_app/templates/product.html` file appears as follows:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <h1>{{ product.name }}<small> {{ product.category.name
      }}</small></h1>
    <h4>{{ product.company }}</h4>
    <h3>{{ product.price }}</h3>
  </div>
{% endblock %}
```

The `flask_catalog_template/my_app/templates/products.html` file appears as follows:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    {% for product in products.items %}
      <div class="well">
        <h2>
          <a href="{{ url_for('catalog.product', id
            =product.id) }}">{{ product.name }}</a>
          <small>$ {{ product.price }}</small>
        </h2>
      </div>
    {% endfor %}
    {% if products.has_prev %}
      <a href="{{ url_for(request.endpoint, page
        =products.prev_num) }}">
        {{"<< Previous Page"}}
      </a>
    {% else %}
      {{"<< Previous Page"}}
```

```
    {% endif %} |
    {% if products.has_next %}
      <a href="{{ url_for(request.endpoint, page
        =products.next_num) }}">
        {{"Next page >>"}}
      </a>
    {% else %}
      {{"Next page >>"}}
    {% endif %}
  </div>
{% endblock %}
```

Note how the URL is being created for the `Previous page` and `Next page` links. We are using `request.endpoint` so that pagination works for the current URL, which will make the template reusable with `search` as well. We will see this later in this chapter.

The `flask_catalog_template/my_app/templates/category.html` file appears as follows:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <h2>{{ category.name }}</h2>
    <div class="well">
      {% for product in category.products %}
        <h3>
          <a href="{{ url_for('catalog.product', id
            =product.id) }}">{{ product.name }}</a>
          <small>$ {{ product.price }}</small>
        </h3>
      {% endfor %}
    </div>
  </div>
{% endblock %}
```

The `flask_catalog_template/my_app/templates/categories.html` file appears as follows:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    {% for category in categories %}
    <a href="{{ url_for('catalog.category',
      id=category.id) }}">
```

```
      <h2>{{ category.name }}</h2>
    </a>
    {% endfor %}
  </div>
{% endblock %}
```

How it works...

Our `view` methods have a `render_template` method call at the end. This means that following the successful completion of the method operations, we will render a template with some parameters added to the context.

> **Information**
>
> Note how pagination has been implemented in the `products.html` file. It can be improved further to show the page numbers as well between the two links for navigation. You should undertake this on your own.

See also

Refer to the *Implementing URL routing and product-based pagination* recipe to understand pagination and the remainder of the application used in this recipe.

Dealing with XHR requests

Asynchronous JavaScript, commonly known as **Ajax**, has become an important part of web applications over the last decade or so. The built-in **XMLHttpRequest** (**XHR**) object in a browser is used to execute Ajax on web pages. With the advent of single-page applications and JavaScript application frameworks such as **Angular**, **Vue**, and **React**, this technique of web development has risen exponentially. In this recipe, we will implement an Ajax request to facilitate asynchronous communication between the backend and the frontend.

> **Note**
>
> In this book, I am opting to use Ajax to demonstrate `async` requests because it is simpler to understand and demonstrate and keeps the focus of the book on Flask. You can choose to use any JavaScript platform/framework. The Flask code would remain the same, while the JavaScript code would have to change according to the framework that you used.

Getting ready

Flask provides an easy way to handle the XHR requests in the view handlers. We can even have common methods for normal web requests and XHRs. We can just check for the `XMLHttpRequest` header in our `request` object to determine the type of call and act accordingly.

We will update the catalog application from the previous recipe to have a feature to demonstrate XHR requests.

How to do it...

The Flask `request` object has a provision to check for the headers sent along with the request from the browser. We can check the `X-Requested-With` header for `XMLHttpRequest`, which tells us whether the request made is an XHR request or a simple web request. Usually, when we have an XHR request, the caller expects the result to be in the JSON format, which can then be used to render content in the correct place on the web page without reloading the page.

So, let's say we have an Ajax call to fetch the number of products in the database on the home page itself. One way to fetch the products is to send the count of products along with the `render_template()` context. Another way is to send this information over as a response to an Ajax call. We will implement the latter to see how Flask handles XHR:

```
from flask import request, render_template, jsonify

@catalog.route('/')
@catalog.route('/home')
def home():
    if request.headers.get("X-Requested-With") ==
      "XMLHttpRequest":
        products = Product.query.all()
        return jsonify({
            'count': len(products)
        })
    return render_template('home.html')
```

In the preceding method, we first checked whether this is an XHR. If it is, we return the JSON data; otherwise, we just render `home.html`, as we have done hitherto.

> **Tip**
>
> This design of handling XHR and regular requests together in one method can become a bit bloated as the application grows in size, and different logic handling has to be executed in the case of XHR, compared to regular requests. In such cases, these two types of requests can be separated into different methods, where the handling of XHR is done separately from regular requests. This can even be extended so that we have different blueprints to make URL handling even cleaner.

Next, modify `flask_catalog_template/my_app/templates/base.html` to a block for `scripts`. This empty block, which is shown here, can be placed after the line where the `Bootstrap.js` script is included:

```
{% block scripts %}
{% endblock %}
```

Next, we have `flask_catalog_template/my_app/templates/home.html`, where we send an Ajax call to the `home()` handler, which checks whether the request is an XHR request. If it is, it fetches the count of products from the database and returns it as a JSON object. Check the code inside the `scripts` block:

```
{% extends 'base.html' %}

{% block container %}
  <h1>Welcome to the Catalog Home</h1>
  <a href="{{ url_for('catalog.products') }}"
    id="catalog_link">
    Click here to see the catalog
  </a>
{% endblock %}

{% block scripts %}
<script>
$(document).ready(function(){
  $.getJSON("/home", function(data) {
    $('#catalog_link').append('<span class="badge">' +
      data.count + '</span>');
  });
});
</script>
{% endblock %}
```

How it works...

Now, our home page contains a badge, which shows the number of products in the database. This badge will load only after the whole page has loaded. The difference in the loading of the badge and the other content on the page will be notable when the database has a substantially high number of products.

The following is a screenshot that shows what the home page looks like now:

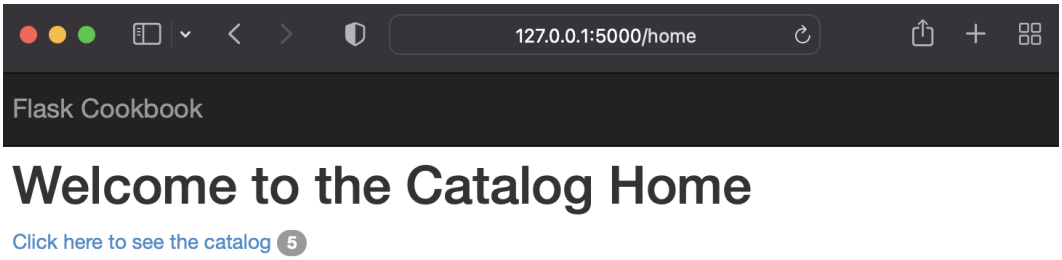


Figure 4.2 – The home page with the count loaded using AJAX calls

Using decorators to handle requests beautifully

Some of you may believe that checking every time whether a request is XHR, as shown in the last recipe, kills code readability. To solve this, we have an easy solution. In this recipe, we will write a simple decorator that can handle this redundant code for us.

Getting ready

In this recipe, we will write a decorator. For some Python beginners, this might seem like alien territory. If so, read `http://legacy.python.org/dev/peps/pep-0318/` for a better understanding of decorators.

How to do it...

The following is the decorator method that we have written for this recipe:

```
from functools import wraps

def template_or_json(template=None):
    """Return a dict from your view and this will either
    pass it to a template or render json. Use like:

    @template_or_json('template.html')
    """
    def decorated(f):
        @wraps(f)
        def decorated_fn(*args, **kwargs):
            ctx = f(*args, **kwargs)
            if request.headers.get("X-Requested-With") ==
              "XMLHttpRequest" or not template:
                return jsonify(ctx)
            else:
```

```
                return render_template(template, **ctx)
        return decorated_fn
    return decorated
```

This decorator simply does what we did in the previous recipe to handle XHR – that is, check whether our request is XHR and, based on the outcome, either render the template or return JSON data.

Now, let's apply this decorator to our `home()` method, which handled the XHR call in the last recipe:

```
@catalog.route('/')
@catalog.route('/home')
@template_or_json('home.html')
def home():
    products = Product.query.all()
    return {'count': len(products)}
```

See also

Refer to the *Dealing with XHR requests* recipe to understand how this recipe changes the coding pattern. The reference for this recipe comes from `http://justindonato.com/notebook/template-or-json-decorator-for-flask.html`.

Creating custom 4xx and 5xx error handlers

Every application throws errors to users at some point in time. These errors can be due to a user typing a non-existent URL (`404`), application overload (`500`), or something forbidden for a certain user to access (`403`). A good application handles these errors in a user-interactive way instead of showing an ugly white page, which makes no sense to most users. Flask provides an easy-to-use decorator to handle these errors. In this recipe, we will understand how we can leverage this decorator.

Getting ready

The Flask `app` object has a method called `errorhandler()`, which enables us to handle our application's errors in a much more beautiful and efficient manner.

How to do it...

Create a method that is decorated with `errorhandler()` and renders the `404.html` template whenever the `404 Not Found` error occurs:

```
@app.errorhandler(404)
def page_not_found(e):
    return render_template('404.html'), 404
```

The following lines of code represent the `flask_catalog_template/my_app/templates/404.html` template, which is rendered if there are any `404` errors:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <h3>Hola Friend! Looks like in your quest you have
      reached a location which does not exist yet.</h3>
    <h4>To continue, either check your map location (URL)
      or go back <a href="{{ url_for('catalog.home')
      }}">home</a></h4>
  </div>
{% endblock %}
```

How it works...

So, now, if we open an incorrect URL – for example, `http://127.0.0.1:5000/i-am- lost` – then we will get the screen shown in the following screenshot:

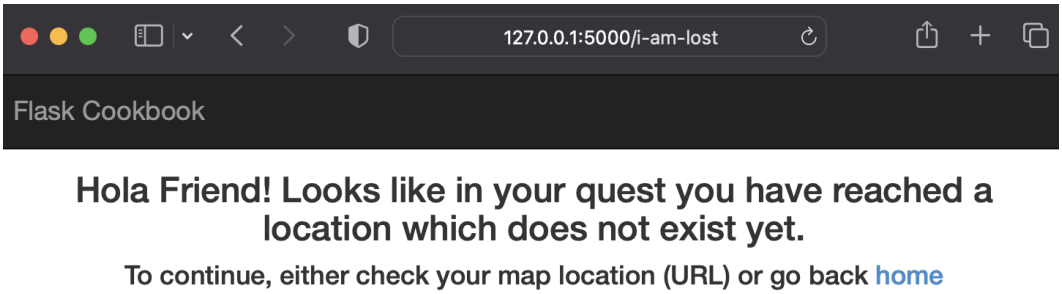


Figure 4.3 – A custom error handler page

Similarly, we can add more error handlers for other error codes too.

There's more...

It is also possible to create custom errors as per application requirements and bind them to error codes and custom error screens. This can be done as follows:

```
class MyCustom404(Exception):
    pass

@app.errorhandler(MyCustom404)
def special_page_not_found(error):
    return render_template("errors/custom_404.html"), 404
```

Flashing messages for better user feedback

An important aspect of all good web applications is to give users feedback regarding various activities. For example, when a user creates a product and is redirected to the newly created product, then it is good practice to tell them that the product has been created. In this recipe, we will see how flashing messages can be used as a good feedback mechanism for users.

Getting ready

We will start by adding the flash message functionality to our existing catalog application. We also have to make sure that we add a secret key to the application because the session depends on it, and if it's absent, the application will error out while flashing.

How to do it...

To demonstrate the flashing of messages, we will flash messages upon a product's creation.

First, we will add a secret key to our app configuration in `flask_catalog_template/my_app__init__.py`:

```
app.secret_key = 'some_random_key'
```

Now, we will modify our `create_product()` handler in `flask_catalog_template/my_app/catalog/views.py` to flash a message to the user regarding the product's creation.

Also, another change has been made to this handler; now, it is possible to create the product from a web interface using a form. This change will make it easier to demonstrate how this recipe would work.

```
@catalog.route('/product-create', methods=['GET', 'POST'])
def create_product():
    if request.method == 'POST':
        name = request.form.get('name')
        price = request.form.get('price')
        categ_name = request.form.get('category')
        category = Category.query.filter_by(
            name=categ_name).first()
        if not category:
            category = Category(categ_name)
        product = Product(name, price, category)
        db.session.add(product)
        db.session.commit()
        flash('The product %s has been created' % name,
          'success')
        return redirect(
            url_for('catalog.product', id=product.id))
    return render_template('product-create.html')
```

In the preceding method, we first check whether the request type is `POST`. If yes, then we proceed to product creation as always, or render the page with a form to create a new product. Also, note the `flash` statement, which will alert a user in the event of the successful creation of a product. The first argument to `flash()` is the message to be displayed, and the second is the category of the message. We can use any suitable identifier in the `message` category. This can be used later to determine the type of alert message to be shown.

A new template is added; this holds the code for the product form. The path of the template will be `flask_catalog_template/my_app/templates/product-create.html`:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <form
        class="form-horizontal"
        method="POST"
        action="{{ url_for('catalog.create_product') }}"
        role="form">
      <div class="form-group">
        <label for="name" class="col-sm-2 control-
          label">Name</label>
        <div class="col-sm-10">
          <input type="text" class="form-control" id="name"
            name="name">
        </div>
      </div>
      <div class="form-group">
        <label for="price" class="col-sm-2 control-
          label">Price</label>
        <div class="col-sm-10">
          <input type="number" class="form-control"
            id="price" name="price">
        </div>
      </div>
      <div class="form-group">
        <label for="category" class="col-sm-2 control-
          label">Category</label>
        <div class="col-sm-10">
          <input type="text" class="form-control"
            id="category" name="category">
        </div>
      </div>
      <button type="submit" class="btn
        btn-default">Submit</button>
```

```
    </form>
  </div>
{% endblock %}
```

We will also modify our base template – that is, `flask_catalog_template/my_app/templates/base.html` – to accommodate flashed messages. Just add the following lines of code inside the `<div>` container before the `container` block:

```
    <br/>
    <div>
      {% for category, message in
        get_flashed_messages(with_categories=true) %}
        <div class="alert alert-{{category}}
          alert-dismissable">
          <button type="button" class="close" data-dismiss
            ="alert" aria-hidden="true">&times;</button>
          {{ message }}
        </div>
      {% endfor %}
    </div>
```

Information

Note that in the `<div>` container, we have added a mechanism to show a flashed message that fetches the flashed messages in the template, using `get_flashed_messages()`.

How it works...

A form like the one shown in the following screenshot will appear upon moving to `http://127.0.0.1:5000/product-create`:

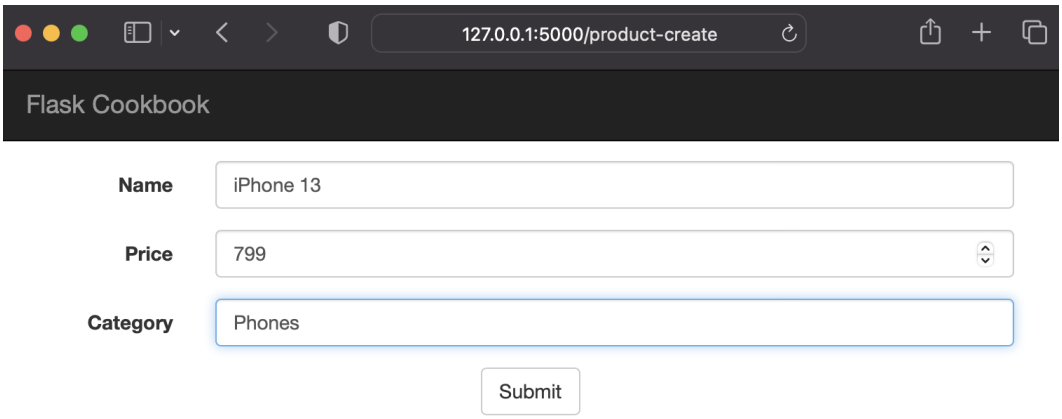


Figure 4.4 – Creating a product

Fill in the form and click on **Submit**. This will lead to the usual product page with an alert message at the top:

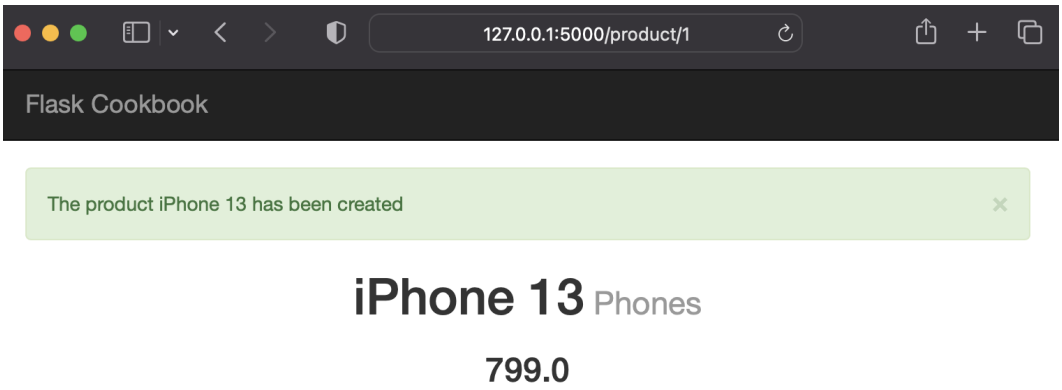


Figure 4.5 – The flash message on successful product creation

Implementing SQL-based searching

In any web application, it is important to be able to search a database for records based on certain criteria. In this recipe, we will go through how to implement basic SQL-based searching in SQLAlchemy. The same principle can be used to search any other database system.

Getting ready

We have implemented some level of search functionality in our catalog application from the beginning. Whenever we show the product page, we search for a specific product using its ID. We will now take it to a slightly more advanced level and search on the basis of name and category.

How to do it...

The following is a method that searches in our catalog application for name, price, company, and category. We can search for any one criterion, or multiple criteria (except for a search by category, which can only be searched alone). Note that we have different expressions for different values. For a float value in `price`, we can search for equality, and in the case of a string, we can search using `like`. Also, carefully note how `join` is implemented in the case of `category`. Place this method in the `views` file – that is, `flask_catalog_template/my_app/catalog/views.py`:

```
from sqlalchemy.orm import join

@catalog.route('/product-search')
@catalog.route('/product-search/<int:page>')
```

```
def product_search(page=1):
    name = request.args.get('name')
    price = request.args.get('price')
    company = request.args.get('company')
    category = request.args.get('category')
    products = Product.query
    if name:
        products = products.filter(Product.name.like('%' +
          name + '%'))
    if price:
        products = products.filter(Product.price == price)
    if company:
        products = products.filter(Product.company.like('%'
          + company + '%'))
    if category:
        products = products.select_from(join(Product,
          Category)).filter(
            Category.name.like('%' + category + '%')
        )
    return render_template(
        'products.html', products=products.paginate(page,
          10)
    )
```

How it works...

We can search for products by entering a URL, something like `http://127.0.0.1:5000/product-search?name=iPhone`. This will search for products with the name `iPhone` and list the results on the `products.html` template. Similarly, we can search for price and/or company or category as required. Try various combinations by yourself to aid your understanding.

> **Information**
>
> We have used the same product list page to render our search results. It will be interesting to implement the search using Ajax. I will leave this to you to implement yourself.

Part 2: Flask Deep Dive

Once the basic Flask web application is built, the next question concerns creating beautiful and reusable web forms and authentication. The first two chapters in this part focus specifically on these topics.

As a developer, you can always build web forms using plain HTML, but it is usually a cumbersome task and difficult to maintain consistent reusable components. This is where Jinja helps, with a better definition of forms and super-easy validations while being extensible and customizable.

Authentication is one of the most important parts of any application, whether web, mobile, or desktop. *Chapter 6* focuses on various techniques of authentication, which range from social to completely managed in-house.

The next chapter deals with APIs, which are an integral part of any web application, and one of the major strengths of Flask lies in building APIs in a very clear, concise, and readable format. This is followed by adding the capability to support multiple languages in your Flask application.

Flask by default does not come with an admin interface as you would find in Django, which is another popular web framework written in Python. However, it is possible to create a completely custom admin interface in Flask quickly by leveraging some extensions. The last chapter in this part deals with this subject.

This part of the book comprises the following chapters:

- *Chapter 5, Web Forms with WTForms*
- *Chapter 6, Authenticating in Flask*
- *Chapter 7, RESTful API Building*
- *Chapter 8, Internationalization and Localization*
- *Chapter 9, Admin Interface for Flask Apps*

5
Web Forms with WTForms

Form handling is an integral part of any web application. There can be innumerable cases that make the presence of forms in any web app very important. Some cases may include situations where users need to log in or submit some data, or where applications might require input from users. As much as forms are important, their validation holds equal importance, if not more. Presenting this information to users in an interactive fashion adds a lot of value to the application.

There are various ways in which we can design and implement forms in a web application. As web applications have matured, form validation and communicating the correct messages to a user have become very important. Client-side validations can be implemented at the frontend using JavaScript and HTML5. Server-side validations have a more important role in adding security to an application, rather than being user-interactive. Server-side validations prevent any incorrect data from going through to the database and, hence, curb fraud and attacks.

WTForms provides many fields with server-side validation by default and, hence, increases development speed and decreases the overall effort required. It also provides the flexibility to write custom validations and custom fields as required.

We will use a Flask extension in this chapter. This extension is called Flask-WTF (`https://flask-wtf.readthedocs.io/en/latest/`); it provides integration between WTForms and Flask, taking care of important and trivial stuff that we would have to otherwise reinvent in order to make our application secure and effective. We can install it using the following command:

```
$ pip install Flask-WTF
```

In this chapter, we will cover the following recipes:

- Representing SQLAlchemy model data as a form
- Validating fields on the server side
- Creating a common form set
- Creating custom fields and validations

- Creating a custom widget
- Uploading files via forms
- Protecting applications from **cross-site request forgery** (**CSRF**)

Representing SQLAlchemy model data as a form

First, let's build a form using a SQLAlchemy model. In this recipe, we will take the product model from our catalog application used previously in this book and add functionality, creating products from the frontend using a web form.

Getting ready

We will use our catalog application from *Chapter 4*, *Working with Views*, and we will develop a form for the `Product` model.

How to do it...

If you recall, the `Product` model looks like the following lines of code in the `models.py` file:

```
class Product(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(255))
    price = db.Column(db.Float)
    category_id = db.Column(db.Integer,
      db.ForeignKey('category.id'))
    category = db.relationship(
        'Category', backref=db.backref('products',
          lazy='dynamic')
    )
```

First, we will create a `ProductForm` class in `models.py`; this will subclass the `FlaskForm` class, which is provided by `flask_wtf`, to represent the fields required on a web form:

```
from wtforms import StringField, DecimalField, SelectField
from flask_wtf import FlaskForm

class ProductForm(FlaskForm):
    name = StringField('Name')
    price = DecimalField('Price')
    category = SelectField('Category', coerce=int)
```

We import `FlaskForm` from the `flask-wtf` extension. Everything else, such as `fields` and `validators`, are imported from `wtforms` directly. The `Name` field is of the `StringField` type, as it requires text data, while `Price` is of the `DecimalField` type, which will parse the data to Python's `Decimal` data type. We have kept `Category` as the `SelectField` type, which means that we can choose only from the categories created previously when creating a product.

Information

Note that we have a parameter called `coerce` in the field definition for `Category` (which is a selection list); this means that the incoming data from the HTML form will be coerced to an integer value prior to validating or any other processing. Here, coercing simply means converting a value, provided in a specific data type, to a different data type.

The `create_product()` handler in `views.py` should now accommodate the form created earlier:

```
from my_app.catalog.models import ProductForm

@catalog.route('/product-create', methods=['GET', 'POST'])
def create_product():
    form = ProductForm(meta={'csrf': False})

    categories = [(c.id, c.name) for c in
      Category.query.all()]
    form.category.choices = categories

    if request.method == 'POST':
        name = request.form.get('name')
        price = request.form.get('price')
        category = Category.query.get_or_404(
            request.form.get('category')
        )
        product = Product(name, price, category)
        db.session.add(product)
        db.session.commit()
        flash('The product %s has been created' % name,
          'success')
        return redirect(url_for('catalog.product',
          id=product.id))
    return render_template('product-create.html',
      form=form)
```

The `create_product()` method accepts values from a form on a `POST` request. This method will render an empty form with the prefilled choices in the `Category` field on a `GET` request. On the `POST` request, the form data will be used to create a new product, and when the creation of the product is completed, the newly created product's page will be displayed.

> **Information**
>
> Note that while creating the `form` object as `form = ProductForm(meta={'csrf': False})`, we set `csrf` to `False`. CSRF is an important part of any secure web application. We will talk about this in detail in the *Protecting applications from CSRF* recipe of this chapter.

The `templates/product-create.html` template also requires some modification. The `form` objects created by WTForms provide an easy way to create HTML forms and keep code readable:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <form method="POST" action="{{
      url_for('catalog.create_product') }}" role="form">
      <div class="form-group">{{ form.name.label }}: {{
        form.name() }}</div>
      <div class="form-group">{{ form.price.label }}: {{
        form.price() }}</div>
      <div class="form-group">{{ form.category.label }}: {{
        form.category() }}</div>
      <button type="submit" class="btn btn-
        default">Submit</button>
    </form>
  </div>
{% endblock %}
```

How it works...

On a `GET` request – that is, upon opening `http://127.0.0.1:5000/product-create` – we will see a form similar to the one shown in the following screenshot:

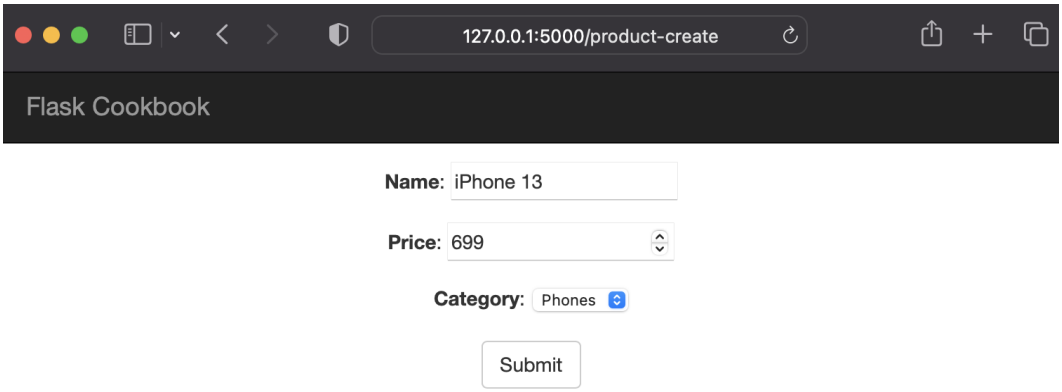


Figure 5.1 – Product creation form using WTForms

You can fill in this form to create a new product.

See also

Refer to the following *Validating fields on the server side* recipe to understand how to validate the fields we just learned to create.

Validating fields on the server side

We have created forms and fields, but we need to validate them in order to make sure that only the correct data goes through to the database and that errors are handled beforehand, rather than corrupting the database. These validations can also protect an application against **cross-site scripting** (**XSS**) and CSRF attacks. WTForms provides a whole lot of field types that, themselves, have validations written for them by default. Apart from these, there are a bunch of validators that can be used based on choice and need. In this recipe, we will use a few of them to understand the concept.

How to do it...

It is pretty easy to add validations to our WTForm fields. We just need to pass a `validators` parameter, which accepts a list of validators to be implemented. Each of the validators can have their own arguments, which enables us to control the validations to a great extent.

Let's modify our `ProductForm` object in the `models.py` class to have validations:

```
from decimal import Decimal

class ProductForm(FlaskForm):
    name = StringField('Name',
      validators=[InputRequired()])
```

```
    price = DecimalField('Price', validators=[
        InputRequired(), NumberRange(min=Decimal('0.0'))
    ])
    category = SelectField(
        'Category', validators=[InputRequired()],
          coerce=int
    )
```

Here, we have the `InputRequired` validator on all three fields; this means that these fields are required, and the form will not be submitted unless we have values for these fields.

The `Price` field has an additional validator, `NumberRange`, with a `min` parameter set to `0.0`. This implies that we cannot have a value of less than `0` as the price of a product. To complement these changes, we will have to modify our `create_product()` method in `views.py`:

```
@catalog.route('/product-create', methods=['GET', 'POST'])
def create_product():
    form = ProductForm(meta={'csrf': False})

    categories = [(c.id, c.name) for c in
      Category.query.all()]
    form.category.choices = categories

    if form.validate_on_submit():
        name = form.name.data
        price = form.price.data
        category = Category.query.get_or_404(
            form.category.data
        )
        product = Product(name, price, category)
        db.session.add(product)
        db.session.commit()
        flash('The product %s has been created' % name,
          'success')
        return redirect(url_for('catalog.product',
          id=product.id))

    if form.errors:
        flash(form.errors, 'danger')

    return render_template('product-create.html',
      form=form)
```

> **Tip**
>
> The flashing of `form.errors` will just display the errors in the form of a JSON object. This can be formatted to be shown in a pleasing format to a user. This is left for you to try yourself.

Here, we modified our `create_product()` method to validate the form for the input value when submitted. Some of the validations will be translated and applied to the frontend as well, just like the `InputRequired` validation will add a `required` property to the form field's HTML. On a `POST` request, the form data will be validated first. If the validation fails for some reason, the same page will be rendered again, with error messages flashed on it. If the validation succeeds and the creation of the product is completed, the newly created product's page will be displayed.

> **Note**
>
> Note the very convenient `validate_on_submit()` method. This will automatically check whether the request is `POST` and whether it is valid. It is essentially a combination of `request.method == 'POST'` and `form.validate()`.

How it works...

Now, try to submit the form without any field filled in – that is, an empty form. An alert message with an error will be shown as follows:

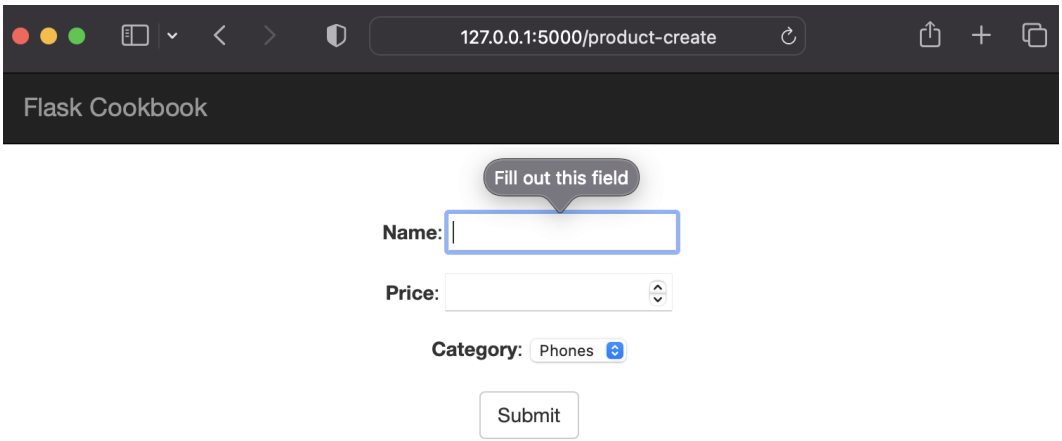


Figure 5.2 – In-built error handling in WTForms

If you try to submit the form with a negative price value, the flashed error will look something like the following screenshot:

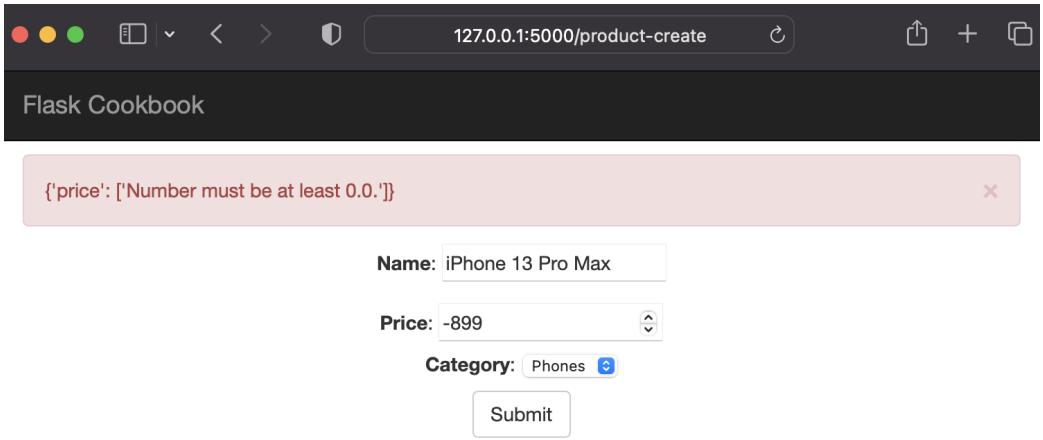


Figure 5.3 – Custom error handling in WTForms

Try different combinations of form submissions that will violate the defined validators, and note the different error messages that come up.

See also

Refer to the previous recipe, *Representing SQLAlchemy model data as a form*, to understand basic form creation using WTForms.

Creating a common form set

An application can have many forms, depending on the design and purpose. Some of these forms will have common fields with common validators. You might think, "*Why not have common form parts and then reuse them as and when needed?*" In this recipe, we will see that this is certainly possible with the class structure for forms' definition provided by WTForms.

How to do it...

In our catalog application, we can have two forms, one each for the `Product` and `Category` models. These forms will have a common field called `Name`. We can create a common form for this field, and then the separate forms for the `Product` and `Category` models can use this form, instead of having a `Name` field in each of them.

This can be implemented as follows in `models.py`:

```
class NameForm(FlaskForm):
    name = StringField('Name',
      validators=[InputRequired()])
```

```
class ProductForm(NameForm):
    price = DecimalField('Price', validators=[
        InputRequired(), NumberRange(min=Decimal('0.0'))
    ])
    category = SelectField(
        'Category', validators=[InputRequired()],
          coerce=int
    )

class CategoryForm(NameForm):
    pass
```

We created a common form called `NameForm`, and the other forms, `ProductForm` and `CategoryForm`, inherit from this form to have a field called `Name` by default. Then, we can add more fields as necessary.

We can modify the `create_category()` method in `views.py` to use `CategoryForm` to create categories:

```
@catalog.route('/category-create', methods=['GET', 'POST'])
def create_category():
    form = CategoryForm(meta={'csrf': False})

    if form.validate_on_submit():
        name = form.name.data
        category = Category(name)
        db.session.add(category)
        db.session.commit()
        flash(
            'The category %s has been created' % name,
              'success'
        )
        return redirect(url_for('catalog.category',
          id=category.id))

    if form.errors:
        flash(form.errors)

    return render_template('category-create.html',
      form=form)
```

A new template, `templates/category-create.html`, also needs to be added for category creation:

```
{% extends 'home.html' %}

{% block container %}
```

```
    <div class="top-pad">
      <form method="POST" action="{{
        url_for('catalog.create_category') }}" role="form">
        <div class="form-group">{{ form.name.label }}: {{
          form.name() }}</div>
        <button type="submit" class="btn btn-
          default">Submit</button>
      </form>
    </div>
{% endblock %}
```

How it works...

Open the `http://127.0.0.1:5000/category-create` URL in your browser. The newly created category form will look like the following screenshot:

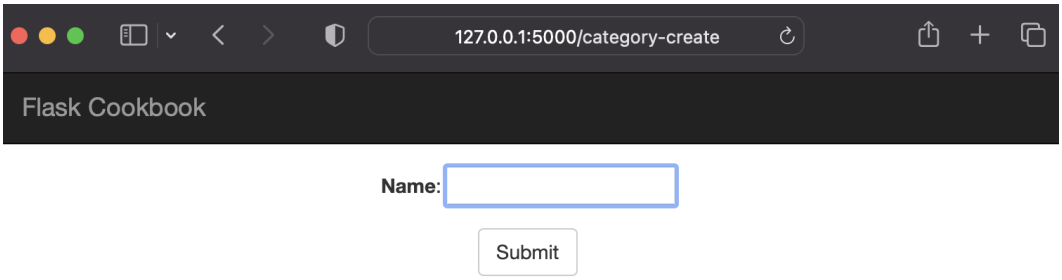


Figure 5.4 – A common form used for category creation

> **Tip**
>
> This is a very small example of how a common form set can be implemented. The actual benefits of this approach can be seen in e-commerce applications, where we can have common address forms, and then they can be expanded to have separate billing and shipping addresses.

Creating custom fields and validations

Apart from providing a bunch of fields and validations, Flask and WTForms also provide you with the flexibility to create custom fields and validations. Sometimes, we might need to parse some form of data that cannot be processed using the available current fields. In such cases, we can implement our own fields.

How to do it...

In our catalog application, we used `SelectField` for the category, and we populated the values for this field in our `create_product()` method on a `GET` request by querying the `Category` model. It would be much more convenient if we did not concern ourselves with this and the population of this field took care of itself.

Now, let's implement a custom field to do this in `models.py`:

```
class CategoryField(SelectField):

    def iter_choices(self):
        categories = [(c.id, c.name) for c in
          Category.query.all()]
        for value, label in categories:
            yield (value, label, self.coerce(value) ==
              self.data)

    def pre_validate(self, form):
        for v, _ in [(c.id, c.name) for c in
          Category.query.all()]:
            if self.data == v:
                break
        else:
            raise ValueError(self.gettext('Not a valid
              choice'))

class ProductForm(NameForm):
    price = DecimalField('Price', validators=[
        InputRequired(), NumberRange(min=Decimal('0.0'))
    ])
    category = CategoryField(
        'Category', validators=[InputRequired()],
          coerce=int
    )
```

`SelectField` implements a method called `iter_choices()`, which populates the values to the form using the list of values provided to the `choices` parameter. We overwrite the `iter_choices()` method to get the values of categories directly from the database, and this eliminates the need to populate this field every time we need to use this form.

> **Information**
>
> The behavior created by `CategoryField` here can also be achieved using `QuerySelectField`. Refer to `https://wtforms-sqlalchemy.readthedocs.io/en/stable/wtforms_sqlalchemy/#wtforms_sqlalchemy.fields.QuerySelectField` for more information.

Due to the changes described in this section, our `create_product()` method in `views.py` will have to be modified. For this, just remove the following two statements that populated the categories in the form:

```
categories = [(c.id, c.name) for c in Category.query.all()]
form.category.choices = categories
```

How it works...

There will not be any visual effect on the application. The only change will be in the way the categories are populated in the form, as explained in the previous section.

There's more...

We just saw how to write custom fields. Similarly, we can write custom validations, too. Let's assume that we do not want to allow duplicate categories. We can implement this in our models easily, but let's do this using a custom validator on our form:

```
def check_duplicate_category(case_sensitive=True):
    def _check_duplicate(form, field):
        if case_sensitive:
            res = Category.query.filter(
                Category.name.like('%' + field.data + '%')
            ).first()
        else:
            res = Category.query.filter(
                Category.name.ilike('%' + field.data + '%')
            ).first()
        if res:
            raise ValidationError(
                'Category named %s already exists' %
                  field.data
            )
    return _check_duplicate

class CategoryForm(NameForm):
    name = StringField('Name', validators=[
        InputRequired(), check_duplicate_category()
    ])
```

So, we created our validator in a factory style, where we can get separate validation results based on whether we want a case-sensitive comparison. We can even write a class-based design, which makes the validator much more generic and flexible, but I will leave that for you to explore.

Now, if you try to create a new category with the same name as the one that already exists, the following error will be shown:

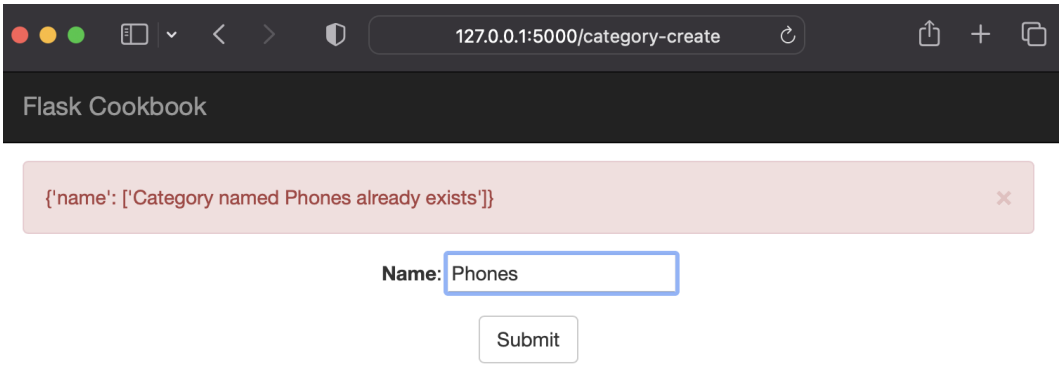


Figure 5.5 – An error on the duplicate category creation

Creating a custom widget

Just like we can create custom fields and validators, we can also create custom widgets. These widgets allow us to control how our fields will look on the frontend. Each field type has a widget associated with it, and WTForms, by itself, provides a lot of basic and HTML5 widgets. In this recipe, to understand how to write a custom widget, we will convert our custom selection field for `Category` into a radio field. I agree with those of you who would argue that we can directly use the radio field provided by WTForms. Here, we are just trying to understand how to do it ourselves.

> **Information**
>
> The widgets provided by default by WTForms can be found at `https://wtforms.readthedocs.io/en/3.0.x/widgets/`.

How to do it...

In our previous recipe, we created `CategoryField`. This field used the `Select` widget, which was provided by the `Select` superclass. Let's replace the `Select` widget with a radio input in `models.py`:

```
from wtforms.widgets import html_params, Select
from markupsafe import Markup
class CustomCategoryInput(Select):
```

```
    def __call__(self, field, **kwargs):
        kwargs.setdefault('id', field.id)
        html = []
        for val, label, selected in field.iter_choices():
            html.append(
                '<input type="radio" %s> %s' % (
                    html_params(
                        name=field.name, value=val,
                          checked=selected, **kwargs
                    ), label
                )
            )
        return Markup(' '.join(html))

class CategoryField(SelectField):
    widget = CustomCategoryInput()
    # Rest of the code remains same as in last recipe
      Creating custom field and validation
```

Here, we added a class attribute called `widget` to our `CategoryField` class. This widget points to `CustomCategoryInput`, which takes care of HTML code generation for the field to be rendered. This class has a `__call__()` method, which is overwritten to return radio inputs corresponding to the values provided by the `iter_choices()` method of `CategoryField`.

How it works...

When you open the product creation page, `http://127.0.0.1:5000/product-create`, it will look like the following screenshot:

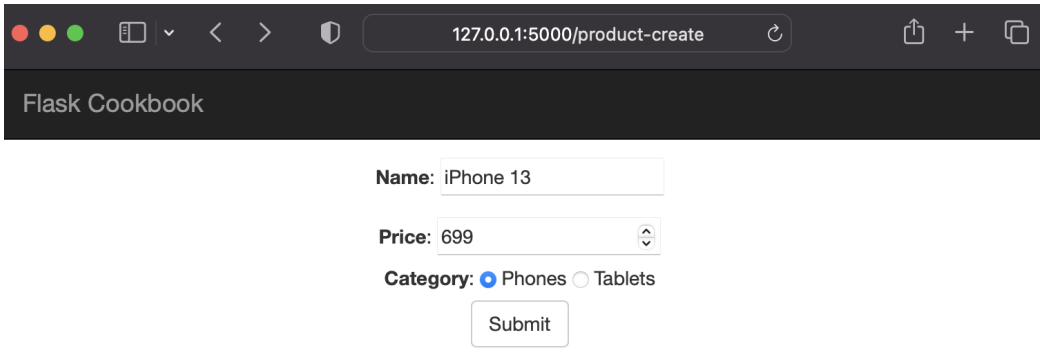


Figure 5.6 – A custom widget for category selection

See also

Refer to the previous recipe, *Creating custom fields and validation*, to understand more about the level of customization that can be done to the components of WTForms.

Uploading files via forms

Uploading files via forms, and doing it properly, is usually a matter of concern for many web frameworks. In this recipe, we will see how Flask and WTForms handle this for us in a simple and streamlined manner.

How to do it...

In this recipe, we will implement a feature to store product images while creating products. First, we will start with the configuration bit. We need to provide a parameter to our application configuration – that is, `UPLOAD_FOLDER`. This parameter tells Flask about the location where our uploaded files will be stored.

> **Tip**
> One way to store product images can be to store images in a binary-type field in our database, but this method is highly inefficient and never recommended in any application. We should always store images and other uploads in a filesystem, and store their locations in a database using a `string` field.

Add the following statements to the configuration in `my_app/__init__.py`:

```
import os

ALLOWED_EXTENSIONS = set(['txt', 'pdf', 'png', 'jpg',
  'jpeg', 'gif'])
app.config['UPLOAD_FOLDER'] = os.path.realpath('.') +
  '/my_app/static/uploads'
```

> **Tip**
> Note the `app.config['UPLOAD_FOLDER']` statement, where we store the images inside a subfolder in the `static` folder itself. This will make the process of rendering images easier. Also, note the `ALLOWED_EXTENSIONS` statement, which is used to make sure that only files of a specific format go through. The list here is actually for demonstration purposes only, and for image types, we can filter this list even more. Make sure the folder path specified in the `app.config['UPLOAD_FOLDER']` statement exists; otherwise, the application will error out.

In the `models` file – that is, `my_app/catalog/models.py` – add the following highlighted statements to their designated places:

```
from flask_wtf.file import FileField, FileRequired

class Product(db.Model):
    image_path = db.Column(db.String(255))
    def __init__(self, name, price, category, image_path):
        self.image_path = image_path

class ProductForm(NameForm):
    image = FileField('Product Image',
      validators=[FileRequired()])
```

Check `FileField` for `image` in `ProductForm` and the field for `image_path` to the `Product` model. Here, the uploaded file will be stored on the filesystem at the path defined in the config, and the path generated will be stored in the database.

Now, modify the `create_product()` method to save the file in `my_app/catalog/views.py`:

```
import os
from werkzeug.utils import secure_filename
from my_app import ALLOWED_EXTENSIONS

@catalog.route('/product-create', methods=['GET', 'POST'])
def create_product():
    form = ProductForm(meta={'csrf': False})

    if form.validate_on_submit():
        name = form.name.data
        price = form.price.data
        category = Category.query.get_or_404(
            form.category.data
        )
        image = form.image.data
        if allowed_file(image.filename):
            filename = secure_filename(image.filename)
            image.save(os.path.join(app.config
              ['UPLOAD_FOLDER'], filename))
        product = Product(name, price, category, filename)
        db.session.add(product)
        db.session.commit()
        flash('The product %s has been created' % name,
```

```
            'success')
        return redirect(url_for('catalog.product',
          id=product.id))

    if form.errors:
        flash(form.errors, 'danger')

    return render_template('product-create.html',
      form=form)
```

Add the new field to the product create form in `template templates/product-create.html`. Modify the `form` tag definition to include the `enctype` parameter, and add the field for the image before the **Submit** button (or wherever you feel it is necessary inside the form):

```
<form method="POST"
        action="{{ url_for('catalog.create_product') }}"
        role="form"
        enctype="multipart/form-data">
      <!-- The other field definitions as always -->
      <div class="form-group">{{ form.image.label }}: {{
        form.image(style='display:inline;') }}</div>
      <button type="submit" class="btn btn-
        default">Submit</button>
    </form>
```

The form should have the `enctype="multipart/form-data"` statement to tell the application that the form input will have multipart data.

Rendering the image is very easy, as we are storing the files in the `static` folder itself. Just add the `img` tag wherever the image needs to be displayed in `templates/product.html`:

```
<img src="{{ url_for('static', filename='uploads/' +
  product.image_path) }}"/>
```

How it works...

The field to upload the image will look something like the following screenshot:

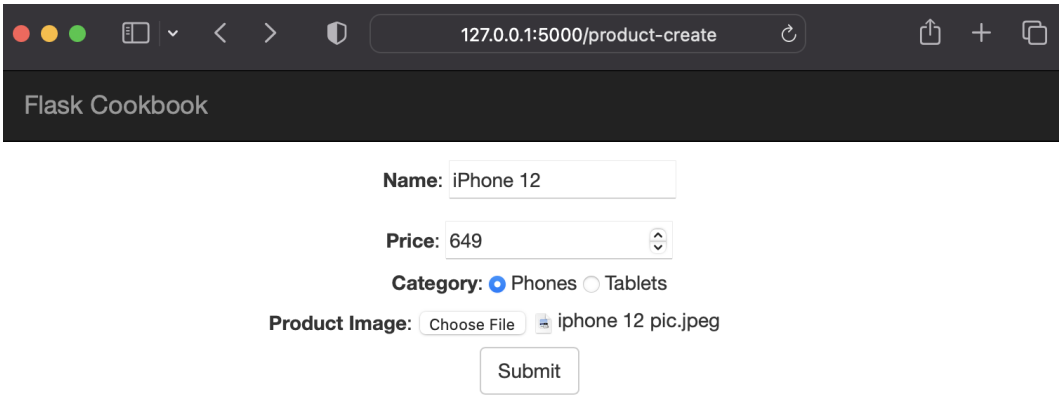


Figure 5.7 – Uploading files for the product image

Following the creation of the product, the image will be displayed, as shown in the following screenshot:

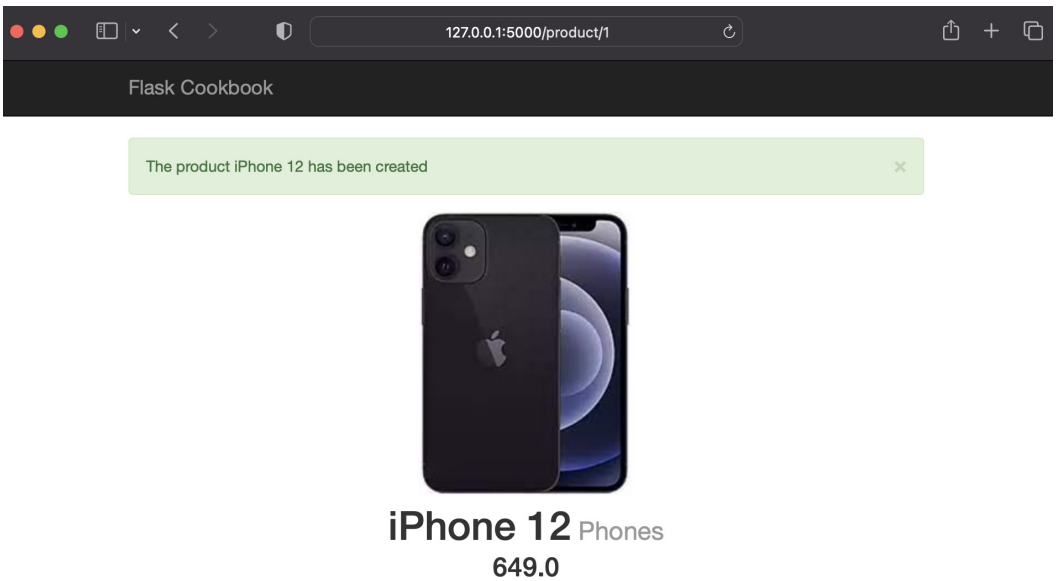


Figure 5.8 – The product page with the uploaded file

Protecting applications from CSRF

In the first recipe of this chapter, we learned that CSRF is an important part of web form security. We will now talk about this in detail. CSRF basically means that someone can hack into the request that carries a cookie and use this to trigger a destructive action. We won't be discussing CSRF in detail here, since ample resources are available on the internet to learn about it. We will talk about how WTForms helps us to prevent CSRF. Flask does not provide any security against CSRF by default, as this has to be handled at the form-validation level, which is not a core feature of Flask as a framework. However, in this recipe, we will see how this can be done for us by using the Flask-WTF extension.

Information

More information about CSRF can be found at `https://owasp.org/www-community/attacks/csrf`.

How to do it...

Flask-WTF, by default, provides a form that is CSRF-protected. If we have a look at the recipes so far, we can see that we have explicitly told our form to *not be CSRF-protected*. We just have to remove the corresponding statement to enable CSRF.

So, `form = ProductForm(meta={'csrf': False})` will become `form = ProductForm()`.

Some configuration bits also need to be done in our application:

```
app.config['WTF_CSRF_SECRET_KEY'] = 'random key for form'
```

By default, the CSRF key is the same as our application's secret key.

With CSRF enabled, we will have to provide an additional field in our forms; this is a hidden field and contains the CSRF token. WTForms takes care of the hidden field for us, and we just have to add `{{ form.csrf_token }}` to our form:

```
<form method="POST" action="/some-action-like-create-
  product">
    {{ form.csrf_token }}
</form>
```

That was easy! Now, this is not the only type of form submission that we do. We also submit AJAX form posts; this actually happens a lot more than normal forms since the advent of JavaScript-based web applications, which are replacing traditional web applications.

For this, we need to include another step in our application's configuration:

```
from flask_wtf.csrf import CSRFProtect

#
# Add configurations #
CSRFProtect(app)
```

The preceding configuration will allow us to access the CSRF token using `{{ csrf_token() }}` anywhere in our templates. Now, there are two ways to add a CSRF token to AJAX `POST` requests.

One way is to fetch the CSRF token in our `script` tag and use it in the `POST` request:

```
<script type="text/javascript">
    var csrfToken = "{{ csrf_token() }}";
</script>
```

Another way is to render the token in a `meta` tag and use it whenever required:

```
<meta name="csrf-token" content="{{ csrf_token() }}"/>
```

The difference between the two approaches is that the first approach may have to be repeated in multiple places, depending on the number of `script` tags in the application.

Now, to add the CSRF token to the AJAX `POST` request, we have to add the `X-CSRFToken` attribute to it. This attribute's value can be taken from either of the two approaches stated here. We will take the second one for our example:

```
$.ajaxSetup({
    beforeSend: function(xhr, settings) {
        if (!/^(GET|HEAD|OPTIONS|TRACE)$/i
          .test(settings.type)) {
            xhr.setRequestHeader("X-CSRFToken", csrftoken)
        }
    }
})
```

This will make sure that a CSRF token is added to all the AJAX `POST` requests that go out.

How it works...

The following screenshot shows what the CSRF token added by WTForms in our form looks like:

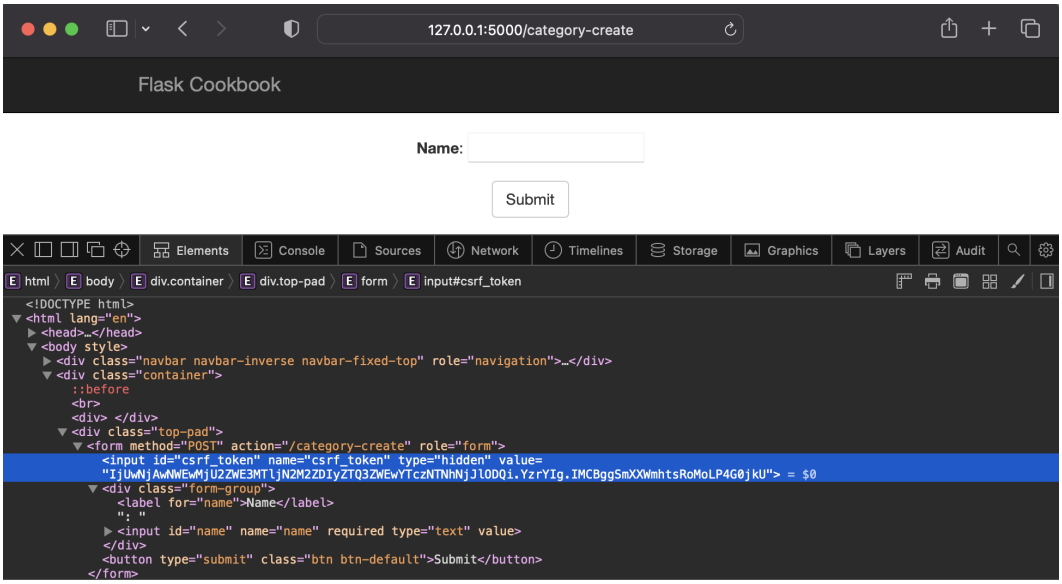


Figure 5.9 – The CSRF token

The token is completely random and different for all the requests. There are multiple ways of implementing CSRF token generation, but this is beyond the scope of this book, although I encourage you to explore some alternative implementations on your own to understand how it's done.

6
Authenticating in Flask

Authentication is an important part of any application, be it web-based, desktop, or mobile. Each kind of application has certain best practices when it comes to handling user authentication. In web-based applications, especially **Software-as-a-Service** (**SaaS**) applications, this process is of utmost importance, as it acts as the thin red line between the application being secure and insecure.

To keep things simple and flexible, Flask, by default, does not provide any mechanism for authentication. It always has to be implemented by us, the developers, as per our requirements and the application's requirements.

Authenticating users for your application can be done in multiple ways. It can be a simple session-based implementation or a more secure approach using the `Flask-Login` extension. We can also implement authentication by integrating popular third-party services such as the **Lightweight Directory Access Protocol** (**LDAP**) or social logins such as Facebook, Google, and so on. In this chapter, we will go through all of these methods.

In this chapter, we will cover the following recipes:

- Creating a simple session-based authentication
- Authenticating using the Flask-Login extension
- Using Facebook for authentication
- Using Google for authentication
- Using Twitter for authentication
- Authenticating with LDAP

Creating a simple session-based authentication

In session-based authentication, when the user logs in for the first time, the user details are set in the session of the application's server side and stored in a cookie on the browser.

After that, when the user opens the application, the details stored in the cookie are used to check against the session, and the user is automatically logged in if the session is alive.

> **Info**
>
> `SECRET_KEY` is an application configuration setting that should always be specified in your application's configuration; otherwise, the data stored in the cookie, as well as the session on the server side, will be in plain text, which is highly insecure.

We will implement a simple mechanism to do this ourselves.

> **Tip**
>
> The implementation done in this recipe is designed to explain how authentication works at a lower level. This approach should *not* be adopted in any production-level application.

Getting ready

We will start with a Flask app configuration, as seen in *Chapter 5*, *Web Forms with WTForms*.

How to do it...

Configure the application to use the SQLAlchemy and WTForms extensions (refer to the previous chapter for details). Follow these steps to understand how:

1. Before starting with authentication, first, create a model to store the user details. This is achieved by creating models in `flask_authentication/my_app/auth/models.py`, as follows:

```
from werkzeug.security import generate_password_hash, check_
password_hash
from flask_wtf import FlaskForm
from wtforms import StringField, PasswordField
from wtforms.validators import InputRequired, EqualTo
from my_app import db


class User(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    username = db.Column(db.String(100))
    pwdhash = db.Column(db.String())

    def __init__(self, username, password):
        self.username = username
```

```
        self.pwdhash = generate_password_hash(password)

    def check_password(self, password):
        return check_password_hash(self.pwdhash, password)
```

The preceding code is the `User` model, which has two fields: `username` and `pwdhash`. The `username` field works as its name suggests. The `pwdhash` field stores the salted hash of the password because it is not recommended that you store passwords directly in databases.

2. Then, create two forms in `flask_authentication/my_app/auth/models.py` – one for user registration and the other for login. In `RegistrationForm`, create two fields of the `PasswordField` type, just like any other website's registration; this is to make sure that the user enters the same password in both fields, as shown in the following snippet:

```
class RegistrationForm(FlaskForm):
    username = StringField('Username', [InputRequired()])
    password = PasswordField(
        'Password', [
            InputRequired(), EqualTo('confirm',
            message='Passwords must match')
        ]
    )
    confirm = PasswordField('Confirm Password',
      [InputRequired()])

class LoginForm(FlaskForm):
    username = StringField('Username', [InputRequired()])
    password = PasswordField('Password', [InputRequired()])
```

3. Next, create views in `flask_authentication/my_app/auth/views.py` to handle the user requests for registration and login, as follows:

```
from flask import request, render_template, flash, redirect,
url_for, session, Blueprint
from my_app import app, db
from my_app.auth.models import User, RegistrationForm, LoginForm

auth = Blueprint('auth', __name__)

@auth.route('/')
@auth.route('/home')
def home():
    return render_template('home.html')

@auth.route('/register', methods=['GET', 'POST'])
def register():
    if session.get('username'):
```

```
            flash('Your are already logged in.', 'info')
            return redirect(url_for('auth.home'))

        form = RegistrationForm()

        if form.validate_on_submit():
            username = request.form.get('username')
            password = request.form.get('password')
            existing_username = User.query.filter(
                User.username.like('%' + username + '%')
            ).first()
            if existing_username:
                flash(
                    'This username has been already taken. Try
                    another one.',
                    'warning'
                )
                return render_template('register.html', form=form)
            user = User(username, password)
            db.session.add(user)
            db.session.commit()
            flash('You are now registered. Please login.',
            'success')
            return redirect(url_for('auth.login'))

        if form.errors:
            flash(form.errors, 'danger')

        return render_template('register.html', form=form)
```

The preceding method handles user registration. On a `GET` request, the registration form is shown to the user; this form asks for the `username` and `password`. Then, on a `POST` request, the `username` is checked for its uniqueness after the form validation is complete. If the `username` is not unique, the user is asked to choose a new `username`; otherwise, a new user is created in the database and redirected to the login page.

After successful registration, the user is redirected to log in, which is handled as shown in the following code:

```
@auth.route('/login', methods=['GET', 'POST'])
def login():
    form = LoginForm()

    if form.validate_on_submit():
        username = request.form.get('username')
```

```
        password = request.form.get('password')
        existing_user = User.query.filter_by(username=username).
        first()

        if not (existing_user and existing_user.check_
        password(password)):
            flash('Invalid username or password. Please try again.',
            'danger')
            return render_template('login.html', form=form)

        session['username'] = username
        flash('You have successfully logged in.', 'success')
        return redirect(url_for('auth.home'))

    if form.errors:
        flash(form.errors, 'danger')

    return render_template('login.html', form=form)
```

The preceding method handles the user login. After form validation, it first checks whether the `username` exists in the database. If not, it asks the user to enter the correct username. Similarly, it checks whether the `password` is correct. If not, it asks the user for the correct password. If all the checks pass, the session is populated with a `username` key, which holds the username of the user. The presence of this key on the session indicates that the user is logged in. Consider the following code:

```
@auth.route('/logout')
def logout():
    if 'username' in session:
        session.pop('username')
        flash('You have successfully logged out.', 'success')

    return redirect(url_for('auth.home'))
```

The preceding method becomes self-implied once we've understood the `login()` method. Here, we just popped out the `username` key from the session, and the user got logged out automatically.

Next, create the templates that are rendered by the `register()` and `login()` handlers for the registration and login, respectively, created previously.

The `flask_authentication/my_app/templates/base.html` template remains almost the same as it was in *Chapter 5*, *Web Forms with WTForms*. The only change will be with the routing, where `catalog` will be replaced by `auth`.

First, create a simple home page, `flask_authentication/my_app/templates/home.html`, as shown in the following code. This reflects whether the user is logged in or not and also shows links for registration and login if the user is not logged in:

```
{% extends 'base.html' %}

{% block container %}
  <h1>Welcome to the Authentication Demo</h1>
  {% if session.username %}
    <h3>Hey {{ session.username }}!!</h3>
    <a href="{{ url_for('auth.logout') }}">Click here to logout</a>
  {% else %}
  Click here to <a href="{{ url_for('auth.login') }}">login</a> or <a
  href="{{ url_for('auth.register') }}">register</a>
  {% endif %}
{% endblock %}
```

Now create a registration page, `flask_authentication/my_app/templates/register.html`, as follows:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <form
        method="POST"
        action="{{ url_for('auth.register') }}"
        role="form">
      {{ form.csrf_token }}
      <div class="form-group">{{ form.username.label }}: {{ form.
      username() }}</div>
      <div class="form-group">{{ form.password.label }}: {{ form.
      password() }}</div>
      <div class="form-group">{{ form.confirm.label }}: {{ form.
      confirm() }}</div>
      <button type="submit" class="btn btn-default">Submit</button>
    </form>
  </div>
{% endblock %}
```

Finally, create a simple login page, `flask_authentication/my_app/templates/login.html`, with the following code:

```
{% extends 'home.html' %}

{% block container %}
```

```
  <div class="top-pad">
    <form
        method="POST"
        action="{{ url_for('auth.login') }}"
        role="form">
      {{ form.csrf_token }}
      <div class="form-group">{{ form.username.label }}: {{ form.
      username() }}</div>
      <div class="form-group">{{ form.password.label }}: {{ form.
      password() }}</div>
      <button type="submit" class="btn btn-default">Submit</button>
    </form>
  </div>
{% endblock %}
```

How it works...

The working of this application is demonstrated with the help of the screenshots in this section.

The following screenshot displays the home page that comes up on opening `http://127.0.0.1:5000/home`:

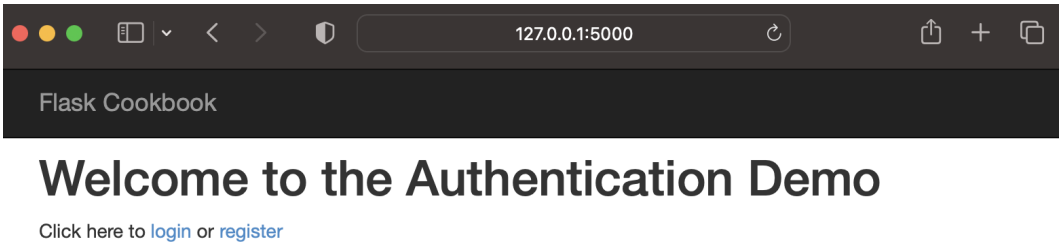


Figure 6.1 – Home page visible to a user who is not logged in

The registration page that comes up on opening `http://127.0.0.1:5000/register` looks like the following screenshot:

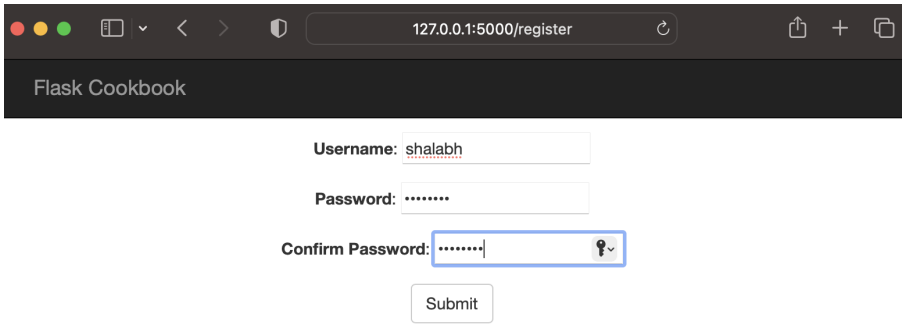


Figure 6.2 – The registration form

After registration, the login page will be shown on opening `http://127.0.0.1:5000/login`, as shown in the following screenshot:

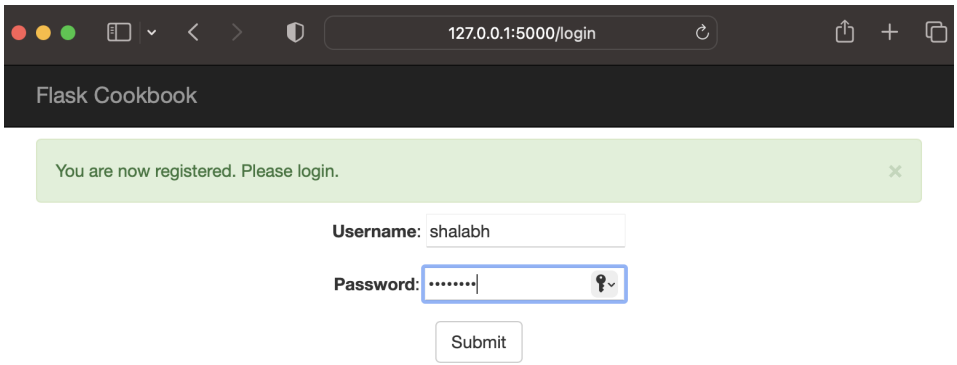


Figure 6.3 – Login page rendered after successful registration

Finally, the home page is shown to the logged-in user at `http://127.0.0.1:5000/home`, as shown in the following screenshot:

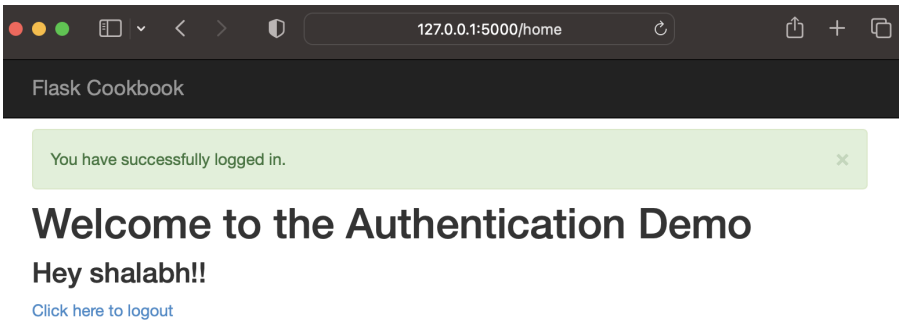


Figure 6.4 – Home page as shown to a logged-in user

See also

The next recipe, *Authenticating using the Flask-Login extension*, will cover a more secure and production-ready method of performing user authentication.

Authenticating using the Flask-Login extension

In our previous recipe, we learned how to implement session-based authentication ourselves. `Flask-Login` is a popular extension that handles a lot of the same stuff in a helpful and efficient way and thus saves us from reinventing the wheel all over again. In addition, `Flask-Login` will not bind us to any specific database or limit us to using any specific fields or methods for authentication. It can also handle the **Remember me** feature, account recovery features, and so on. In this recipe, we will understand how to use `Flask-Login` with our application.

Getting ready

Modify the application created in the previous recipe to accommodate the changes to be done by the `Flask-Login` extension.

Before that, we have to install the extension itself with the following command:

```
$ pip install Flask-Login
```

How to do it...

Follow these steps to understand how `Flask-Login` can be integrated with a Flask application:

1. To use `Flask-Login`, first, modify the application's configuration, which is in `flask_authentication/my_app/__init__.py`, as follows:

```
from flask_login import LoginManager

#
# Do other application configurations
#

login_manager = LoginManager()
login_manager.init_app(app)
login_manager.login_view = 'auth.login'
```

   In the preceding code snippet, after importing the `LoginManager` class from the extension, we created an object of this class. Then, we configured the `app` object for use with `LoginManager` using `init_app()`. There are then multiple configurations that can be done in the `login_manager` object, as and when needed. Here, we have just demonstrated one basic and compulsory configuration, that is, `login_view`, which points to the view handler for

login requests. In addition, we can also configure messages to be shown to the users, such as how long a session will last, handling logins using request headers, and so on. Refer to the `Flask-Login` documentation at `https://flask-login.readthedocs.org/en/latest/#customizing-the-login-process` for more details.

2. `Flask-Login` calls for some additional methods to be added to the `User` model/class in `my_app/auth/models.py`, as shown in the following snippet:

```
    @property
    def is_authenticated(self):
        return True

    @property
    def is_active(self):
        return True

    @property
    def is_anonymous(self):
        return False

    def get_id(self):
        return str(self.id)
```

In the preceding code, we added four methods, which are explained as follows:

- `is_authenticated()`: This property returns `True`. This should return `False` only in cases where we do not want a user to be authenticated.
- `is_active()`: This property returns `True`. This should return `False` only in cases where we have blocked or banned a user.
- `is_anonymous()`: This property is used to indicate a user who is not supposed to be logged in to the system and should access the application as anonymous. This should return `False` for regular logged-in users.
- `get_id()`: This method represents the unique `ID` used to identify the user. This should be a Unicode value.

Information

It is not necessary to implement all of the methods and properties discussed while implementing a `user` class. To make things easier, you can always subclass the `UserMixin` class from `flask_login`, which has default implementations already done for the methods and properties we mentioned. For more information on this, visit `https://flask-login.readthedocs.io/en/latest/#flask_login.UserMixin`.

3. Next, make the following changes to the views in `my_app/auth/views.py`:

```
from flask import g
from flask_login import current_user, login_user, logout_user, \
    login_required
from my_app import login_manager

@login_manager.user_loader
def load_user(id):
    return User.query.get(int(id))

@auth.before_request
def get_current_user():
    g.user = current_user
```

In the preceding method, the `@auth.before_request` decorator implies that the method will be called before the view function whenever a request is received.

4. In the following snippet, we have memorized our logged-in user:

```
@auth.route('/login', methods=['GET', 'POST'])
def login():
    if current_user.is_authenticated:
        flash('You are already logged in.', 'info')
        return redirect(url_for('auth.home'))

    form = LoginForm()

    if form.validate_on_submit():
        username = request.form.get('username')
        password = request.form.get('password')
        existing_user = User.query.filter_by(username=username).
        first()

        if not (existing_user and existing_user.check_
        password(password)):
            flash('Invalid username or password. Please try
            again.', 'danger')
            return render_template('login.html', form=form)

        login_user(existing_user)
        flash('You have successfully logged in.', 'success')
        return redirect(url_for('auth.home'))

    if form.errors:
        flash(form.errors, 'danger')
```

```
    return render_template('login.html', form=form)

@auth.route('/logout')
@login_required
def logout():
    logout_user()
    return redirect(url_for('auth.home'))
```

Notice that now, in `login()`, we check whether the `current_user` is authenticated before doing anything else. Here, `current_user` is a proxy that represents the object for the currently logged-in `User` record. After all validations and checks are done, the user is then logged in using the `login_user()` method. This method accepts the `user` object and handles all of the session-related activities required to log in a user.

Now, if we move on to the `logout()` method, we can see that a decorator has been added for `login_required()`. This decorator makes sure that the user is logged in before this method is executed. It can be used for any view method in our application. To log a user out, we just have to call `logout_user()`, which will clean up the session for the currently logged-in user and, in turn, log the user out of the application.

As we do not handle sessions ourselves, a minor change in the templates is required, as shown in the following snippet. This happens whenever we want to check whether a user is logged in and whether particular content needs to be shown to them:

```
{% if current_user.is_authenticated %}
...do something...
{% endif %}
```

How it works...

The demonstration in this recipe works exactly as it did in the previous recipe, *Creating a simple session-based authentication*. Only the implementation differs, but the end result remains the same.

There's more...

The `Flask-Login` extension makes the implementation of the **Remember me** feature pretty simple. To do so, just pass `remember=True` to the `login_user()` method. This will save a cookie on the user's computer, and `Flask-Login` will use this to log the user in automatically if the session is active. You should try implementing this on your own.

See also

See the previous recipe, *Creating a simple session-based authentication*, to understand the complete working of this recipe.

Flask provides a special object called `g`. You can read more about this at `https://flask.palletsprojects.com/en/2.2.x/api/#flask.g`.

Another interesting way of authentication is using JWT tokens, which work in a way that is very similar to `Flask-Login`. See more details at `https://flask-jwt-extended.readthedocs.io/en/stable/`.

Using Facebook for authentication

You will have noticed that many websites provide an option to log in to their own site using third-party authentication, such as Facebook, Google, Twitter, LinkedIn, and so on. This has been made possible by **OAuth 2**, which is an open standard for authorization. It allows the client site to use an access token to access the protected information and resources provided by the resource server. In this recipe, we will show you how to implement OAuth-based authorization via Facebook. In later recipes, we will do the same using other providers.

> **Information**
>
> OAuth is a mechanism that allows users to grant websites or applications access to their information on other websites (such as Google, Facebook, Twitter, etc.) without sharing the password. It essentially means that the third-party client application (your Flask application) gets access to data stored on the resource server (Google, Facebook, etc.) by means of an access token, which is issued by the resource server's authentication engine on approval of the resource owner (the user).

Getting ready

OAuth 2 only works with SSL, so the application should run with HTTPS. To do this on a local machine, please follow these steps:

1. Install `pyopenssl` using the `$ pip3 install pyopenssl` command.
2. Add additional options to `app.run()`, including `ssl_context` with the `adhoc` value. The completed `app.run` should look as follows: `app.run(debug=True, ssl_context='adhoc')`.
3. Once these changes have been made, run the application using the URL `https://localhost:5000/`. Before the app loads, your browser will display warnings about the certificate not being safe. Just accept the warning and proceed.

> **Tip**
> This is not a recommended method. In production systems, SSL certificates should be obtained from a proper certifying authority.

To install `Flask-Dance` and generate Facebook credentials, follow these step:.

1. First, install the `Flask-Dance` extension and its dependencies with the following command:

```
$ pip3 install Flask-Dance
```

2. Next, register for a Facebook application that will be used for login. Although the process for registration on the Facebook app is pretty straightforward and self-explanatory, in this case, we are only concerned with the **App ID**, **App secret**, and **Site URL** options, as shown in the following screenshot (more information on this can be found on the Facebook developer pages at `https://developers.facebook.com/`):

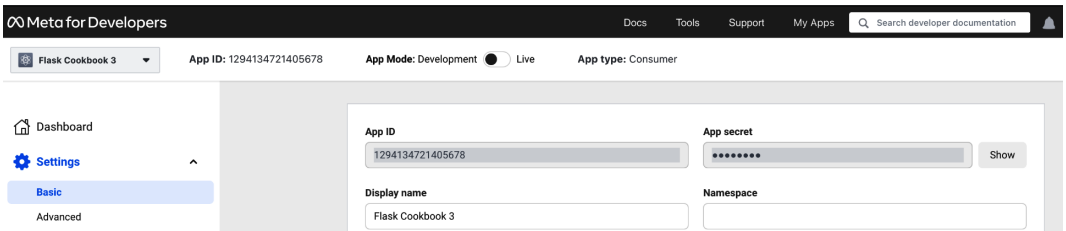


Figure 6.5 – Facebook app credentials

While configuring Facebook, make sure to configure the site URL to `https://localhost:5000/` for the purpose of this recipe, and the valid OAuth redirect URIs, as shown in the following screenshots:

Figure 6.6 – Facebook site URL config

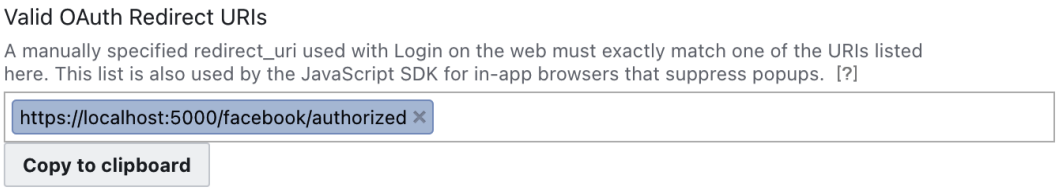


Figure 6.7 – Facebook OAuth Redirect URIs config

How to do it...

To enable Facebook authentication for your application, follow these steps:

1. As always, start with the configuration part in `my_app/__init__.py`. Add the following lines of code; do not remove or edit anything else unless you are confident of the change:

```
app.config["FACEBOOK_OAUTH_CLIENT_ID"] = 'my facebook APP ID'
app.config["FACEBOOK_OAUTH_CLIENT_SECRET"] = 'my facebook app
secret'

from my_app.auth.views import facebook_blueprint
app.register_blueprint(auth)
app.register_blueprint(facebook_blueprint)
```

   In the preceding code snippet, we used Flask-Dance with our application for authentication. This blueprint will be created in the `views` file, which we will cover next.

2. Now modify the views, that is, `my_app/auth/views.py`, as follows:

```
    from flask_dance.contrib.facebook import
      make_facebook_blueprint, facebook

    facebook_blueprint =
      make_facebook_blueprint(scope='email',
      redirect_to='auth.facebook_login')
```

   `make_facebook_blueprint` reads `FACEBOOK_OAUTH_CLIENT_ID` and `FACEBOOK_OAUTH_CLIENT_SECRET` from the application configuration and takes care of all the OAuth-related handling in the background. While making the Facebook blueprint, we set `scope` to `email`, so that an email address can be used as a unique username. We also set `redirect_to` to `auth.facebook_login`, so Facebook routes the application back to this URL once authentication succeeds. If this option is not set, the application will be automatically redirected to the home page, that is, `/`.

3. Now, create a new route handler to handle the login using Facebook, as follows:

```
@auth.route("/facebook-login")
def facebook_login():
    if not facebook.authorized:
        return redirect(url_for("facebook.login"))

    resp = facebook.get("/me?fields=name,email")

    user = User.query.filter_by(username
      =resp.json()["email"]).first()
    if not user:
        user = User(resp.json()["email"], '')
```

```
            db.session.add(user)
            db.session.commit()

        login_user(user)
        flash(
            'Logged in as name=%s using Facebook login' % (
                resp.json()['name']), 'success' )
        return redirect(request.args.get('next',
          url_for('auth.home')))
```

This method first checks whether a user is already authorized with Facebook. If not, it redirects the app to Facebook's login handler, where the user will need to follow the steps outlined by Facebook and give the necessary permissions to our application in order to access the requested user details, as per the settings in `make_facebook_blueprint`. Once the user is authorized with Facebook, the method then requests a user's details, such as their name and email address, from Facebook. Using these user details, it is determined whether a user already exists with the email entered or not. If not, a new user is created and logged in; otherwise, the existing user is directly logged in.

4. Finally, modify the `login.html` template to allow for broader social login functionality. This will act as a placeholder for the Facebook login, as well as a number of alternative social logins, which we will cover later. The code for the updated `login.html` template is as follows:

```
      {% extends 'home.html' %}

  {% block container %}
    <div class="top-pad">
      <ul class="nav nav-tabs">
       <li class="active"><a href="#simple-form" data-
         toggle="tab">Old Style Login</a></li>
       <li><a href="#social-logins" data-
         toggle="tab">Social Logins</a></li>
      </ul>
      <div class="tab-content">
        <div class="tab-pane active" id="simple-form">
          <form
              method="POST"
              action="{{ url_for('auth.login') }}"
              role="form">
            {{ form.csrf_token }}
            <div class="form-group">{{ form.username
              .label }}: {{ form.username() }}</div>
            <div class="form-group">{{ form.password
              .label }}: {{ form.password() }}</div>
            <button type="submit" class="btn btn-
              default">Submit</button>
```

```
          </form>
        </div>
        <div class="tab-pane" id="social-logins">
          <a href="{{ url_for('auth.facebook_login',
            next=url_for('auth.home')) }}"
            >Login via Facebook</a>
        </div>
      </div>
    </div>
  {% endblock %}
```

In the preceding code, we created a tabbed structure in which the first tab is our conventional login and the second tab corresponds to social logins.

Currently, there is just one option for Facebook available. More options will be added in upcoming recipes. Note that the link is currently simple; we can always add styles and buttons as needed later on.

How it works...

The login page has a new tab that provides an option for the user to log in using **Social Logins**, as shown in the following screenshot:

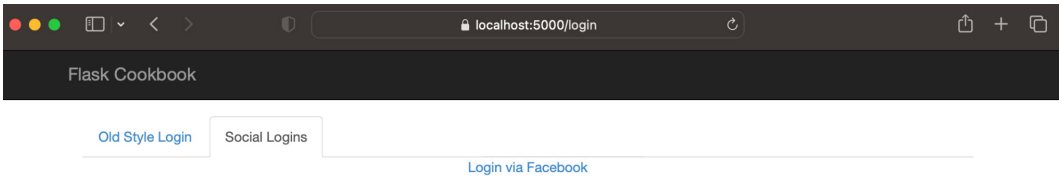


Figure 6.8 – Social Logins page

When we click on the **Login via Facebook** link, the application is taken to Facebook, where the user will be asked for their login details and permission. Once the permission is granted, the user will be logged in to the application.

Using Google for authentication

Just like we did for Facebook, we can integrate our application to enable login using Google.

Getting ready

Start by building over the last recipe. It is easy to implement Google authentication by simply leaving out the Facebook-specific elements as it is.

Now, create a new project from the Google developer console (`https://console.developers.google.com`). In the **APIs and Services** section, click on **Credentials**. Then, create a new client ID for the web application; this ID will provide the credentials needed for OAuth 2 to work. You will also need to configure the OAuth consent screen before a client ID can be created, as shown in the following screenshot:

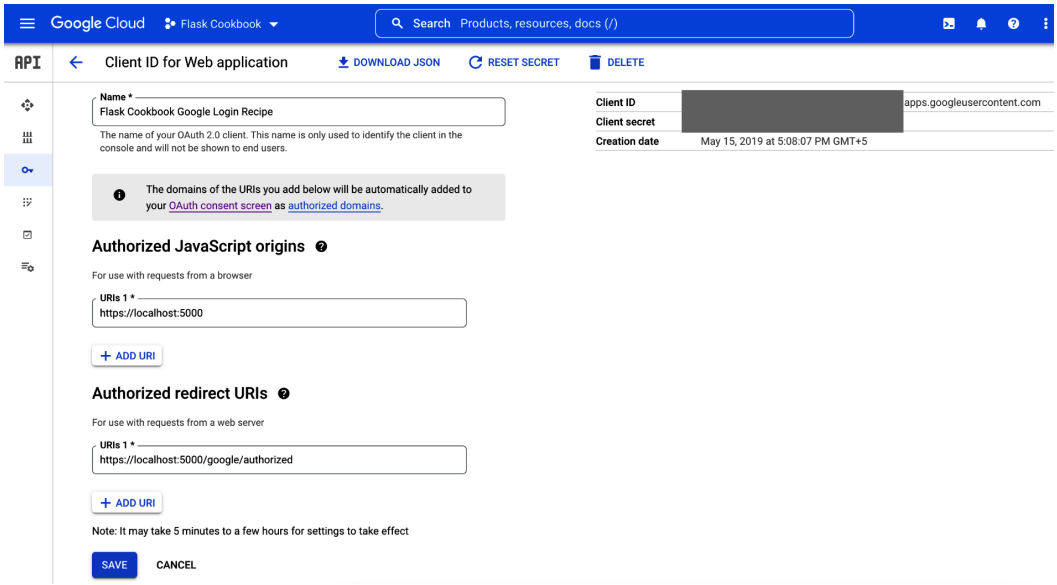


Figure 6.9 – Google app configuration

How to do it...

To enable Google authentication in your application, follow these steps:

1. As always, start with the configuration part in `my_app/__init__.py`, as follows:

```
app.config["GOOGLE_OAUTH_CLIENT_ID"] = "my Google
  OAuth client ID"
app.config["GOOGLE_OAUTH_CLIENT_SECRET"] = "my Google
  OAuth client secret"
app.config["OAUTHLIB_RELAX_TOKEN_SCOPE"] = True

from my_app.auth.views import auth,
  facebook_blueprint, google_blueprint
app.register_blueprint(google_blueprint)
```

In the preceding code snippet, we registered the Google blueprint provided by Flask-Dance with our application for authentication. This blueprint will be created in the `views` file, which we will take a look at next. Note the additional configuration option, `OAUTHLIB_RELAX_TOKEN_SCOPE`. This is suggested for use when implementing Google authentication because Google tends to provide data that sometimes diverges from the scope mentioned.

2. Next, modify the views, that is, `my_app/auth/views.py`, as follows:

```
from flask_dance.contrib.google import
  make_google_blueprint, google

google_blueprint = make_google_blueprint(
    scope=[
        "openid",
        "https://www.googleapis.com
          /auth/userinfo.email",
        "https://www.googleapis.com
          /auth/userinfo.profile"],
    redirect_to='auth.google_login')
```

In the preceding code snippet, `make_google_blueprint` reads `GOOGLE_OAUTH_CLIENT_ID` and `GOOGLE_OAUTH_CLIENT_SECRET` from the application configuration and takes care of all the OAuth-related handling in the background. While making the Google blueprint, we set `scope` to `openid`, `https://www.googleapis.com/auth/userinfo.email`, and `https://www.googleapis.com/auth/userinfo.profile`, because we want to use a user's email address as their unique username and display name after login. `openid` is required in `scope` because Google prefers it.

We also set `redirect_to` to `auth.google_login` so Google is able to route the application back to this URL after authentication has succeeded. If this option is not set, the application will be automatically redirected to the home page, that is, `/`.

3. Next, create a new route handler that handles the login using Google with the following code:

```
@auth.route("/google-login")
def google_login():
    if not google.authorized:
        return redirect(url_for("google.login"))

    resp = google.get("/oauth2/v1/userinfo")

    user = User.query.filter_by(username=resp.json()
      ["email"]).first()
    if not user:
        user = User(resp.json()["email"], '')
        db.session.add(user)
```

```
            db.session.commit()

        login_user(user)
        flash(
            'Logged in as name=%s using Google login' % (
                resp.json()['name']), 'success' )
        return redirect(request.args.get('next',
          url_for('auth.home')))
```

Here, the method first checks whether the user is already authorized with Google. If not, it redirects the app to the Google login handler, where the user will need to follow the steps outlined by Google and give permission to our application so it can access the requested user details. Once the user is authorized with Google, the method requests the user's details, including their name and email address, from Google. Using these user details, it is determined whether a user already exists with this email or not. If not, a new user is created and logged in; otherwise, the existing user is directly logged in.

4. Finally, modify the login template, `login.html`, to allow the Google login. Add the following line inside the `social-logins` tab:

```
<a href="{{ url_for('auth.google_login',
  next=url_for('auth.home'))
}}">Login via Google</a>
```

How it works...

The Google login works in a manner similar to the Facebook login from the previous recipe.

Using Twitter for authentication

OAuth was actually born while writing the OpenID API for Twitter. In this recipe, we will integrate Twitter login with our application.

Getting ready

We will continue by building over the *Using Google for authentication* recipe. It is easy to implement Twitter authentication – simply leave out the Facebook or Google-specific parts from the previous authentication recipes.

First, we have to create an application from the Twitter **Application Management** page (`https://developer.twitter.com/en/portal/dashboard`). It will automatically create consumer API keys (**API Key** and **API Key Secret**) for us to use, as shown in the following screenshot:

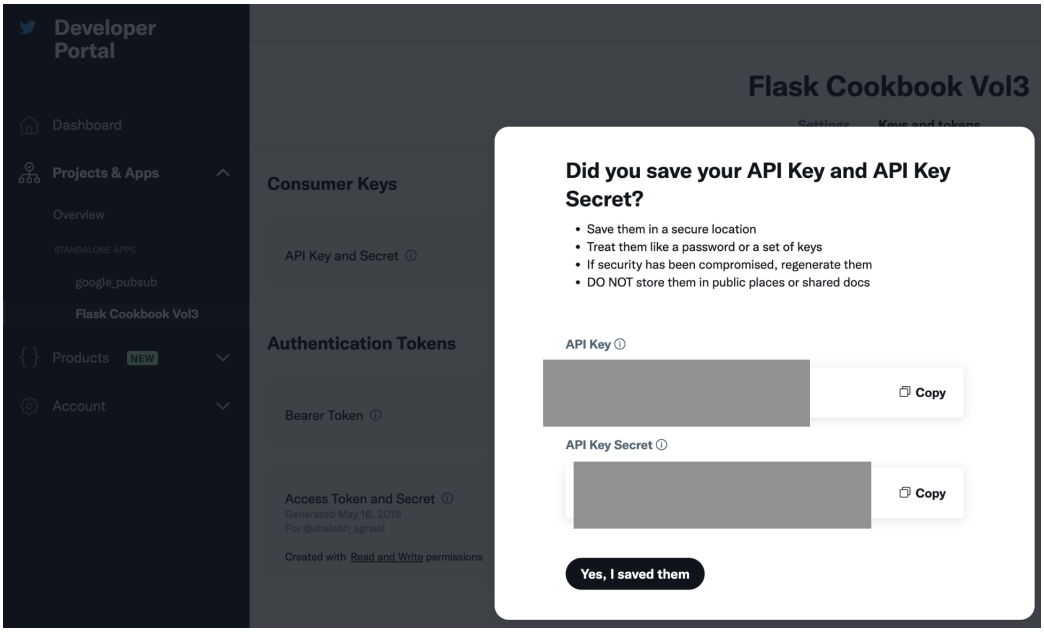


Figure 6.10 – Twitter app configuration

How to do it...

To enable Twitter authentication for your application, follow these steps:

1. First, start with the configuration part in `my_app/__init__.py`, as follows:

```
app.config["TWITTER_OAUTH_CLIENT_KEY"] = "my Twitter
  app ID"
app.config["TWITTER_OAUTH_CLIENT_SECRET"] = "my
  Twitter app secret"
from my_app.auth.views import twitter_blueprint
app.register_blueprint(twitter_blueprint)
```

   In the preceding code snippet, we registered the Twitter blueprint provided by Flask-Dance with our application for authentication. This blueprint will be created in the `views` file, which we will take a look at next.

2. Next, modify the views, that is, `my_app/auth/views.py`, as follows:

```
from flask_dance.contrib.twitter import
  make_twitter_blueprint, twitter

twitter_blueprint = make_twitter_blueprint
  (redirect_to='auth.twitter_login')
```

In the preceding code, `make_twitter_blueprint` reads `TWITTER_OAUTH_CLIENT_KEY` and `TWITTER_OAUTH_CLIENT_SECRET` from the application configuration and takes care of all the OAuth-related handling in the background. There is no need to set `scope`, as we did during Facebook and Google authentication, as this recipe will use a Twitter handle as the username, which is provided by default.

We also set `redirect_to` to `auth.twitter_login` so that Twitter can route the application back to this URL after authentication has succeeded. If this option is not set, the application will be automatically redirected to the home page, that is, `/`.

3. Next, create a new route handler that handles the login using Twitter, as follows:

```
@auth.route("/twitter-login")
def twitter_login():
    if not twitter.authorized:
        return redirect(url_for("twitter.login"))

    resp = twitter.get("account/verify_credentials
      .json")

    user = User.query.filter_by(username=resp
      .json()["screen_name"]).first()
    if not user:
        user = User(resp.json()["screen_name"], '')
        db.session.add(user)
        db.session.commit()

    login_user(user)
    flash(
        'Logged in as name=%s using Twitter login' % (
            resp.json()['name']), 'success' )
    return redirect(request.args.get('next',
      url_for('auth.home')))
```

The preceding method first checks whether the user is already authorized with Twitter. If not, it redirects the app to the Twitter login handler, where the user will need to follow the steps outlined by Twitter and give permission to our application so it can access the requested user details. Once the user is authorized with Twitter, the method requests the user's details, including their screen name or handle from Twitter. Using these user details, it is determined whether a user already exists with this Twitter handle or not. If not, a new user is created and logged in; otherwise, the existing user is directly logged in.

4. Finally, modify the login template, `login.html`, to allow the Twitter login. Add the following line inside the `social-logins` tab:

```
<a href="{{ url_for('auth.twitter_login',
next=url_for('auth.home')) }}">Login via Twitter</a>
```

How it works...

This recipe works in a manner similar to the Facebook and Google logins from previous recipes.

> **Information**
>
> Similarly, we can integrate LinkedIn, GitHub, and scores of other third-party providers that provide support for login and authentication using OAuth. It's up to you to implement any more integrations. The following links have been added for your reference:
>
> *LinkedIn*: `https://learn.microsoft.com/en-us/linkedin/shared/authentication/authentication`
>
> *GitHub*: `https://docs.github.com/en/developers/apps/building-oauth-apps`

Authenticating with LDAP

LDAP is essentially an internet protocol for looking up contact information about users, certificates, network pointers, and more from a server, where the data is stored in a directory-style structure. Of LDAP's multiple use cases, the most popular is the single sign-on functionality, where a user can access multiple services by logging in to just one, as the credentials are shared across the system.

Getting ready

In this recipe, we will create a login page similar to the one we created in the first recipe of this chapter, *Creating a simple session-based authentication*. The user can log in using their LDAP credentials. If the credentials are successfully authenticated on the provided LDAP server, the user is logged in.

If you already have an LDAP server that you can access, feel free to skip the LDAP setup instructions explained in this section.

The first step is to get access to an LDAP server. This can be a server already hosted somewhere, or you can create your own local LDAP server. The easiest way to spawn a demo LDAP server is by using Docker.

> **Important**
>
> Here, we are assuming that you have prior experience in Docker and have Docker installed on your machine. If not, please refer to `https://docs.docker.com/get-started/`.

To create an LDAP server using Docker, run the following command on the terminal:

```
$ docker run -p 389:389 -p 636:636 --name my-openldap-container
--detach osixia/openldap:1.5.0
```

Once the preceding command has successfully executed, test the server by searching for an example user with the username and password `admin` and `admin`, as follows:

```
$ docker exec my-openldap-container ldapsearch -x -H ldap://localhost
-b dc=example,dc=org -D "cn=admin,dc=example,dc=org" -w admin
```

The successful execution of the preceding command indicates that the LDAP server is running and is ready for use.

> **Tip**
>
> Refer to `https://github.com/osixia/docker-openldap` for more information on the OpenLDAP Docker image.

Now, install the Python library that will help our application talk to the LDAP server with the following code:

```
$ pip install python-ldap
```

How to do it...

To enable LDAP authentication for your application, follow these steps:

1. As always, start with the configuration part in `my_app/__init__.py`, as follows:

```
import ldap

app.config['LDAP_PROVIDER_URL'] = 'ldap://localhost'

def get_ldap_connection():
    conn = ldap.initialize(app.config
      ['LDAP_PROVIDER_URL'])
    return conn
```

   In the preceding code snippet, we imported `ldap`, then created an app configuration option that points to the LDAP server address. This is followed by the creation of a simple function, `get_ldap_connection`, which creates the LDAP connection object on the server and then returns that connection object.

2. Next, modify the views, that is, `my_app/auth/views.py`, where a new route, `ldap_login`, is created to facilitate login via LDAP, as follows:

```
import ldap
from my_app import db, login_manager,
  get_ldap_connection

@auth.route("/ldap-login", methods=['GET', 'POST'])
def ldap_login():
    if current_user.is_authenticated:
        flash('Your are already logged in.', 'info')
        return redirect(url_for('auth.home'))

    form = LoginForm()

    if form.validate_on_submit():
        username = request.form.get('username')
        password = request.form.get('password')
        try:
            conn = get_ldap_connection()
            conn.simple_bind_s(
                'cn=%s,dc=example,dc=org' % username,
                password
            )
        except ldap.INVALID_CREDENTIALS:
            flash('Invalid username or password.
              Please try again.', 'danger')
            return render_template('login.html',
              form=form)

        user = User.query.filter_by(username=username)
          .first()
        if not user:
            user = User(username, password)
            db.session.add(user)
            db.session.commit()

        login_user(user)
        flash('You have successfully logged in.',
          'success')
        return redirect(url_for('auth.home'))

    if form.errors:
        flash(form.errors, 'danger')

    return render_template('login.html', form=form)
```

Here, we first checked whether the user is already authenticated. If they were, we redirected them to the home page; otherwise, we moved ahead. We then used `LoginForm`, which we created in the *Creating a simple session-based authentication* recipe, as we also require a username and password. Next, we validated the form and then fetched the connection object using `get_ldap_connection`. After, the application tried to authenticate the user from the LDAP server using `simple_bind_s`. Notice the string inside this method, `'cn=%s,dc=example,dc=org'` – this string might vary for each LDAP server depending on the configurations internal to the server. You are urged to contact your LDAP server admin if these details are not known.

If the user is successfully authenticated, then a new user record is created in our local database and the user is logged in. Otherwise, the LDAP connection fails and throws the error `INVALID_CREDENTIALS`, which is then caught and the user is notified accordingly.

Tip

We just witnessed the power of reusable components! As you can see, `LoginForm` has now been used for two different purposes. This is a good coding practice.

3. Finally, modify the login template, `login.html`, to allow the LDAP login, as follows:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <ul class="nav nav-tabs">
     <li class="active"><a href="#simple-form" data-
       toggle="tab">Old Style Login</a></li>
     <li><a href="#social-logins" data-
       toggle="tab">Social Logins</a></li>
     <li><a href="#ldap-form" data-toggle="tab">LDAP
       Login</a></li>
    </ul>
    <div class="tab-content">
      <div class="tab-pane active" id="simple-form">
        <br/>
        <form
            method="POST"
            action="{{ url_for('auth.login') }}"
            role="form">
          {{ form.csrf_token }}
```

```
            <div class="form-group">{{ form.username
              .label }}: {{ form.username() }}</div>
            <div class="form-group">{{ form.password
              .label }}: {{ form.password() }}</div>
            <button type="submit" class="btn btn-
              default">Submit</button>
          </form>
        </div>
        <div class="tab-pane" id="social-logins">
          <a href="{{ url_for('auth.facebook_login',
            next=url_for('auth.home')) }}"
            >Login via Facebook</a>
          <br/>
          <a href="{{ url_for('auth.google_login',
            next=url_for('auth.home')) }}"
            >Login via Google</a>
          <br/>
          <a href="{{ url_for('auth.twitter_login',
            next=url_for('auth.home')) }}"
            >Login via Twitter</a>
        </div>
        <div class="tab-pane" id="ldap-form">
          <br/>
          <form
              method="POST"
              action="{{ url_for('auth.ldap_login') }}"
              role="form">
            {{ form.csrf_token }}
            <div class="form-group">{{ form.username
              .label }}: {{ form.username() }}</div>
            <div class="form-group">{{ form.password
              .label }}: {{ form.password() }}</div>
            <button type="submit" class="btn btn-
              default">Submit</button>
          </form>
        </div>
      </div>
    </div>
{% endblock %}
```

How it works...

The new login screen with the LDAP tab should look like the following screenshot:

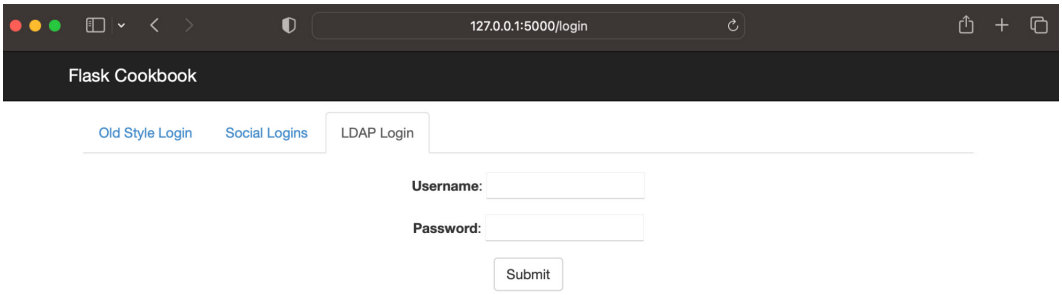


Figure 6.11 – LDAP Login screen

Here, the user simply needs to enter their username and password. If the credentials are correct, the user will be logged in and taken to the home screen; otherwise, an error will occur.

See also

You can read more about LDAP at `https://en.wikipedia.org/wiki/Lightweight_Directory_Access_Protocol` and `https://www.python-ldap.org`.

7
RESTful API Building

An **Application Programming Interface** (**API**) can be summarized as a developer's interface with an application. Just as end users have a visible frontend user interface with which they can work on and talk to the application, developers also need an interface to it. **Representational State Transfer** (**REST**) is not a protocol or a standard. It is just a software architectural style or a set of suggestions defined for writing applications, the aim of which is to simplify the interfaces within and without the application. When web service APIs are written in a way that adheres to the REST definitions, then they are known as RESTful APIs. Being RESTful keeps the API decoupled from the internal application details. This results in ease of scalability and keeps things simple. The uniform interface ensures that each and every request is documented.

> **Information**
>
> It is a topic of debate as to whether REST or simple object access protocol (SOAP) is better. This is actually a subjective question, as it depends on what needs to be done. Each has its own benefits and should be chosen based on the requirements of the application.

REST calls for segregating your API into logical resources, which can be accessed and manipulated using HTTP requests, where each request consists of one of the following methods – `GET`, `POST`, `PUT`, `PATCH`, and `DELETE` (there can be more, but these are the ones used most frequently). Each of these methods has a specific meaning. One of the key implied principles of REST is that the logical grouping of resources should be easily understandable and, hence, provide simplicity along with portability.

We have a resource called `product`, as used in our book hitherto. Now, let's see how we can logically map our API calls to the resource segregation:

- `GET /products/1`: This gets the product with an ID of `1`
- `GET /products`: This gets the list of products
- `POST /products`: This creates a new product
- `PUT /products/1`: This replaces or recreates the product with an ID of `1`

- `PATCH /products/1`: This partially updates the product with an ID of `1`
- `DELETE /products/1`: This deletes the product with an ID of `1`

In this chapter, we will cover the following recipes:

- Creating a class-based REST interface
- Creating an extension-based REST interface
- Creating a complete RESTful API

Creating a class-based REST interface

We saw how class-based views work in Flask, using the concept of pluggable views, in the *Writing class-based views* recipe in *Chapter 4*, *Working with Views*. In this recipe, we will now see how we can use the same to create views, which will provide a REST interface to our application.

Getting ready

Let's take a simple view that will handle the REST-style calls to our `Product` model.

How to do it...

We simply have to modify our views for product handling to extend the `MethodView` class in `views.py`:

```
import json
from flask.views import MethodView

class ProductView(MethodView):

    def get(self, id=None, page=1):
        if not id:
            products = Product.query.paginate(page,
              10).items
            res = {}
            for product in products:
                res[product.id] = {
                    'name': product.name,
                    'price': product.price,
                    'category': product.category.name
                }
        else:
            product =
              Product.query.filter_by(id=id).first()
            if not product:
```

```
                abort(404)
                res = json.dumps({
                    'name': product.name,
                    'price': product.price,
                    'category': product.category.name
                })
        return res
```

The preceding `get()` method searches for the product and sends back a JSON result. Similarly, we can write the `post()`, `put()`, and `delete()` methods too:

```
def post(self):
    # Create a new product.
    # Return the ID/object of the newly created product.
    return

def put(self, id):
    # Update the product corresponding provided id.
    # Return the JSON corresponding updated product.
    return

def delete(self, id):
    # Delete the product corresponding provided id.
    # Return success or error message.
    return
```

Many of us would question why we have no routing here. To include routing, we have to do the following:

```
product_view =  ProductView.as_view('product_view')
app.add_url_rule('/products/', view_func=product_view,
    methods=['GET', 'POST'])
app.add_url_rule('/products/<int:id>',
    view_func=product_view,
    methods=['GET', 'PUT', 'DELETE'])
```

The first statement here converts the class to an actual view function internally that can be used with the routing system. The next two statements are the URL rules corresponding to the calls that can be made.

How it works...

The `MethodView` class identified the type of HTTP method in the sent request and converted the name to lowercase. Then, it matched this to the methods defined in the class and called the matched method. So, if we make a `GET` call to `ProductView`, it will automatically be mapped to the `get()` method and processed accordingly.

Creating an extension-based REST interface

In the previous recipe, *Creating a class-based REST interface*, we saw how to create a REST interface using pluggable views. In this recipe, we will use an extension called **Flask- RESTful**, which is written over the same pluggable views we used in the previous recipe, but which handles a lot of nuances by itself to allow us developers to focus on actual API development. It is also independent of **object-relational mapping** (**ORM**), so there are no strings attached to the ORM we may want to use.

Getting ready

First, we will begin with the installation of the extension:

```
$ pip install flask-restful
```

We will modify the catalog application from the last recipe to add a REST interface using this extension.

How to do it...

As always, start with changes to the application's configuration in `my_app/__init__.py`, which will look something like the following lines of code:

```
from flask_restful import Api
api = Api(app)
```

Here, `app` is our Flask application object/instance.

Next, create the API inside the `views.py` file. Here, we will just try to understand how to lay out the skeleton of the API. Actual methods and handlers will be covered in the *Creating a complete RESTful API* recipe:

```
from flask_restful import Resource
from my_app import api

class ProductApi(Resource):

    def get(self, id=None):
        # Return product data
        return 'This is a GET response'

    def post(self):
        # Create a new product
        return 'This is a POST response'

    def put(self, id):
        # Update the product with given id
```

```
        return 'This is a PUT response'

    def delete(self, id):
        # Delete the product with given id
        return 'This is a DELETE response'
```

The preceding API structure is self-explanatory. Consider the following code:

```
api.add_resource(
    ProductApi,
    '/api/product',
    '/api/product/<int:id>'
)
```

Here, we created the routing for `ProductApi`, and we can specify multiple routes as necessary.

How it works...

We will see how this REST interface works on the Python shell using the `requests` library.

> **Information**
>
> `requests` is a very popular Python library that makes the rendering of HTTP requests very easy. It can simply be installed by running the `$ pip install requests` command.

The command will show the following information:

```
>>> import requests
>>> res = requests.get('http://127.0.0.1:5000/api/product')
>>> res.json()
'This is a GET response'
>>> res = requests.post('http://127.0.0.1:5000/api/product')
>>> res.json()
'This is a POST response'
>>> res = requests.put('http://127.0.0.1:5000/api/product/1')
>>> res.json()
'This is a PUT response'
>>> res = requests.delete('http://127.0.0.1:5000/api/product/1')
>>> res.json()
'This is a DELETE response'
```

In the preceding snippet, we saw that all our requests are properly routed to the respective methods; this is evident from the response received.

See also

Refer to the following recipe, *Creating a complete RESTful API*, to see the API skeleton from this recipe come to life.

Creating a complete RESTful API

In this recipe, we will convert the API structure created in the last recipe, *Creating an extension-based REST interface*, into a full-fledged RESTful API.

Getting ready

We will take the API skeleton from the last recipe as a basis to create a completely functional SQLAlchemy-independent RESTful API. Although we will use SQLAlchemy as the ORM for demonstration purposes, this recipe can be written in a similar fashion for any ORM or underlying database.

How to do it...

The following lines of code are the complete RESTful API for the `Product` model. These code snippets will go into the `views.py` file.

Start with imports and add `parser`:

```
import json
from flask_restful import Resource, reqparse

parser = reqparse.RequestParser()
parser.add_argument('name', type=str)
parser.add_argument('price', type=float)
parser.add_argument('category', type=dict)
```

In the preceding snippet, we created `parser` for the arguments that we expected to have in our requests for `POST` and `PUT`. The request expects each of the arguments to have a value. If a value is missing for any argument, then `None` is used as the value.

Write the method as shown in the following code block to fetch products:

```
class ProductApi(Resource):

    def get(self, id=None, page=1):
        if not id:
            products = Product.query.paginate(page=page,
              per_page=10).items
        else:
            products = [Product.query.get(id)]
```

```
        if not products:
            abort(404)
        res = {}
        for product in products:
            res[product.id] = {
                'name': product.name,
                'price': product.price,
                'category': product.category.name
            }
        return json.dumps(res)
```

The preceding `get()` method corresponds to `GET` requests and returns a paginated list of products if no `id` is passed; otherwise, it returns the corresponding product.

Create the following method to add a new product:

```
    def post(self):
        args = parser.parse_args()
        name = args['name']
        price = args['price']
        categ_name = args['category']['name']
        category =
          Category.query.filter_by(name=categ_name).first()
        if not category:
            category = Category(categ_name)
        product = Product(name, price, category)
        db.session.add(product)
        db.session.commit()
        res = {}
        res[product.id] = {
            'name': product.name,
            'price': product.price,
            'category': product.category.name,
        }
        return json.dumps(res)
```

The preceding `post()` method will lead to the creation of a new product by making a `POST` request.

Write the following method to update or essentially replace an existing product record:

```
    def put(self, id):
        args = parser.parse_args()
        name = args['name']
        price = args['price']
        categ_name = args['category']['name']
        category =
```

```
            Category.query.filter_by(name=categ_name).first()
        Product.query.filter_by(id=id).update({
            'name': name,
            'price': price,
            'category_id': category.id,
        })
        db.session.commit()
        product = Product.query.get_or_404(id)
        res = {}
        res[product.id] = {
            'name': product.name,
            'price': product.price,
            'category': product.category.name,
        }
        return json.dumps(res)
```

In the preceding code, we updated an existing product using a `PUT` request. Here, we should provide all the arguments even if we intend to change a few of them. This is because of the conventional way in which `PUT` has been defined to work. If we want to have a request where we intend to pass only those arguments that we intend to update, then we should use a `PATCH` request. I would urge you to try that by yourself.

Delete a product using the following method:

```
    def delete(self, id):
        product = Product.query.filter_by(id=id)
        product.delete()
        db.session.commit()
        return json.dumps({'response': 'Success'})
```

Last, but not least, we have the `DELETE` request, which will simply delete the product that matches the `id` passed.

The following is a definition of all the possible routes that our API can accommodate:

```
api.add_resource(
    ProductApi,
    '/api/product',
    '/api/product/<int:id>',
    '/api/product/<int:id>/<int:page>'
)
```

How it works...

To test and see how this works, we can send a number of requests using the Python shell by means of the `requests` library:

```
>>> import requests
>>> import json
>>> res = requests.get('http://127.0.0.1:5000/api/product')
>>> res.json()
{'message': 'The requested URL was not found on the server. If you
entered the URL manually please check your spelling and try again.'}
```

We made a `GET` request to fetch the list of products, but there is no record of this. Let's create a new product now:

```
>>> d = {'name': u'iPhone', 'price': 549.00, 'category':
...     {'name':'Phones'}}
>>> res = requests.post('http://127.0.0.1:5000/api/product',
data=json.
...     dumps(d), headers={'Content-Type': 'application/json'})
>>> res.json()
'{"1": {"name": "iPhone", "price": 549.0, "category": "Phones"}}'
```

We sent a `POST` request to create a product with some data. Note the `headers` argument in the request. Each `POST` request sent in Flask-RESTful should have this header. Now, we should look for the list of products again:

```
>>> res = requests.get('http://127.0.0.1:5000/api/product')
>>> res.json()
'{"1": {"name": "iPhone", "price": 549.0, "category": "Phones"}}'
```

If we look for the products again via a `GET` request, we can see that we now have a newly created product in the database.

I will leave it to you to try to incorporate other API requests by themselves.

> **Important**
>
> An important facet of RESTful APIs is the use of token-based authentication to allow only limited and authenticated users to be able to use and make calls to the API. I urge you to explore this on your own. We covered the basics of user authentication in *Chapter 6*, *Authenticating in Flask*, which will serve as a basis for this concept.

8

Admin Interface for Flask Apps

Many applications require an interface that provides special privileges to some users and can be used to maintain and upgrade an application's resources. For example, we can have an interface in an e-commerce application that will allow some special users to create categories, products, and more. Some users might have special permissions to handle other users who shop on the website, deal with their account information, and so on. Similarly, there can be many cases where we need to isolate some parts of the interface of our application from normal users.

In comparison to the very popular Python-based web framework, Django, Flask does not provide any admin interface by default. Although this can be seen as a shortcoming by many, this gives developers the flexibility to create the admin interface as per their requirements and have complete control over the application.

We can choose to write an admin interface for our application from scratch or use an extension of Flask, which does most of the work for us and gives us the option to customize the logic as needed. One very popular extension for creating admin interfaces in Flask is Flask-Admin (`https://flask-admin.readthedocs.io/en/latest/`). It is inspired by the Django admin but is implemented in a way that gives the developer complete control over the look, feel, and functionality of the application. In this chapter, we will start with the creation of an admin interface on our own, and then move on to using the `Flask-Admin` extension and fine-tune this as needed.

In this chapter, we will cover the following recipes:

- Creating a simple CRUD interface
- Using the Flask-Admin extension
- Registering models with Flask-Admin
- Creating custom forms and actions
- Using a WYSIWYG editor for `textarea` integration
- Creating user roles

Creating a simple CRUD interface

CRUD refers to **Create, Read, Update, and Delete**. A basic necessity of an admin interface is to have the ability to create, modify, or delete the records/resources from the application as and when needed. We will create a simple admin interface that will allow admin users to perform these operations on the records that other normal users generally can't.

Getting ready

We will start with the authentication application from the *Authenticating using the Flask-Login extension* recipe in *Chapter 6*, *Authenticating in Flask*, and add admin authentication with an interface for admins, which would allow only the admin users to create, update, and delete user records. Here, in this recipe, I will cover some specific parts that are necessary to understand the concepts. For the complete application, you can refer to the code samples available for the book.

How to do it...

To create a simple admin interface, perform the following steps:

1. Start with the models by adding a new `BooleanField` field called `admin` to the `User` model in `auth/models.py`. This field will help in identifying whether the user is an admin or not:

```
from wtforms import BooleanField

class User(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    username = db.Column(db.String(100))
    pwdhash = db.Column(db.String())
    admin = db.Column(db.Boolean())

    def __init__(self, username, password,
      admin=False):
        self.username = username
        self.pwdhash =
          generate_password_hash(password)
        self.admin = admin

    def is_admin(self):
        return self.admin
```

   The preceding method simply returns the value of the admin field. This can have a custom implementation as per our requirements.

Tip

Since this is a new field being added to the `User` model, database migration should be done. You can refer to the *Migrating databases using Alembic and Flask-Migrate* recipe in *Chapter 3*, *Data Modeling in Flask*, for more details.

2. Create two forms that will be used by the admin views in `auth/models.py`:

```
class AdminUserCreateForm(FlaskForm):
    username = StringField('Username',
      [InputRequired()])
    password = PasswordField('Password',
      [InputRequired()])
    admin = BooleanField('Is Admin ?')


class AdminUserUpdateForm(FlaskForm):
    username = StringField('Username',
      [InputRequired()])
    admin = BooleanField('Is Admin ?')
```

3. Now, modify the views in `auth/views.py` to implement the admin interface:

```
from functools import wraps
from flask import abort
from my_app.auth.models import AdminUserCreateForm,
  AdminUserUpdateForm

def admin_login_required(func):
    @wraps(func)
    def decorated_view(*args, **kwargs):
        if not current_user.is_admin():
            return abort(403)
        return func(*args, **kwargs)
    return decorated_view
```

The preceding code is the `admin_login_required` decorator, which works just like the `login_required` decorator. Here, the difference is that it needs to be implemented along with `login_required`, and it checks whether the currently logged-in user is an admin.

4. Create the following handlers, which will be needed to create a simple admin interface. Note the usage of the `@admin_login_required` decorator. Everything else is pretty much standard, as we learned in the previous chapters of this book that focused on views and authentication handling. All the handlers will go in `auth/views.py`:

```
@auth.route('/admin')
@login_required
```

```
@admin_login_required
def home_admin():
    return render_template('admin-home.html')


@auth.route('/admin/users-list')
@login_required
@admin_login_required
def users_list_admin():
    users = User.query.all()
    return render_template('users-list-admin.html',
      users=users)


@auth.route('/admin/create-user', methods=['GET',
  'POST'])
@login_required
@admin_login_required
def user_create_admin():
    form = AdminUserCreateForm()

    if form.validate_on_submit():
        username = form.username.data
        password = form.password.data
        admin = form.admin.data
        existing_username = User.query.filter_by
          (username=username).first()
        if existing_username:
            flash(
                'This username has been already taken.
                  Try another one.',
                'warning'
            )
            return render_template('register.html',
              form=form)
        user = User(username, password, admin)
        db.session.add(user)
        db.session.commit()
        flash('New User Created.', 'info')
        return
          redirect(url_for('auth.users_list_admin'))

    if form.errors:
        flash(form.errors, 'danger')
```

```
    return render_template('user-create-admin.html',
      form=form)
```

The preceding method allows admin users to create new users in the system. This works in a manner that is pretty similar to the `register()` method but allows the admin to set the `admin` flag on the user.

The following method allows the admin users to update the records of other users:

```
@auth.route('/admin/update-user/<id>', methods=['GET', 'POST'])
@login_required
@admin_login_required
def user_update_admin(id):
    user = User.query.get(id)
    form = AdminUserUpdateForm(
        username=user.username,
        admin=user.admin
    )

    if form.validate_on_submit():
        username = form.username.data
        admin = form.admin.data

        User.query.filter_by(id=id).update({
            'username': username,
            'admin': admin,
        })

        db.session.commit()
        flash('User Updated.', 'info')
        return
          redirect(url_for('auth.users_list_admin'))

    if form.errors:
        flash(form.errors, 'danger')

    return render_template('user-update-admin.html', form=form,
      user=user)
```

However, as per the best practices of writing web applications, we do not allow the admin to simply view and change the passwords of any user. In most cases, the provision to change passwords should rest with the user who owns the account. Although admins can have the provision to update the password in some cases, still, it should never be possible for them to see the passwords set by the user earlier. This topic is discussed in the *Creating custom forms and actions* recipe.

The following method handles the deletion of a user by an admin:

```
@auth.route('/admin/delete-user/<id>')
@login_required
@admin_login_required
def user_delete_admin(id):
    user = User.query.get(id)
    db.session.delete(user)
    db.session.commit()
    flash('User Deleted.', 'info')
    return redirect(url_for('auth.users_list_admin'))
```

The `user_delete_admin()` method should actually be implemented on a `POST` request. This is left to you to implement by yourself.

5. Followed by models and views, create some templates to complement them. It might have been evident to many of you from the code of the views itself that we need to add four new templates, namely, `admin-home.html`, `user-create- admin.html`, `user-update-admin.html`, and `users-list-admin.html`. How these work is shown in the next section. You should now be able to implement these templates by yourself; however, for reference, the code is always available with the samples provided with the book.

How it works...

To begin, we added a menu item to the application; this provides a direct link to the admin home page, which will look like the following screenshot:

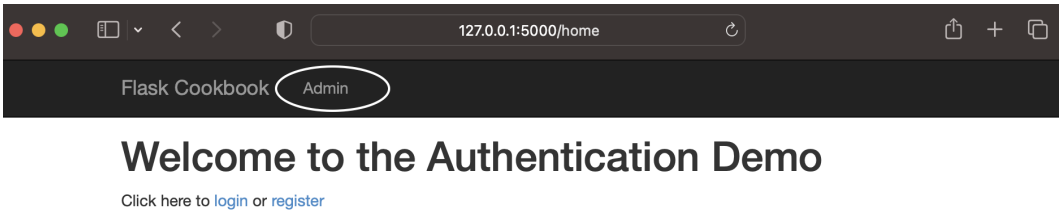


Figure 8.1 – Menu item for admin access

A user must be logged in as the admin to access this page and other admin-related pages. If a user is not logged in as the admin, then the application will show an error, as shown in the following screenshot:

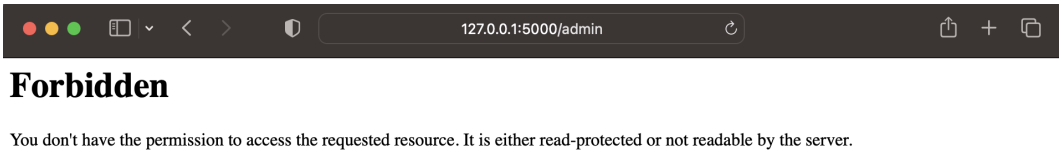


Figure 8.2 – Forbidden error for non-admin users

Information

Create an admin user before you can log in as the admin. To create an admin user, you can make DB changes in SQLAlchemy from the command line using SQL queries. Another simpler but hacky way of doing this is to change the `admin` flag to `True` in `auth/models.py` and then register a new user. This new user will be an admin user. Make sure that you revert the `admin` flag to `False` as the default after this is done.

To a logged-in admin user, the admin home page will look as follows:

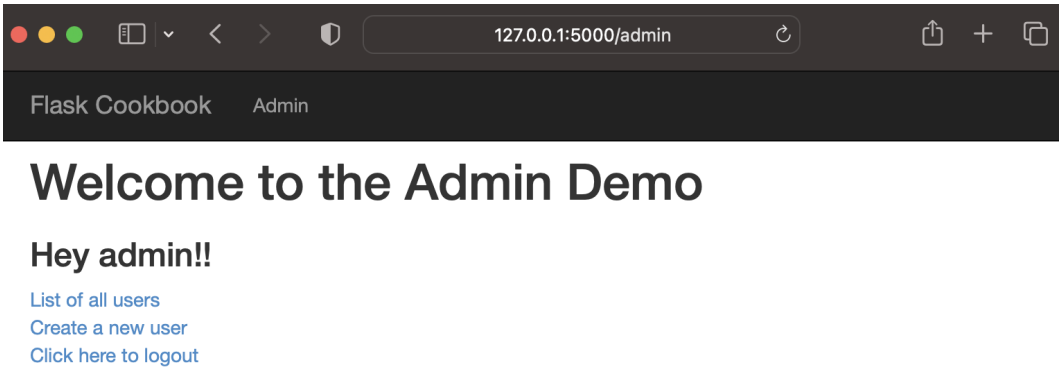


Figure 8.3 – Admin home page

From here, the admin can see the list of users on a system or create a new user. The options to edit or delete the users will be available on the user list page itself.

Using the Flask-Admin extension

`Flask-Admin` is an available extension that helps in the creation of admin interfaces for our application in a simpler and faster way. All the subsequent recipes in this chapter will focus on using and extending this extension.

Getting ready

First, we need to install the `Flask-Admin` extension:

```
$ pip install Flask-Admin
```

We will extend our application from the previous recipe and keep building on the same.

How to do it...

Adding a simple admin interface to any Flask application using the `Flask-Admin` extension is just a matter of a couple of statements.

Simply add the following lines to the application's configuration in `my_app/__init__.py`:

```
from flask_admin import Admin

app = Flask(__name__)

# Add any other application configurations

admin = Admin(app)
```

You can also add your own views to this; this is as simple as adding a new class as a new view that inherits from the `BaseView` class, as shown in the following code block. This code block goes in `auth/views.py`:

```
from flask_admin import BaseView, expose

class HelloView(BaseView):
    @expose('/')
    def index(self):
        return self.render('some-template.html')
```

After this, add this view to the `admin` object in the Flask configuration in `my_app/__init__.py`:

```
import my_app.auth.views as views
admin.add_view(views.HelloView(name='Hello'))
```

One thing to notice here is that this page does not have any authentication or authorization logic implemented by default, and it will be accessible to all. The reason for this is that `Flask-Admin` does not make any assumptions about the authentication system in place. As we are using `Flask-Login` for our applications, you can add a method named `is_accessible()` to your `HelloView` class:

```
    def is_accessible(self):
        return current_user.is_authenticated and \
            current_user.is_admin()
```

How it works...

Just initializing an application with the `Admin` class from the `Flask-Admin extension`, as demonstrated in the first step of this recipe, will put up a basic admin page, as shown in the following screenshot:

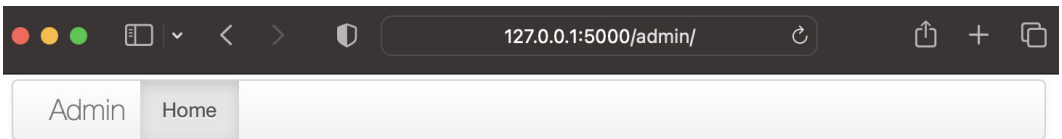


Figure 8.4 – Admin home page using Flask-Admin

Notice the URL in the screenshot, which is `http://127.0.0.1:5000/admin/`. Pay special attention to the forward slash (`/`) at the end of the URL. If you miss that forward slash, then it would open the web page from the last recipe.

The addition of the custom `HelloView` in the second step will make the admin page look like the following screenshot:

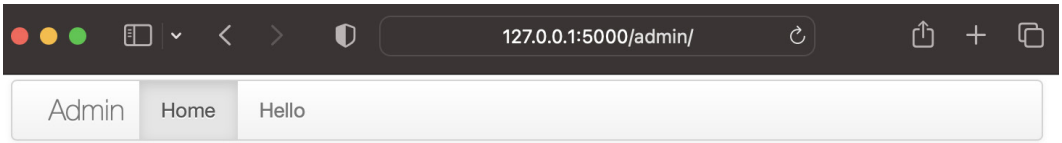


Figure 8.5 – Adding a dummy Hello view

There's more...

After implementing the preceding code, there is still an admin view that won't be completely user-protected and will be publicly available. This will be the admin home page. To make this available only to the admins, we have to inherit from `AdminIndexView` and implement `is_accessible()`:

```
from flask_admin import BaseView, expose, AdminIndexView

class MyAdminIndexView(AdminIndexView):
    def is_accessible(self):
        return current_user.is_authenticated and
          current_user.is_admin()
```

Then, just pass this view to the `admin` object in the application's configuration as `index_view`, and we are done:

```
admin = Admin(app, index_view=views.MyAdminIndexView())
```

This approach makes all our admin views accessible only to the admin users. We can also implement any permission or conditional access rules in `is_accessible()` as and when required.

Registering models with Flask-Admin

In the previous recipe, we learned how to get started with the `Flask-Admin` extension to create admin interfaces/views for our application. In this recipe, we will examine how to implement admin views for our existing models with the facilities to perform CRUD operations.

Getting ready

We will extend our application from the previous recipe to include an admin interface for the `User` model.

How to do it...

Again, with `Flask-Admin`, registering a model with the admin interface is very easy; perform the following steps:

1. Just add the following single line of code to `auth/views.py`:

```
from flask_admin.contrib.sqla import ModelView

# Other admin configuration as shown in last recipe
admin.add_view(ModelView(views.User, db.session))
```

   Here, in the first line, we imported `ModelView` from `flask_admin.contrib.sqla`, which is provided by `Flask-Admin` to integrate SQLAlchemy models.

   Looking at the screenshot corresponding to the first step in the *How it works…* section of this recipe (*Figure 8.6*), most of us will agree that showing the password hash to any user, be they an admin or a normal user, does not make sense. Additionally, the default model-creation mechanism provided by `Flask-Admin` will fail for our `User` creation, because we have an `__init__()` method in our `User` model. This method expects values for the three fields (`username`, `password`, and `is_admin`), while the model-creation logic implemented in `Flask-Admin` is very generic and does not provide any value during model creation.

2. Now, customize the default behavior of `Flask-Admin` to something of your own, where you fix the `User` creation mechanism and hide the password hash from view in `auth/views.py`:

```
from wtforms import PasswordField
from flask_admin.contrib.sqla import ModelView

class UserAdminView(ModelView):
    column_searchable_list = ('username',)
    column_sortable_list = ('username', 'admin')
    column_exclude_list = ('pwdhash',)
    form_excluded_columns = ('pwdhash',)
    form_edit_rules = ('username', 'admin')

    def is_accessible(self):
        return current_user.is_authenticated and
          current_user.is_admin()
```

   The preceding code shows some rules and settings that our admin view for `User` will follow. These are self-explanatory via their names. A couple of them, `column_exclude_list` and `form_excluded_columns`, might appear to be slightly confusing. The former will exclude the columns mentioned from the admin view itself and refrain from using them in search, creation, and other CRUD operations. The latter will prevent the field from being shown on the form for CRUD operations.

3. Create a method in `auth/views.py` that overrides the creation of the form from the model and adds a `password` field, which will be used in place of the password hash:

```
    def scaffold_form(self):
        form_class = super(UserAdminView,
          self).scaffold_form()
        form_class.password =
          PasswordField('Password')
        return form_class
```

4. Then, override the model-creation logic in `auth/views.py` to suit the application:

```
    def create_model(self, form):
        model = self.model(
            form.username.data, form.password.data,
              form.admin.data
        )
        form.populate_obj(model)
        self.session.add(model)
        self._on_model_change(form, model, True)
        self.session.commit()
```

5. Finally, add this model to the `admin` object in the application config in `my_app/__init__.py` by writing the following:

```
admin.add_view(views.UserAdminView(views.User,
  db.session))
```

Information

Notice the `self._on_model_change(form, model, True)` statement. Here, the last parameter, `True`, signifies that the call is for the creation of a new record.

How it works...

The first step will create a new admin view for the `User` model, which will look like the following screenshot:

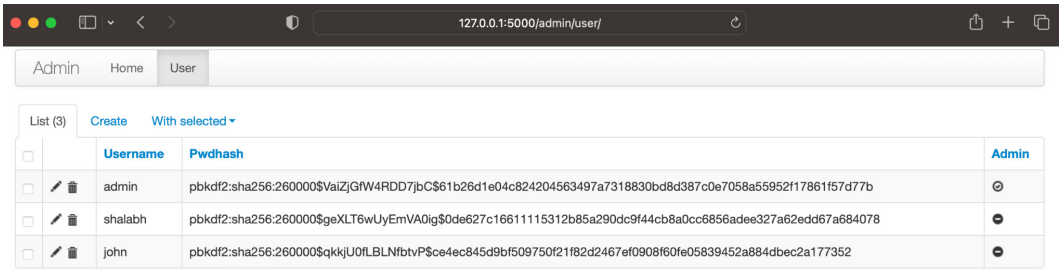


Figure 8.6 – List of users without custom logic

After all the steps have been followed, the admin interface for the `User` model will look like the following screenshot:

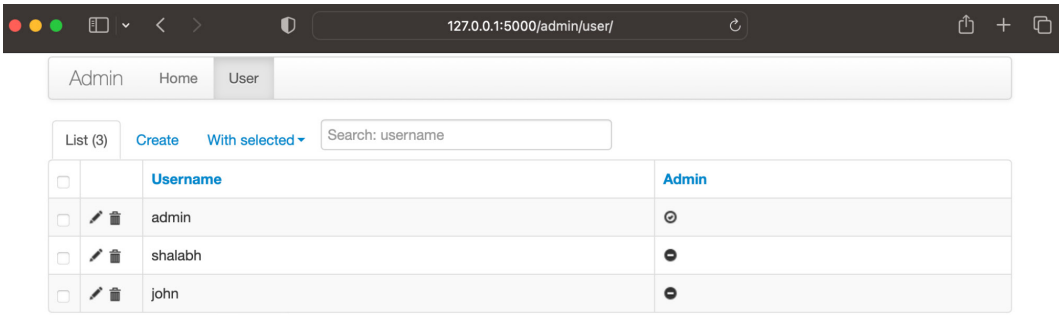


Figure 8.7 – List of users with password hash hidden

We have a search box here, and no password hash is visible. There are changes to the user creation and edit views too. I recommend that you run the application to see this for yourself.

Creating custom forms and actions

In this recipe, we will create a custom form using the forms provided by `Flask-Admin`. Additionally, we will create a custom action using the custom form.

Getting ready

In the previous recipe, we saw that the edit form view for the `User` record update had no option to update the password for the user. The form looked like the following screenshot:

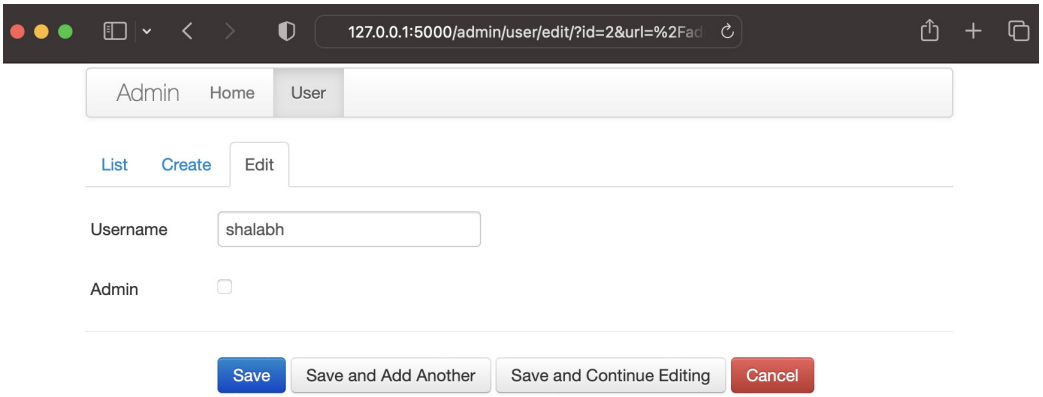


Figure 8.8 – Built-in user edit form

In this recipe, we will customize this form to allow administrators to update the password for any user.

How to do it...

The implementation of this feature will only require changes to `views.py`:

1. First, start by importing `rules` from the `Flask-Admin` form:

   ```
   from flask_admin.form import rules
   ```

   In the previous recipe, we had `form_edit_rules`, which had just two fields – that is, `username` and `admin` – as a list. This denoted the fields that will be available for editing to the admin user in the `User` model's update view.

2. Updating the password is not simply a case of just adding one more field to the `form_edit_rules` list; this is because we do not store cleartext passwords. Instead, we store password hashes that cannot be edited directly by users. We need to input the password from the user and then convert it to a hash while storing. Take a look at how to do this in the following code:

   ```
   form_edit_rules = (
           'username', 'admin',
           rules.Header('Reset Password'),
           'new_password', 'confirm'
       )
       form_create_rules = (
           'username', 'admin', 'notes', 'password'
       )
   ```

   The preceding piece of code signifies that we now have a header in our form; this header separates the password reset section from the rest of the section. Then, add two new fields, `new_password` and `confirm`, which will help us safely change the password.

3. This also calls for a change to the `scaffold_form()` method so that the two new fields become valid while form rendering:

```
    def scaffold_form(self):
        form_class = super(UserAdminView,
          self).scaffold_form()
        form_class.password =
          PasswordField('Password')
        form_class.new_password = PasswordField('New
          Password')
        form_class.confirm = PasswordField('Confirm
          New Password')
        return form_class
```

4. Finally, implement the `update_model()` method, which is called when we try to update the record:

```
    def update_model(self, form, model):
        form.populate_obj(model)
        if form.new_password.data:
            if form.new_password.data !=
              form.confirm.data:
                flash('Passwords must match')
                return
            model.pwdhash = generate_password_hash(
                form.new_password.data)
        self.session.add(model)
        self._on_model_change(form, model, False)
        self.session.commit()
```

In the preceding code, we will first make sure that the password entered in both fields is the same. If it is, then we will proceed with resetting the password, along with any other change.

How it works...

The user update form will now look like the following screenshot:

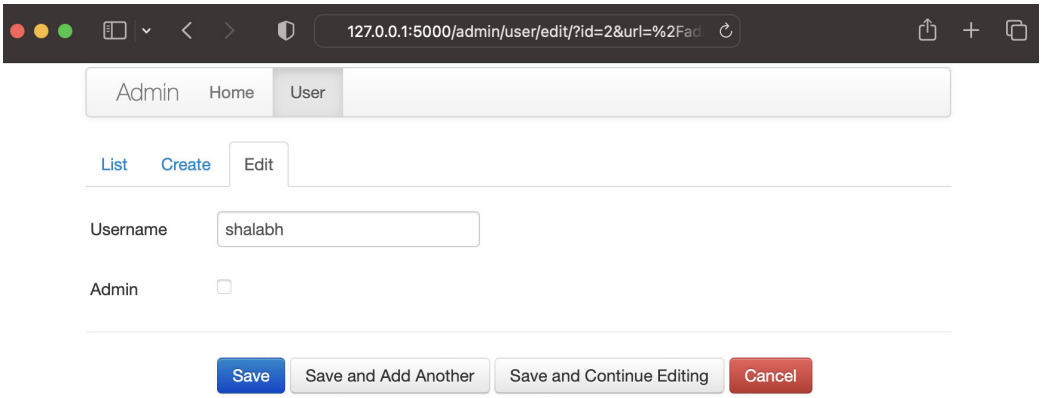


Figure 8.9 – Custom form with a custom action

Here, if we enter the same password in both of the password fields, the user password will be updated.

Using a WYSIWYG editor for textarea integration

As users of websites, we all know that writing beautifully formatted text using the normal `textarea` fields is a nightmare. There are plugins that make our life easier and turn simple `textarea` fields into **What You See Is What You Get** (**WYSIWYG**) editors. One such editor is **CKEditor**. It is open source, provides good flexibility, and has a huge community for support. Additionally, it is customizable and allows users to build add-ons as needed. In this recipe, we will understand how CKEditor can be leveraged to build beautiful `textarea` fields.

Getting ready

We start by adding a new `textarea` field to our `User` model for notes and then integrate this field with CKEditor to write formatted text. This will include the addition of a JavaScript library and a CSS class to a normal `textarea` field to convert this into a CKEditor-compatible `textarea` field.

How to do it...

To integrate CKEditor with your application, perform the following steps:

1. First, add the `notes` field to the `User` model in `auth/models.py`, as follows:

```
class User(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    username = db.Column(db.String(100))
    pwdhash = db.Column(db.String())
    admin = db.Column(db.Boolean())
```

```
    notes = db.Column(db.UnicodeText)

    def __init__(self, username, password,
      admin=False, notes=''):
        self.username = username
        self.pwdhash =
          generate_password_hash(password)
        self.admin = admin
        self.notes = notes
```

Important

In order to add a new field, you might need to run migration scripts. You can refer to the *Migrating databases using Alembic and Flask-Migrate* recipe in *Chapter 3*, *Data Modeling in Flask*, for more details.

2. After this, create a custom `wtform` widget and a field for the CKEditor `textarea` field in `auth/models.py`:

```
from wtforms import widgets, TextAreaField

class CKTextAreaWidget(widgets.TextArea):
    def __call__(self, field, **kwargs):
        kwargs.setdefault('class_', 'ckeditor')
        return super(CKTextAreaWidget,
          self).__call__(field, **kwargs)
```

   In the custom widget in the preceding code, we added a `ckeditor` class to our `TextArea` widget. For more insights into the WTForms widgets, you can refer to the *Creating a custom widget* recipe in *Chapter 5*, *Web Forms with WTForms*.

3. Next, create a custom field that inherits `TextAreaField` and updates it to use the widget created in the previous step:

```
class CKTextAreaField(TextAreaField):
    widget = CKTextAreaWidget()
```

   In the custom field in the preceding code, we set the widget to `CKTextAreaWidget`, and when this field will be rendered, the `ckeditor` CSS class will be added to it.

4. Next, modify `form_edit_rules` in the `UserAdminView` class in `auth/views.py`, where we specify the template to be used for the `create` and `edit` forms. Additionally, override the normal `TextAreaField` object with `CKTextAreaField` for `notes`. Make sure that you import `CKTextAreaField` from `auth/models.py`:

```
    form_overrides = dict(notes=CKTextAreaField)
```

```
    create_template = 'edit.html'
    edit_template = 'edit.html'
```

In the preceding code block, `form_overrides` enables the overriding of a normal `textarea` field with the CKEditor `textarea` field.

5. The final part of this recipe is the `templates/edit.html` template, which was mentioned earlier:

```
{% extends 'admin/model/edit.html' %}

{% block tail %}
    {{ super() }}
    <script src="https://cdn.ckeditor.com
      /4.20.1/standard/ckeditor.js"></script>
{% endblock %}
```

Here, we extend the default `edit.html` file provided by Flask-Admin and add the CKEditor JS file so that our `ckeditor` class in `CKTextAreaField` works.

How it works...

After we have made all the changes, the create user form will look like the following screenshot; in particular, notice the **Notes** field:

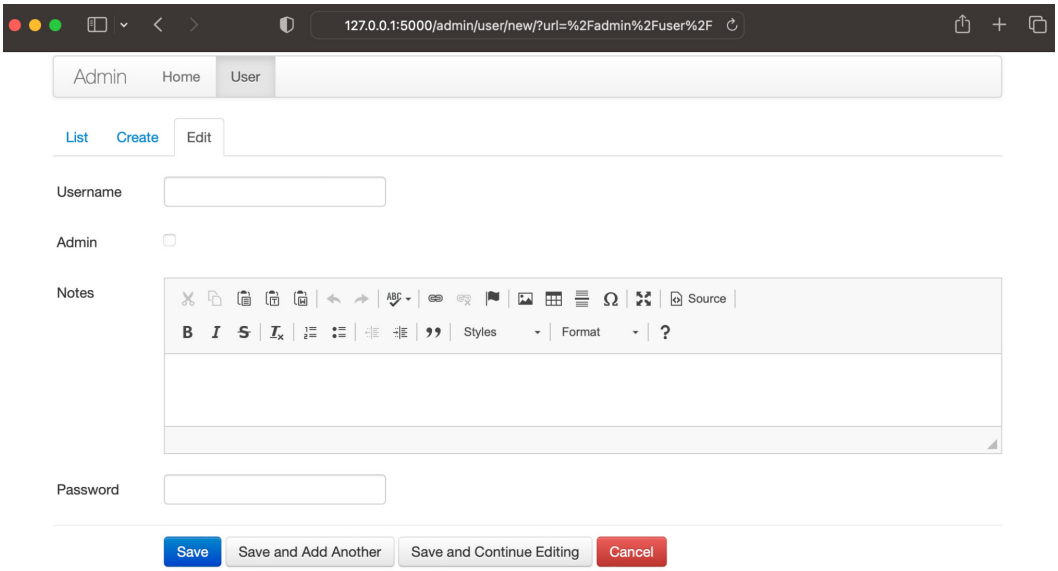


Figure 8.10 – Notes field created using a WYSIWYG editor

Here, anything entered in the **Notes** field will be automatically formatted in HTML while saving and can be used anywhere later for display purposes.

See also

This recipe is inspired by the **gist** by the author of Flask-Admin. The gist can be found at `https://gist.github.com/mrjoes/5189850`.

You can also choose to directly use the Flask-CKEditor extension, which can be found at `https://flask-ckeditor.readthedocs.io/en/latest/`. I have not used the extension because I wanted to demonstrate the concept from a lower level.

Creating user roles

So far, we have discovered how a view that is accessible to a certain set of admin users can be created easily using the `is_accessible()` method. This can be extended to have different kinds of scenarios, where specific users will be able to view specific views. There is another way of implementing user roles at a much more granular level in a model, where the roles determine whether a user can perform all, some, or any of the CRUD operations.

Getting ready

In this recipe, we will explore a basic way of creating user roles, where an admin user can only perform actions they are entitled to.

> **Information**
>
> Remember that this is just one way of implementing user roles. There are a number of better ways of doing this, but this one appears to be the best one to demonstrate the concept of creating user roles. One such method would be to create user groups and assign roles to the groups, rather than individual users. Another method can be the more complex policy-based user roles, which will include defining the roles according to complex business logic. This approach is usually employed by business systems such as ERP, CRM, and more.

How to do it...

To add basic user roles to the application, perform the following steps:

1. First, add a field named `roles` to the `User` model in `auth/models.py`, as follows:

```
class User(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    username = db.Column(db.String(100))
    pwdhash = db.Column(db.String())
```

```
    admin = db.Column(db.Boolean())
    notes = db.Column(db.UnicodeText)
    roles = db.Column(db.String(4))

    def __init__(self, username, password,
      admin=False, notes='', roles='R'):
        self.username = username
        self.pwdhash =
          generate_password_hash(password)
        self.admin = admin
        self.notes = notes
        self.roles = self.admin and roles or ''
```

Here, we added a new field, `roles`, which is a string field with a length of `4`. We assumed that the only entries that are possible in this field are any combinations of `C`, `R`, `U`, and `D`. A user with the `roles` value as `CRUD` will have permission to perform all the actions, while any missing permissions will prevent the user from performing that action. Note that read permissions are always implied to any admin user, whether specified or not.

Important

In order to add a new field, you might need to run migration scripts. You can refer to the *Migrating databases using Alembic and Flask-Migrate* recipe in *Chapter 3*, *Data Modeling in Flask*, for more details.

2. Next, make some changes to the `UserAdminView` class in `auth/views.py`:

```
from flask_admin.actions import ActionsMixin

class UserAdminView(ModelView, ActionsMixin):
    form_edit_rules = (
        'username', 'admin', 'roles', 'notes',
        rules.Header('Reset Password'),
        'new_password', 'confirm'
    )
    form_create_rules = (
        'username', 'admin', 'roles', 'notes',
          'password'
    )
```

In the preceding code, we just added the `roles` field to our `create` and `edit` forms. We also inherited a class called `ActionsMixin`. This is necessary to handle the mass update actions such as mass deletion.

3. Next, we have the methods that we need to implement conditions and handle the logic for various roles:

   I. First is the method that handled the creation of a model:

```
def create_model(self, form):
    if 'C' not in current_user.roles:
        flash('You are not allowed to create
          users.', 'warning')
        return
    model = self.model(
        form.username.data, form.password.data,
          form.admin.data,
        form.notes.data
    )
    form.populate_obj(model)
    self.session.add(model)
    self._on_model_change(form, model, True)
    self.session.commit()
```

   In the preceding method, we first checked whether the `roles` field in `current_user` has permission to create records (this is denoted by `C`). If not, we show an error message and return from the method.

   II. Next is the method that would handle the update:

```
def update_model(self, form, model):
    if 'U' not in current_user.roles:
        flash('You are not allowed to edit
          users.', 'warning')
        return
    form.populate_obj(model)
    if form.new_password.data:
        if form.new_password.data !=
          form.confirm.data:
            flash('Passwords must match')
            return
        model.pwdhash = generate_password_hash(
            form.new_password.data)
    self.session.add(model)
    self._on_model_change(form, model, False)
    self.session.commit()
```

   In the preceding method, we first checked whether the `roles` field in `current_user` has permission to update records (this is denoted by `U`). If not, we show an error message and return from the method.

III. The next method handles the deletion:

```
    def delete_model(self, model):
        if 'D' not in current_user.roles:
            flash('You are not allowed to delete
              users.', 'warning')
            return
        super(UserAdminView, self).delete_model(model)
```

Similarly, in the preceding method, we checked whether `current_user` is allowed to delete records.

IV. Finally, the need to check for relevant roles and permission is addressed:

```
    def is_action_allowed(self, name):
        if name == 'delete' and 'D' not in
          current_user.roles:
            flash('You are not allowed to delete
              users.', 'warning')
            return False
        return True
```

In the preceding method, we checked whether the action is `delete` and whether `current_user` is allowed to delete. If not, then we flash the error message and return a `False` value. This method can be extended to handle any custom-written actions too.

How it works...

This recipe works in a manner that is very similar to how our application has been working so far, except for the fact that, now, users with designated roles will be able to perform specific operations. Otherwise, error messages will be displayed.

The user list will now look like the following screenshot:

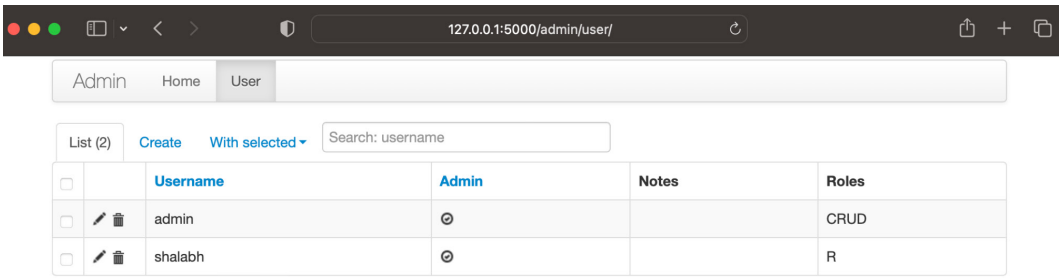


Figure 8.11 – Admin role assigned to users

To test the rest of the functionality, such as creating new users (both normal and admin), deleting users, updating user records, and more, I urge you to try it for yourself.

9
Internationalization and Localization

Web applications are usually not limited to one geographical region or only serve people from one linguistic domain. For example, a web application intended for users in Europe will be expected to support more than one European language, such as German, French, Italian, and Spanish, as well as English. This chapter will cover the basics of how to enable support for multiple languages in a Flask application.

Adding support for a second language in any web application is a tricky affair. It increases the overhead a bit every time some change is made to the application, and this increases with the number of languages. There can be a number of things that need to be taken care of, apart from just changing the text, depending on the language. Some of the major things that need changing are currency, number, time, and date formatting.

Flask-Babel, an extension that adds **internationalization** (**i18n**) and **localization** (**l10n**) support to any Flask application, provides a number of tools and techniques to make this process easy to implement.

In this chapter, we will cover the following recipes:

- Adding a new language
- Implementing lazy evaluation and the `gettext`/`ngettext` functions
- Implementing the global language-switching action

Adding a new language

By default, English is the language for applications built in Flask (and almost all web frameworks). In this recipe, we will add a second language to our application and add some translations for the display strings used in the application. The language displayed to the user will vary depending on the language that is currently set in the browser.

Getting ready

We will start with the installation of the `Flask-Babel` extension:

```
$ pip install Flask-Babel
```

This extension uses **Babel** and **pytz** to add i18n and l10n support to the application.

We will use our catalog application from *Chapter 5*, *Web Forms with WTForms*.

How to do it...

We will use French as the second language. Follow these steps to achieve this:

1. Start with the configuration part by creating an instance of the `Babel` class, using the `app` object in `my_app/__init__.py`. We will also specify all the languages that will be available here:

```
from flask import request
from flask_babel import Babel

ALLOWED_LANGUAGES = {
    'en': 'English',
    'fr': 'French',
}

babel = Babel(app)
```

> **Tip**
> Here, we used `en` and `fr` as the language codes. These refer to English (standard) and French (standard), respectively. If we intend to support multiple languages that are from the same standard language origin, but differ on the basis of region, such as English (US) and English (GB), then we should use codes such as `en-us` and `en-gb`.

2. The locale of the application depends on the output of the method that is provided while initializing the `babel` object:

```
def get_locale():
    return request.accept_languages.best_match
      (ALLOWED_LANGUAGES.keys())

babel.init_app(app, locale_selector=get_locale)
```

   The preceding method gets the `accept_languages` header from the request and finds the language that best matches the languages we allow.

Tip

You can change the language preferences of your browser to test the application's behavior in another language.

Earlier, it used to be pretty easy to change the language preferences in the browser, but with the locale becoming more ingrained in the OS, it has become difficult to do so without changing the global locale of the OS. Hence, if you do not want to mess with the language preferences of the browser or your OS, simply return the expected language code from the `get_locale()` method.

3. Next, create a file in the application folder called `babel.cfg`. The path of this file will be `my_app/babel.cfg`, and it will have the following content:

```
[python: catalog/**.py]
[jinja2: templates/**.html]
```

Here, the first two lines tell `Babel` about the filename patterns that are to be searched for marked translatable text.

Information

In earlier versions of this book, I suggested loading a couple of extensions from Jinja2, namely, `jinja2.ext.autoescape` and `jinja2.ext.with_`. But as of version 3.1.0 of Jinja, these modules have got built-in support and, hence, there is no need to load them separately now.

4. Next, mark some text that is intended to be translated as per the language. Let's start with the first text we see when we start our application, which is in `home.html`:

```
{% block container %}
<h1>{{ _('Welcome to the Catalog Home') }}</h1>
  <a href="{{ url_for('catalog.products') }}"
    id="catalog_link">
  {{ _('Click here to see the catalog ') }}
  </a>
{% endblock %}
```

Here, _ is a shortcut for the `gettext` function provided by Babel to translate strings.

5. After this, run the following commands so that the marked text is actually available as translated text in our template when it is rendered in the browser:

```
$ pybabel extract -F my_app/babel.cfg -o
  my_app/messages.pot my_app/
```

The preceding command traverses the content of the files. This command matches the patterns in `babel.cfg` and picks out the texts that have been marked as translatable. All these texts are placed in the `my_app/messages.pot` file. The following is the output of the preceding command:

```
extracting messages from my_app/catalog/__init__.py
extracting messages from my_app/catalog/models.py
extracting messages from my_app/catalog/views.py
extracting messages from my_app/templates/404.html
extracting messages from my_app/templates/base.html
extracting messages from
  my_app/templates/categories.html
extracting messages from my_app/templates/category-
  create.html
extracting messages from
  my_app/templates/category.html
extracting messages from my_app/templates/home.html
extracting messages from my_app/templates/product-
  create.html
extracting messages from my_app/templates/product.html
extracting messages from
  my_app/templates/products.html
writing PO template file to my_app/messages.pot
```

6. Run the following command to create a `.po` file that will hold the translations for the texts to be translated into:

```
$ pybabel init -i my_app/messages.pot -d
  my_app/translations -l fr
```

This file is created in the specified folder, `my_app/translations`, as `fr/LC_MESSAGES/messages.po`. As we add more languages, more folders will be added.

7. Now, add translations to the `messages.po` file. This can be performed manually, or we can use GUI tools such as Poedit (`http://poedit.net/`). Using this tool, the translations will look as in the following screenshot:

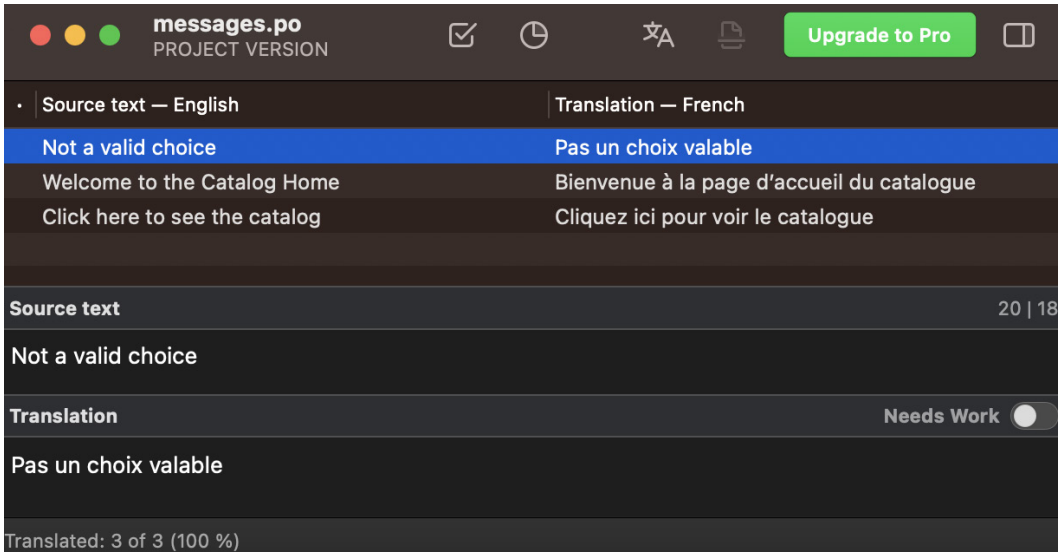


Figure 9.1 – Poedit screen while editing translations

Manually editing `messages.po` will look as in the following code. Only one message translation is shown for demonstration purposes:

```
#: my_app/catalog/models.py:75
msgid "Not a valid choice"
msgstr "Pas un choix valable"
```

8. Save the `messages.po` file after the translations have been incorporated and run the following command:

```
$ pybabel compile -d my_app/translations
```

This will create a `messages.mo` file next to the `message.po` file, which will be used by the application to render the translated text.

Information

Sometimes, the messages do not get compiled after running the preceding command. This is because the messages might be marked as fuzzy (starting with a # symbol). These need to be looked into by a human, and the # sign has to be removed if the message is OK to be updated by the compiler. To bypass this check, add an `-f` flag to the preceding `compile` command, as it will force everything to be compiled.

How it works...

If we run the application with French set as the primary language in the browser (or returned as the language of choice from the `get_locale()` method), the home page will look as in the following screenshot:

Figure 9.2 – Home page in French

If the primary language is set to a language other than French, then the content will be shown in English, which is the default language.

There's more...

Next time, if there is a need to update the translations in our `messages.po` file, we do not need to call the `init` command again. Instead, we can run an `update` command, which is as follows:

```
$ pybabel update -i my_app/messages.pot -d
  my_app/translations
```

After this, run the `compile` command as usual.

> **Information**
>
> It is often preferable to change the language of a website based on the user IP and location (determined from the IP). However, this is, in general, less recommended than using the accept-language header as we did in our application.

See also

Refer to the *Implementing the global language-switching action* recipe later in this chapter, which allows the user to change the language directly from the application rather than doing it at the browser level.

An important aspect of multiple languages is to be able to format the date, time, and currency accordingly. Babel also handles this pretty neatly. I urge you to try your hand at this. Refer to the Babel documentation, available at `http://babel.pocoo.org/en/latest/`, for this.

Implementing lazy evaluation and the gettext/ngettext functions

Lazy evaluation is an evaluation strategy that delays the evaluation of an expression until its value is needed; that is, it is a call-when-needed mechanism. In our application, there can be several instances of texts that are evaluated later while rendering the template. This usually happens when we have texts that are marked as translatable outside the request context, so we defer the evaluation of these until they are actually needed.

Getting ready

Let's start with the application from the previous recipe. Now, we want the labels in the product and category creation forms to show the translated values.

How to do it...

Follow these steps in order to implement the lazy evaluation of translations:

1. To mark all the field labels in the product and category forms as translatable, make the following changes to `my_app/catalog/models.py`:

```
from flask_babel import _

class NameForm(FlaskForm):
    name = StringField(
        _('Name'), validators=[InputRequired()])

class ProductForm(NameForm):
    price = DecimalField(_('Price'), validators=[
        InputRequired(),
          NumberRange(min=Decimal('0.0'))
    ])
    category = CategoryField(
        _('Category'), validators=[InputRequired()],
          coerce=int
    )
    image = FileField(
        _('Product Image'),
          validators=[FileRequired()])


class CategoryForm(NameForm):
    name = StringField(_('Name'), validators=[
```

```
            InputRequired(), check_duplicate_category()
        ])
```

Notice that all the field labels are enclosed within `_()` to be marked for translation.

2. Now, run the `extract` and `update pybabel` commands to update the `messages.po` file, and then fill in the relevant translations and run the `compile` command. Refer to the previous recipe, *Adding a new language*, for details.

3. Now, open the product creation page using the following link: `http://127.0.0.1:5000/product-create`. Does it work as expected? No! As most of us would have guessed by now, the reason for this behavior is that this text is marked for translation outside the request context.

   To make this work, modify the `import` statement to the following:

   ```
   from flask_babel import lazy_gettext as _
   ```

4. Now, we have more text to translate. Let's say we want to translate the product creation flash message content, which looks like this:

   ```
   flash('The product %s has been created' % name)
   ```

   To mark it as translatable, we cannot simply wrap the whole thing inside `_()` or `gettext()`. The `gettext()` function supports placeholders, which can be used as `%(name)s`. Using this, the preceding code will become something like this:

   ```
   flash(_('The product %(name)s has been created',
     name=name), 'success')
   ```

   The resulting translated text for this will be something like `La produit %(name)s a été créée`.

5. There may be cases where we need to manage the translations based on the number of items, that is, singular or plural names. This is handled by the `ngettext()` method. Let's take an example where we want to show the number of pages in our `products.html` template. For this, add the following code:

   ```
   {{ ngettext('%(num)d page', '%(num)d pages',
     products.pages) }}
   ```

   Here, the template will render `page` if there is only one page, and `pages` if there is more than one page.

   It is interesting to note how this translation appears in the `messages.po` file:

   ```
   #: my_app/templates/products.html:20
   #, python-format
   msgid "%(num)d page"
   msgid_plural "%(num)d pages"
   msgstr[0] "%(num)d page"
   msgstr[1] "%(num)d pages"
   ```

How it works...

Open the product creation form at `http://127.0.0.1:5000/product-create`. The following screenshot shows how it would look with translation to French:

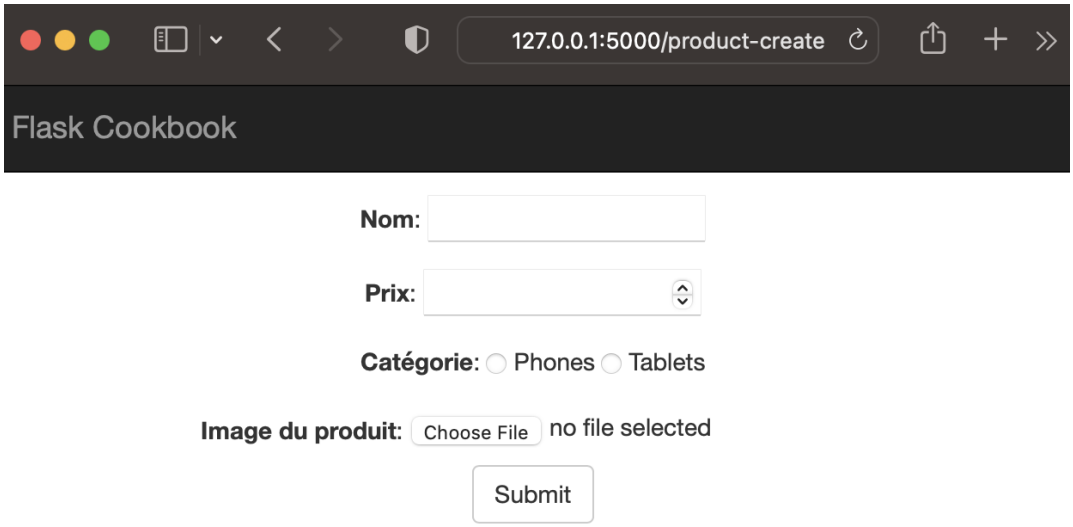


Figure 9.3 – Form fields translated using lazy evaluation

Implementing the global language-switching action

In the previous recipes, we saw that the language changes based on the current language preferences in the browser. Now, however, we want a mechanism where we can switch the language being used, irrespective of the language in the browser. In this recipe, we will understand how to handle changing the language at the application level.

Getting ready

We start by modifying the application from the last recipe, *Implementing lazy evaluation and the gettext/ngettext functions*, to accommodate the changes to enable language switching. We will add an extra URL part to all our routes to allow us to add the current language. We can just change this language part in the URL in order to switch between languages.

How to do it...

Observe the following steps to understand how to implement language switching globally:

1. First, modify all the URL rules to accommodate an extra URL part. `@catalog.route('/')` will become `@catalog.route('/<lang>/')`, and `@catalog.route('/home')` will become `@catalog.route('/<lang>/home')`. Similarly, `@catalog.route('/product-search/<int:page>')` will become `@catalog.route('/<lang>/product-search/<int:page>')`. The same needs to be done for all the URL rules.
2. Now, add a function that will add the language passed in the URL to the global proxy object, `g`:

```
@app.before_request
def before():
    if request.view_args and 'lang' in
      request.view_args:
        g.current_lang = request.view_args['lang']
        request.view_args.pop('lang')
```

   This method will run before each request and add the current language to `g`.
3. However, this will mean that all the `url_for()` calls in the application need to be modified so that an extra parameter called `lang` can be passed. Fortunately, there is an easy way out of this, which is as follows:

```
from flask import url_for as flask_url_for

@app.context_processor
def inject_url_for():
    return {
        'url_for': lambda endpoint, **kwargs:
          flask_url_for(
            endpoint, lang=g.get('current_lang',
              'en'), **kwargs
        )
    }

url_for = inject_url_for()['url_for']
```

   In the preceding code, we first imported `url_for` from `flask` as `flask_url_for`. Then, we updated the application context processor to have the `url_for()` function, which is a modified version of `url_for()` provided by Flask in order to have `lang` as an extra parameter. Also, we used the same `url_for()` method that we used in our views.

How it works...

Now, run the application as it is, and you will notice that all the URLs have a language part. The following two screenshots show what the rendered templates will look like.

For English, the following screenshot shows what the home page looks like after opening `http://127.0.0.1:5000/en/home`:

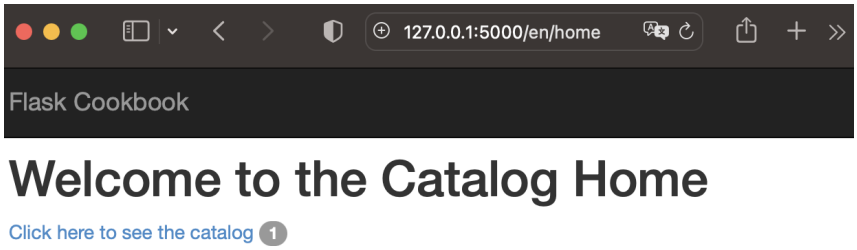


Figure 9.4 – Home page in English

For French, just change the URL to `http://127.0.0.1:5000/fr/home`, and the home page will look like this:

Figure 9.5 – Home page in French

There's more...

There is more to l10n than just translating alphabetical languages. Different geographies follow different formats for numbers, decimals, currencies, and so on. For example, 1.5 million USD would be written as 1,5 Mio USD in Dutch, and 123.56 in English would be written as 123,56 in French.

Babel makes it very easy to implement this kind of formatting. There is a whole suite of methods available for this purpose. Some examples follow:

```
>>> from babel import numbers
>>> numbers.format_number(12345, 'en_US')
'12,345'
```

```
>>> numbers.format_number(12345, 'fr_FR')
'12\u202f345'
>>> numbers.format_number(12345, 'de_DE')
'12.345'
>>> numbers.format_decimal(12.345, locale='de_DE')
'12,345'
>>> numbers.format_decimal(12.345, locale='en_US')
'12.345'
>>> numbers.format_currency(12.345, 'USD', locale='en_US')
'$12.34'
>>> numbers.format_currency(12345789, 'USD', locale='en_US')
'$12,345,789.00'
>>> numbers.format_compact_currency(12345789, 'USD', locale='de_DE')
'12\xa0Mio.\xa0$'
>>> numbers.format_compact_currency(12345789, 'USD', locale='en_US')
'$12M'
```

You can read more about this at `https://babel.pocoo.org/en/latest/api/numbers.html#module-babel.numbers`.

Part 3: Advanced Flask

Once the web applications are built in Flask, the next question concerns how to test applications, followed by deployment, and finally, maintaining them. This final part of this book covers these important topics. This is where the book moves from being completely development-oriented to focusing on post-development activities.

It is very important to test an application by writing unit tests, which allow for the introspection of code that has been written and also preemptively identifies any issues that might creep into further development of features. Once the application is built, you will want to measure the performance of the application in terms of clear metrics. *Chapter 10* deals with these topics, among others.

The next couple of chapters focus on various tools and techniques that can be leveraged to deploy a Flask web application on different platforms, ranging from cloud-native services to bare shell servers. You will read about how to use state-of-the-art technologies such as Docker and Kubernetes to effectively deploy your web applications.

A new chapter on GPT has been added, which talks about how to integrate this cutting-edge technology with Flask for some popular use cases, and how to make your applications future-ready with AI.

The final chapter is a collection of additional tips and tricks that can be used anywhere, based on specific use cases. There are many more such topics, but I have covered the ones that I have dealt with most frequently.

This part of the book comprises the following chapters:

- *Chapter 10, Debugging, Error Handling, and Testing*
- *Chapter 11, Deployment and Post-Deployment*
- *Chapter 12, Microservices and Containers*
- *Chapter 13, GPT with Flask*
- *Chapter 14, Additional Tips and Tricks*

10
Debugging, Error Handling, and Testing

So far in this book, we have concentrated on developing applications and adding features to them one at a time. It is very important to know how robust our application is and to keep track of how it has been working and performing. This, in turn, gives rise to the need to be informed when something goes wrong in the application. It is normal to miss out on certain edge cases while developing the application, and usually, even the test cases miss them out. It would be great to know about these edge cases whenever they occur so that they can be handled accordingly.

Effective logging and the ability to debug quickly are a couple of the deciding factors when choosing a framework for application development. The better the logging and debugging support from the framework, the quicker the process of application development and maintenance is. A better level of logging and debugging support helps developers quickly find out the issues in the application, and on many occasions, logging points out issues even before they are identified by end users. Effective error handling plays an important role in end user satisfaction and eases the pain of debugging at the developer's end. Even if its code is perfect, the application is bound to throw errors at times. Why? The answer is simple – the code might be perfect, but the world in which it works is not. There can be innumerable issues that can occur, and as developers, we always want to know the reason behind any anomaly. Writing test cases along with the application is one of the most important pillars of software writing.

Python's built-in logging system works pretty well with Flask. We will work with this logging system in this chapter before moving on to an awesome service called **Sentry**, which eases the pain of debugging and error logging to a huge extent.

As we have already talked about the importance of testing for application development, we will now see how to write test cases for a Flask application. We will also see how we can measure code coverage and profile our application to tackle any bottlenecks.

Testing in itself is a huge topic and has several books attributed to it. Here, we will try to understand the basics of testing with Flask.

In this chapter, we will cover the following recipes:

- Setting up basic file logging
- Sending emails on the occurrence of errors
- Using Sentry to monitor exceptions
- Debugging with `pdb`
- Creating application factories
- Creating the first simple test
- Writing more tests for views and logic
- Integrating the nose2 library
- Using mocking to avoid external API access
- Determining test coverage
- Using profiling to find bottlenecks

Setting up basic file logging

By default, Flask will not log anything for us anywhere, except for the errors with the stack traces, which are sent to the logger (we will see more of this in the rest of the chapter). It does create a lot of stack traces while we run the application in the development mode using `run.py`, but in production systems, we don't have this luxury. Thankfully, the logging library provides a whole lot of log handlers, which can be used as per requirements. In this recipe, we will understand how the `logging` library can be leveraged to ensure that effective logs are being captured from Flask applications.

Getting ready

We will start with our catalog application from the previous chapter and add some basic logging to it using `FileHandler`, which logs messages to a specified file on the filesystem. We will start with a basic log format and then see how to format the log messages to be more informative.

How to do it...

Follow these steps to configure and set up the `logging` library to use with our application:

1. The first change is made to the `my_app/__init__.py` file, which serves as the application's configuration file:

```
app.config['LOG_FILE'] = 'application.log'

if not app.debug:
    import logging
    from logging import FileHandler, Formatter
    file_handler = FileHandler(app.config['LOG_FILE'])
    app.logger.setLevel(logging.INFO)
    app.logger.addHandler(file_handler)
```

   Here, we added a configuration parameter to specify the log file's location. This takes the relative path from the application folder unless an absolute path is explicitly specified. Next, we will check whether the application is already in debug mode, and then we will add a handler logging to a file with the logging level as `INFO`. Now, `DEBUG` is the lowest logging level and will log everything at any level. For more details, refer to the `logging` library documentation (in the *See also* section).

2. After this, add loggers to the application wherever they are needed, and the application will start logging to the deputed file. Now, let's add a couple of loggers to `my_app/catalog/views.py` for demonstration:

```
@catalog.route('/')
@catalog.route('/<lang>/')
@catalog.route('/<lang>/home')
@template_or_json('home.html')
def home():
    products = Product.query.all()
    app.logger.info(
        'Home page with total of %d products'
          % len(products)
    )
    return {'count': len(products)}


@catalog.route('/<lang>/product/<id>')
def product(id):
    product = Product.query.filter_by(id=id).first()
    if not product:
        app.logger.warning('Requested product not
```

```
            found.')
        abort(404)
    return render_template('product.html',
      product=product)
```

In the preceding code, we have added loggers for a couple of our view handlers. Note that the first of the loggers in `home()` is at the `info` level, and the other in `product()` is `warning`. If we set our log level in `__init__.py` as `INFO`, then both will be logged, and if we set the level as `WARNING`, then only the warning logger will be logged.

> **Information**
>
> Make sure to import `abort` from `Flask` if this has not already been done – `from flask import abort`.

How it works...

The preceding steps will create a file called `application.log` in the root application folder. The logger statements as specified will be logged to `application.log` and will look something like the following snippet, depending on the handler called; the first one is from the home page, and the second is from requesting a product that does not exist:

```
Home page with total of 0 products
Requested product not found.
```

> **Important**
>
> To enable logging, either run your application with a WSGI server (refer to *Chapter 11*) or run using `flask run` on your terminal prompt (refer to *Chapter 1*).

Running the application using `run.py` will always make it run with the `debug` flag as `True`, which will not allow logging to work as expected.

The information logged does not help much. It would be great to know when the issue was logged, with what level, which file caused the issue at what line number, and so on. This can be achieved using advanced logging formats. For this, we need to add a couple of statements to the configuration file – that is, `my_app/__init__.py`:

```
if not app.debug:
    import logging
    from logging import FileHandler, Formatter
    file_handler = FileHandler(app.config['LOG_FILE'])
    app.logger.setLevel(logging.INFO)
```

```
    app.logger.addHandler(file_handler)
    file_handler.setFormatter(Formatter(
        '%(asctime)s %(levelname)s: %(message)s '
        '[in %(pathname)s:%(lineno)d]'
    ))
```

In the preceding code, we added a formatter to `file_handler`, which will log the time, log level, message, file path, and line number. After this, the logged message will look like this:

```
2023-01-02 13:01:25,125 INFO: Home page with total of 0 products [in /
Users/apple/workspace/flask-cookbook-3/Chapter-10/Chapter-10/my_app/
catalog/views.py:72]
2023-01-02 13:01:27,657 WARNING: Requested product not found. [in /
Users/apple/workspace/flask-cookbook-3/Chapter-10/Chapter-10/my_app/
catalog/views.py:82]
```

There's more...

We might also want to log all the errors when a page is not found (the `404` error). For this, we can just tweak the `errorhandler` method a bit:

```
@app.errorhandler(404)
def page_not_found(e):
    app.logger.error(e)
    return render_template('404.html'), 404
```

See also

Go to Python's `logging` library documentation about handlers at `https://docs.python.org/dev/library/logging.handlers.html` to learn more about logging handlers.

Sending emails on the occurrence of errors

It is a good idea to receive notifications when something unexpected happens with the application. Setting this up is pretty easy and adds a lot of convenience to the process of error handling.

Getting ready

We will take the application from the last recipe and add `mail_handler` to it to make our application send emails when an error occurs. Also, we will demonstrate the email setup using Gmail as the SMTP server.

How to do it...

First, add the handler to the configuration in `my_app/__init__.py`. This is similar to how we added `file_handler` in the previous recipe:

```
RECEPIENTS = ['some_receiver@gmail.com']

if not app.debug:
    import logging
    from logging import FileHandler, Formatter
    from logging.handlers import SMTPHandler
    file_handler = FileHandler(app.config['LOG_FILE'])
    app.logger.setLevel(logging.INFO)
    app.logger.addHandler(file_handler)
    mail_handler = SMTPHandler(
        ("smtp.gmail.com", 587), 'sender@gmail.com',
          RECEPIENTS,
        'Error occurred in your application',
        ('some_email@gmail.com', 'some_gmail_password'),
          secure=())
    mail_handler.setLevel(logging.ERROR)
    app.logger.addHandler(mail_handler)
    for handler in [file_handler, mail_handler]:
        handler.setFormatter(Formatter(
            '%(asctime)s %(levelname)s: %(message)s '
            '[in %(pathname)s:%(lineno)d]'
        ))
```

Here, we have a list of email addresses to which the error notification email will be sent. Also, note that we have set the log level to `ERROR` in the case of `mail_handler`. This is because emails will be necessary only in the case of crucial matters.

For more details on the configuration of `SMTPHandler`, refer to the documentation.

> **Important**
> Always make sure that you run your application with the `debug` flag set to `off` to enable the application to log and send emails for internal application errors (the `500` error).

How it works...

To cause an internal application error, just misspell some keyword in any of your handlers. You will receive an email in your mailbox, with the formatting as set in the configuration and a complete stack trace for your reference.

Using Sentry to monitor exceptions

Sentry is a tool that eases the process of monitoring exceptions and also provides insights into the errors that users of the application face while using it. It is highly possible that there are errors in log files that get overlooked by the human eye. Sentry categorizes the errors under different categories and keeps a count of the recurrence of errors. This helps us to understand the severity of the errors on multiple criteria and how to handle them accordingly. It has a nice GUI that facilitates all of these features. In this recipe, we will set up Sentry and use it as an effective error-monitoring tool.

Getting ready

Sentry is available as a cloud service, which is available free for developers and basic users. For the purposes of this recipe, this freely available cloud service will be enough. Head over to `https://sentry.io/signup/` and get started with the registration process. This being said, we need to install the Python SDK for Sentry:

```
$ pip install 'sentry-sdk[flask]'
```

How to do it...

Once the Sentry registration is complete, a screen will be shown that will ask about the type of project that needs to be integrated with Sentry. See the following screenshot:

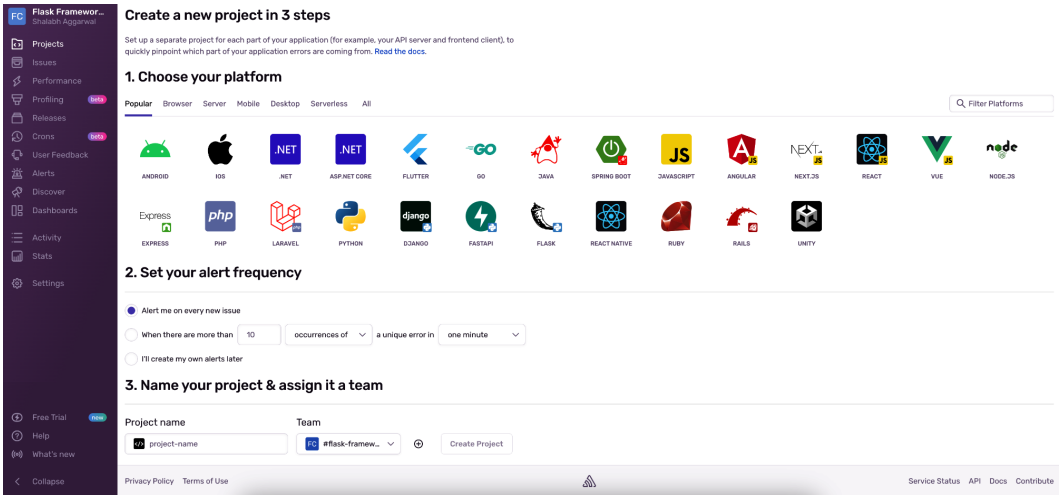


Figure 10.1 – The Sentry project creation screen

This will be followed by another screen that shows the steps on how to configure your Flask application to send events to the newly created and configured Sentry instance. This is shown in the following screenshot:

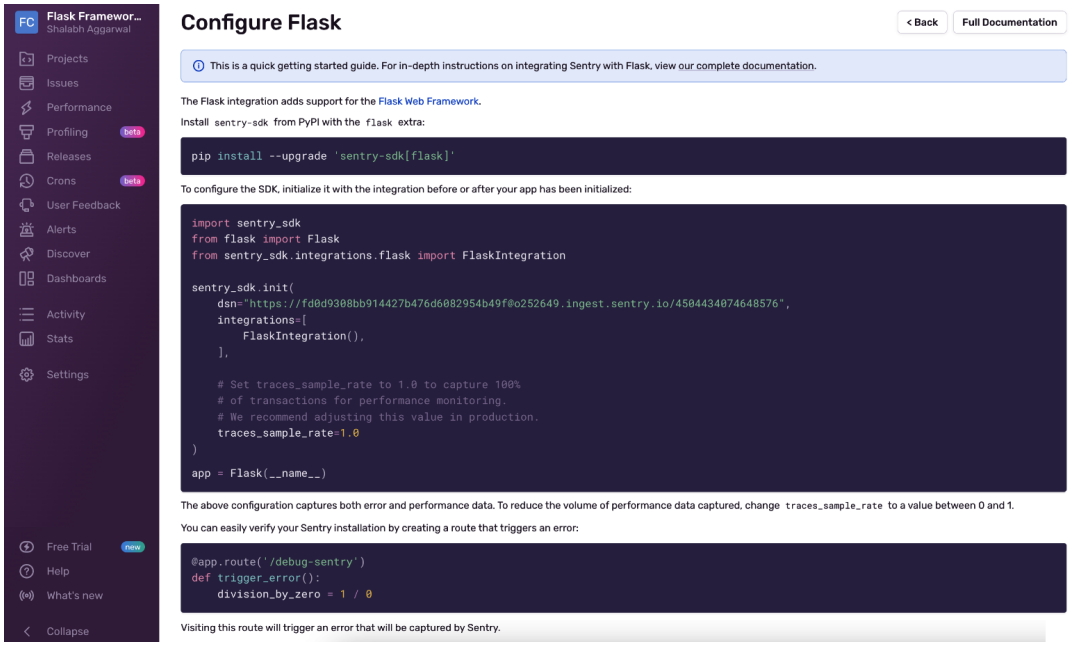


Figure 10.2 – The Sentry project configuration steps

> **Information**
>
> Sentry can also be downloaded for free and installed as an on-premises application. There are multiple ways of installing and configuring Sentry as per your needs. You are free to try this approach on your own, as it goes beyond the scope of this recipe.

After the previous setup is complete, add the following code to your Flask application in `my_app/__init__.py`, replacing `https://1234:5678@fake-sentry-server/1` with the Sentry project URI:

```
import sentry_sdk
from sentry_sdk.integrations.flask import FlaskIntegration

sentry_sdk.init(
    dsn="https://1234:5678@fake-sentry-server/1",
    integrations=[FlaskIntegration()]
)
```

How it works...

An error logged in Sentry will look like the following screenshot:

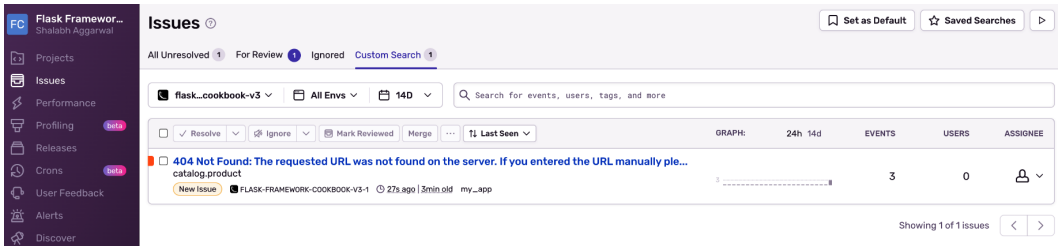


Figure 10.3 – The Sentry error log screen

It is also possible to log messages and user-defined exceptions in Sentry. I will leave this to you to figure out by yourself.

Debugging with pdb

Most of the Python developers reading this book might already be aware of the usage of **python debugger** (**pdb**). For those who are not aware of it, `pdb` is an interactive source code debugger for Python programs. We can set breakpoints wherever needed, debug using single stepping at the source line level, and inspect the stack frames.

Many new developers might be of the opinion that the job of a debugger can be handled using a logger, but debuggers provide a much deeper insight into the flow of control, preserve the state at each step, and hence, potentially save a lot of development time. In this recipe, let's have a look at what `pdb` brings to the table.

Getting ready

We will use Python's built-in `pdb` module for this recipe and use it in our application from the last recipe.

How to do it...

Using `pdb` is pretty simple in most cases. We just need to insert the following statement wherever we want to insert a breakpoint to inspect a certain block of code:

```
import pdb; pdb.set_trace()
```

This will trigger the application to break execution at this point, and then we can step through the stack frames one by one using the debugger commands.

So, let's insert this statement in one of our methods – say, the handler for products:

```
@catalog.route('/<lang>/products')
@catalog.route('/<lang>/products/<int:page>')
def products(page=1):
```

```
    products = Product.query.paginate(page=page,
      per_page=10)
    import pdb; pdb.set_trace()
    return render_template('products.html',
      products=products)
```

How it works...

Whenever the control comes to this line, the debugger prompt will fire up; this will appear as follows:

```
> /Users/apple/workspace/flask-cookbook-3/Chapter-10/Chapter-10/my_
app/catalog/views.py(93)products()
-> return render_template('products.html', products=products)
(Pdb) u
> /Users/apple/workspace/flask-cookbook-3/Chapter-10/lib/python3.10/
site-packages/flask/app.py(1796)dispatch_request()
-> return self.ensure_sync(self.view_functions[rule.endpoint])(**view_
args)
(Pdb) u
> /Users/apple/workspace/flask-cookbook-3/Chapter-10/lib/python3.10/
site-packages/flask/app.py(1820)full_dispatch_request()
-> rv = self.dispatch_request()
(Pdb) u
> /Users/apple/workspace/flask-cookbook-3/Chapter-10/lib/python3.10/
site-packages/flask/app.py(2525)wsgi_app()
-> response = self.full_dispatch_request()
(Pdb) u
> /Users/apple/workspace/flask-cookbook-3/Chapter-10/lib/python3.10/
site-packages/flask/app.py(2548)__call__()
-> return self.wsgi_app(environ, start_response)
```

Note `u` written against `(Pdb)`. This signifies that I am moving the current frame one level up in the stack trace. All the variables, parameters, and properties used in that statement will be available in the same context to help figure out the issue, or just understand the flow of code. There are other debugger commands that could prove helpful in your navigation of the debug logs. Check the following *See also* section for these.

See also

Go to the `pdb` module documentation at `https://docs.python.org/3/library/pdb.html#debugger-commands` to get hold of the various debugger commands.

Creating application factories

Leveraging a factory pattern is a great way of organizing your application object, allowing for multiple application objects with different settings. As discussed in *Chapter 1*, it is always possible to create multiple application instances by using different configurations, but application factories allow you to have multiple application objects inside the same application process. It also aids in testing, as you can choose to have a fresh or different application object with different settings for each test case.

Getting ready

We will use our application from the previous recipe and modify it to use the application factory pattern.

How to do it...

The following are the changes that need to be made:

1. We will start by creating a function named `create_app()` in our `my_app/__init__.py`:

```
def create_app(alt_config={}):
    app = Flask(__name__, template_folder=alt_config
      .get('TEMPLATE_FOLDER', 'templates'))

    app.config['UPLOAD_FOLDER'] =
      os.path.realpath('.') + '/my_app/static/uploads'
    app.config['SQLALCHEMY_DATABASE_URI'] =
      'sqlite:////tmp/test.db'
    app.config['WTF_CSRF_SECRET_KEY'] = 'random key
      for form'
    app.config['LOG_FILE'] = 'application.log'

    app.config.update(alt_config)

    if not app.debug:
        import logging
        from logging import FileHandler, Formatter
        from logging.handlers import SMTPHandler
        file_handler =
          FileHandler(app.config['LOG_FILE'])
        app.logger.setLevel(logging.INFO)
        app.logger.addHandler(file_handler)
        mail_handler = SMTPHandler(
            ("smtp.gmail.com", 587),
              'sender@gmail.com', RECEPIENTS,
            'Error occurred in your application',
            ('some_email@gmail.com',
```

```
                'some_gmail_password'), secure=())
            mail_handler.setLevel(logging.ERROR)
            # app.logger.addHandler(mail_handler)
            for handler in [file_handler, mail_handler]:
                handler.setFormatter(Formatter(
                    '%(asctime)s %(levelname)s:
                      %(message)s '
                    '[in %(pathname)s:%(lineno)d]'
                ))

        app.secret_key = 'some_random_key'

        return app
```

In this function, we have just rearranged all the application configurations inside a function named `create_app()`. This will allow us to create as many application objects as needed by simply calling this function.

2. Next, we create a method named `create_db()`, which initializes the database and then creates tables:

```
db = SQLAlchemy()

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

    return db
```

Again in this function, we have just moved the database-specific code to a function. This method has been kept separate because you might want to use different database configs with different application instances.

3. The final step in `my_app/__init__.py` would be to call/execute these methods and register the blueprints:

```
def get_locale():
    return g.get('current_lang', 'en')

app = create_app()
babel = Babel(app)
babel.init_app(app, locale_selector=get_locale)

from my_app.catalog.views import catalog
```

```
app.register_blueprint(catalog)

db = create_db(app)
```

We have created the objects for `app`, `db`, and `babel` by calling relevant methods and initializing the extensions.

A downside of the application factory pattern is that you cannot use the application object in blueprints during import time. However, you can always utilize the `current_app` proxy to access the current application object. Let's see how this is done in `my_app/catalog/views.py`:

```
from flask import current_app

@catalog.before_request
def before():
    # Existing code

@catalog.context_processor
def inject_url_for():
    # Existing code

# Similarly simply replace all your references to `app` by
  `current_app`. Refer to code provided with the book for a
  complete example.
```

How it works...

The application will continue to work in the same way as it did in the last recipe. It's just that the code has been rearranged to implement the application factory pattern.

See also

The next couple of recipes will help you understand how the factory pattern is used while writing test cases.

Creating the first simple test

Testing is one of the strongest pillars of any software during development and, later, during maintenance and expansion. Especially in the case of web applications, where the application will handle high traffic and be scrutinized by a large number of end users at all times, testing becomes pretty important, as the user feedback determines the fate of the application. In this recipe, we will see how to start with test writing and also see more complex tests in the recipes to follow.

Getting ready

We will start with the creation of a new test file named `app_tests.py` at the root application level – that is, alongside the `my_app` folder.

How to do it...

Let's write our first test case:

1. To start with, the content of the `app_tests.py` test file will be as follows:

```
import os
from my_app import create_app, db, babel
import unittest
import tempfile
```

The preceding code describes the imports needed for this test suite. We will use `unittest` to write our tests. A `tempfile` instance is needed to create SQLite databases on the fly.

2. All the test cases need to subclass from `unittest.TestCase`:

```
class CatalogTestCase(unittest.TestCase):

    def setUp(self):
        test_config = {}
        self.test_db_file = tempfile.mkstemp()[1]
        test_config['SQLALCHEMY_DATABASE_URI'] =
          'sqlite:///' + self.test_db_file
        test_config['TESTING'] = True

        self.app = create_app(test_config)
        db.init_app(self.app)
        babel.init_app(self.app)

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

        from my_app.catalog.views import catalog
        self.app.register_blueprint(catalog)

        self.client = self.app.test_client()
```

The preceding method is run before each test is run and creates a new test client. A test is represented by the methods in this class that start with the `test_` prefix. Here, we set a database name in the app configuration, which is a timestamp-based value that will always be unique. We also set the `TESTING` flag to `True`, which disables error catching to enable better testing. Do pay special attention to how the application factory is used to create an application object before initializing `db` and `babel`.

Finally, we run the `create_all()` method on `db` to create all the tables from our application in the test database created.

3. Remove the temporary database created in the previous step after the test has executed:

```
    def tearDown(self):
        os.remove(self.test_db_file)
```

The preceding method is called after each test is run. Here, we will remove the current database file and use a fresh database file for each test.

4. Finally, write the test case:

```
    def test_home(self):
        rv = self.client.get('/')
        self.assertEqual(rv.status_code, 200)
```

The preceding code is our first test, where we sent an HTTP `GET` request to our application at the `/` URL and tested the response for the status code, which should be `200`, representing a successful `GET` response.

How it works...

To run the test file, just execute the following command in the terminal:

```
$ python app_tests.py
```

The following screenshot shows the output that signifies the outcome of the tests:

```
[2023-01-05 12:29:52,443] INFO in views: Home page with total of 0 products
.
----------------------------------------------------------------------
Ran 1 test in 0.037s

OK
```

Figure 10.4 – The first test result

See also

Refer to the next recipe, *Writing more tests for views and logic*, to see more on how to write complex tests.

Writing more tests for views and logic

In the last recipe, we got started with writing tests for our Flask application. In this recipe, we will build upon the same test file and add more tests for our application; these tests will cover testing the views for behavior and logic.

Getting ready

We will build upon the test file named `app_tests.py` created in the last recipe.

How to do it...

Before we write any tests, we need to add a small bit of configuration to `setUp()` to disable the CSRF tokens, as they are not generated by default for test environments:

```
        test_config['WTF_CSRF_ENABLED'] = False
```

The following are some tests that are created as a part of this recipe. Each test will be described as we go further:

1. Firstly, write a test to make a `GET` request to the products list:

```
    def test_products(self):
        "Test Products list page"
        rv = self.client.get('/en/products')
        self.assertEqual(rv.status_code, 200)
        self.assertTrue('No Previous Page' in
          rv.data.decode("utf-8"))
        self.assertTrue('No Next Page' in
          rv.data.decode("utf-8"))
```

   The preceding test sends a `GET` request to the `/products` endpoint and asserts that the status code of the response is `200`. It also asserts that there is no previous page and no next page (rendered as a part of the template logic).

2. Next, create a category and verify that it has been created correctly:

```
    def test_create_category(self):
        "Test creation of new category"
        rv = self.client.get('/en/category-create')
```

```
        self.assertEqual(rv.status_code, 200)

        rv = self.client.post('/en/category-create')
        self.assertEqual(rv.status_code, 200)
        self.assertTrue('This field is required.' In
          rv.data.decode("utf-8"))

        rv = self.client.get('/en/categories')
        self.assertEqual(rv.status_code, 200)
        self.assertFalse('Phones' in
          rv.data.decode("utf-8"))

        rv = self.client.post('/en/category-create',
          data={
            'name': 'Phones',
        })
        self.assertEqual(rv.status_code, 302)

        rv = self.client.get('/en/categories')
        self.assertEqual(rv.status_code, 200)
        self.assertTrue('Phones' in
          rv.data.decode("utf-8"))

        rv = self.client.get('/en/category/1')
        self.assertEqual(rv.status_code, 200)
        self.assertTrue('Phones' in
          rv.data.decode("utf-8"))
```

The preceding test creates a category and asserts for corresponding status messages. When a category is successfully created, we will be redirected to the newly created category page, and hence, the status code will be `302`.

3. Now, similar to category creation, create a product and then verify its creation:

```
    def test_create_product(self):
        "Test creation of new product"
        rv = self.client.get('/en/product-create')
        self.assertEqual(rv.status_code, 200)

        # Raise a ValueError for a valid category not
          found
        self.assertRaises(ValueError,
          self.client.post, '/en/product-create')

        # Create a category to be used in product
```

```
            creation
        rv = self.client.post('/en/category-create',
          data={
            'name': 'Phones',
        })
        self.assertEqual(rv.status_code, 302)

        rv = self.client.post('/en/product-create',
          data={
            'name': 'iPhone 5',
            'price': 549.49,
            'company': 'Apple',
            'category': 1,
            'image': tempfile.NamedTemporaryFile()
        })
        self.assertEqual(rv.status_code, 302)

        rv = self.client.get('/en/products')
        self.assertEqual(rv.status_code, 200)
        self.assertTrue('iPhone 5' in
          rv.data.decode("utf-8"))
```

The preceding test creates a product and asserts for corresponding status messages on each call/request.

Information

As a part of this test, we identified a small improvement in our `create_product()` method. We had not initiated the `filename` variable before the `if` condition to check for the allowed file type. The earlier code would work fine only when the `if` condition passed. Now, we have just adjusted the code to initiate `filename` as `filename = secure_filename(image.filename)` before the `if` condition, instead of doing it inside the condition.

4. Finally, create multiple products and search for the products that were just created:

```
    def test_search_product(self):
        "Test searching product"
        # Create a category to be used in product
          creation
        rv = self.client.post('/en/category-create',
          data={
            'name': 'Phones',
        })
```

```
        self.assertEqual(rv.status_code, 302)

        # Create a product
        rv = self.client.post('/en/product-create',
          data={
            'name': 'iPhone 5',
            'price': 549.49,
            'company': 'Apple',
            'category': 1,
            'image': tempfile.NamedTemporaryFile()
        })
        self.assertEqual(rv.status_code, 302)

        # Create another product
        rv = self.client.post('/en/product-create',
          data={
            'name': 'Galaxy S5',
            'price': 549.49,
            'company': 'Samsung',
            'category': 1,
            'image': tempfile.NamedTemporaryFile()
        })
        self.assertEqual(rv.status_code, 302)

        self.client.get('/')

        rv = self.client.get('/en/product-
          search?name=iPhone')
        self.assertEqual(rv.status_code, 200)
        self.assertTrue('iPhone 5' in
          rv.data.decode("utf-8"))
        self.assertFalse('Galaxy S5' in
          rv.data.decode("utf-8"))

        rv = self.client.get('/en/product-
          search?name=iPhone 6')
        self.assertEqual(rv.status_code, 200)
        self.assertFalse('iPhone 6' in
          rv.data.decode("utf-8"))
```

The preceding test first creates a category and two products. Then, it searches for one product and makes sure that only the searched product is returned in the result.

How it works...

To run the test file, just execute the following command in the terminal:

```
$ python app_tests.py -v
test_create_category (__main__.CatalogTestCase)
Test creation of new category ... ok
test_create_product (__main__.CatalogTestCase)
Test creation of new product ... ok
test_home (__main__.CatalogTestCase) ... ok
test_products (__main__.CatalogTestCase)
Test Products list page ... ok
test_search_product (__main__.CatalogTestCase)
Test searching product ... ok

----------------------------------------------------------------------
Ran 5 tests in 0.390s

OK
```

What follows the command is the output that shows the outcome of the tests.

See also

Another interesting and popular library that can be used for unit testing is **pytest**. It is similar to Python's in-built **unittest** library but with more out-of-the-box features. Feel free to explore it: `https://docs.pytest.org/en/stable/`.

Integrating the nose2 library

nose2 is a library that makes testing easier and much more fun. It provides a whole lot of tools to enhance our tests. Although `nose2` can be used for multiple purposes, the most important usage remains that of a test collector and runner. `nose2` automatically collects tests from Python source files, directories, and packages found in the current working directory. In this recipe, we will focus on how to run individual tests using `nose2` rather than the whole bunch of tests every time.

> **Important**
>
> In earlier editions of this book, we used the `nose` library. It has since not been under active maintenance and can be deemed deprecated. A replacement for it has been created, with the name `nose2`. This library behaves similarly to `nose` but is not exactly the same. However, for the purpose of our demonstration, the major functionality remains similar.

Getting ready

First, we need to install the `nose2` library:

```
$ pip install nose2
```

`nose2` has a mechanism for test file discovery that mandates that a file should start with `test`. Since, in our case, the test file is named `app_tests.py`, we should now rename it `test_app.py`. On a terminal, you can simply run the following:

```
$ mv app_tests.py test_app.py
```

How to do it...

We can execute all the tests in our application using `nose2` by running the following command:

```
$ nose2 -v
test_create_category (test_app.CatalogTestCase)
Test creation of new category ... ok
test_create_product (test_app.CatalogTestCase)
Test creation of new product ... ok
test_home (test_app.CatalogTestCase) ... ok
test_products (test_app.CatalogTestCase)
Test Products list page ... ok
test_search_product (test_app.CatalogTestCase)
Test searching product ... ok

----------------------------------------------------------------------
Ran 5 tests in 0.241s

OK
```

This will pick out all the tests in our application and run them, even if we have multiple test files.

To run a single test file, simply run the following command:

```
$ nose2 test_app
```

Now, if you want to run a single test, simply run this command:

```
$ nose2 test_app.CatalogTestCase.test_home
```

This becomes important when we have a memory-intensive application and a large number of test cases. In that instance, the tests themselves can take a long time to run, and doing so every time can be very frustrating for a developer. Instead, we will prefer to run only those tests that concern the change made, or the test that broke following a certain change.

See also

There are many other ways to configure `nose2` for optimal and effective usage as per requirements. Refer to the `nose2` documentation at `https://docs.nose2.io/en/latest/index.html` for more details.

Using mocking to avoid external API access

We are aware of how testing works, but now, let's imagine we have a third-party application/service integrated via API calls with our application. It would not be a great idea to make calls to this application/service every time tests are run. Sometimes, these can be paid, too, and making calls during tests can not only be expensive but also affect the statistics of that service. **Mocking** plays a very important role in such scenarios. The simplest example of this can be mocking SMTP for emails. In this recipe, we will integrate our application with the `geoip2` library and then test it via mocking.

Getting ready

In Python 3, `mock` has been included as a standard package in the `unittest` library.

For the purpose of this recipe, we first need to install the `geoip2` library and the corresponding database:

```
$ pip install geoip2
```

You also need to download the free `geoip` database from the MaxMind (`https://dev.maxmind.com/geoip/geolite2-free-geolocation-data`) website to a location of your preference, and then unzip the file. For the sake of simplicity, I have downloaded it to the project folder itself. You will need to create a free account before you can download the `geoip` city database.

After downloading the city database, you should have a folder with the `Geolite2- City-` prefix. This folder contains the `geoip` database with the `.mmdb` extension that we will use in this recipe.

Now, let's say we want to store the location of a user who creates a product (imagine a scenario where the application is administered at multiple global locations).

We need to make some small changes to `my_app/catalog/models.py`, `my_app/catalog/views.py`, and `templates/product.html`.

For `my_app/catalog/models.py`, we will add a new field named `user_timezone`:

```
class Product(db.Model):
    # ... Other fields ...
    user_timezone = db.Column(db.String(255))
```

```
    def __init__(self, name, price, category, image_path,
      user_timezone=''):
        # ... Other fields initialization ...
        self.user_timezone = user_timezone
```

For `my_app/catalog/views.py`, we will modify the `create_product()` method to include the time zone:

```
import geoip2.database, geoip2.errors

@catalog.route('/<lang>/product-create', methods=['GET',
  'POST'])
def create_product():
    form = ProductForm()

    if form.validate_on_submit():
        # ... Non changed code ...
        reader = geoip2.database.Reader(
            'GeoLite2-City_20230113/GeoLite2-City.mmdb'
        )
        try:
            match = reader.city(request.remote_addr)
        except geoip2.errors.AddressNotFoundError:
            match = None
        product = Product(
            name, price, category, filename,
            match and match.location.time_zone or
              'Localhost'
        )
        # ... Non changed code ...
```

Here, we fetched the geolocation data using an IP lookup and passed this during product creation. If no match is found, then the call is made from `localhost`, `127.0.0.1`, or `0.0.0.0`.

Also, we will add this new field in our product template so that it becomes easy to verify in the test. For this, just add `{{ product.user_timezone }}` somewhere in the `product.html` template.

How to do it...

Start by modifying `test_app.py` to accommodate the mocking of the `geoip` lookup:

1. First, configure the mocking of the `geoip` lookup by creating patchers:

```
from unittest import mock
import geoip2.records
```

```
class CatalogTestCase(unittest.TestCase):

    def setUp(self):
        # ... Non changed code ...

        self.geoip_city_patcher =
          mock.patch('geoip2.models.City',
            location=geoip2.records.Location(time_zone
              = 'America/Los_Angeles')
        )
        PatchedGeoipCity =
          self.geoip_city_patcher.start()
        self.geoip_reader_patcher =
          mock.patch('geoip2.database.Reader')
        PatchedGeoipReader =
          self.geoip_reader_patcher.start()
        PatchedGeoipReader().city.return_value =
          PatchedGeoipCity

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

        from my_app.catalog.views import catalog
        self.app.register_blueprint(catalog)

        self.client = self.app.test_client()
```

First, we imported `records` from `geoip2`, which we will use to create the mocked return value that we need to use for testing. Then, we patched `geoip2.models.City` with the `location` attribute on the `City` model preset to `geoip2.records.Location(time_zone = 'America/Los_Angeles')` and started the patcher. This means that whenever an instance of `geoip2.models.City` is created, it will be patched with the time zone on the `location` attribute set to `'America/Los_Angeles'`.

This is followed by the patching of `geoip2.database.Reader`, where we mock the return value of its `city()` method to the `PatchedGeoipCity` class that we created previously.

2. Stop the patchers that were started in the `setUp` method:

```
    def tearDown(self):
        self.geoip_city_patcher.stop()
        self.geoip_reader_patcher.stop()
        os.remove(self.test_db_file)
```

We stopped the mock patchers in `tearDown` so that the actual calls are not affected.

3. Finally, modify the product test case created to assert the location:

```
    def test_create_product(self):
        "Test creation of new product"
        # ... Non changed code ...

        rv = self.client.post('/en/product-create',
          data={
            'name': 'iPhone 5',
            'price': 549.49,
            'company': 'Apple',
            'category': 1,
            'image': tempfile.NamedTemporaryFile()
        })
        self.assertEqual(rv.status_code, 302)

        rv = self.client.get('/en/product/1')
        self.assertEqual(rv.status_code, 200)
        self.assertTrue('iPhone 5' in
          rv.data.decode("utf-8"))
        self.assertTrue('America/Los_Angeles' in
          rv.data.decode("utf-8"))
```

Here, after the creation of the product, we asserted that the `America/Los_Angeles` value is present somewhere in the product template that is rendered.

How it works...

Run the test and see whether it passes:

```
$ nose2 test_app.CatalogTestCase.test_create_product -v
test_create_product (test_app.CatalogTestCase)
Test creation of new product ... ok

----------------------------------------------------------------------
Ran 1 test in 0.079s

OK
```

See also

There are multiple ways in which mocking can be done. I demonstrated just one of them. You can choose any method from the ones available. Refer to the documentation available at `https://docs.python.org/3/library/unittest.mock.html`.

Determining test coverage

In the previous recipes, test case writing was covered, but there is an important aspect to measure the extent of testing, called coverage. Coverage refers to how much of our code has been covered by the tests. The higher the percentage of coverage, the better the testing (although high coverage is not the only criterion for good tests). In this recipe, we will check the code coverage of our application.

> **Tip**
> Remember that 100% test coverage does not mean that code is flawless. However, in any case, it is better than having no tests or lower coverage. Remember that "*if it's not tested, it's broken.*"

Getting ready

We will use a library called `coverage` for this recipe. The following is the installation command:

```
$ pip install coverage
```

How to do it...

The simplest way of measuring code coverage is to use the command line:

1. Simply run the following command:

   ```
   $ coverage run --source=<Folder name of the application>
   --omit=test_app.py,run.py test_app.py
   ```

   Here, `--source` indicates the directories that are to be considered in coverage, and `--omit` indicates the files that need to be omitted in the process.

2. Now, to print the report on the terminal itself, run the following command:

   ```
   $ coverage report
   ```

   The following screenshot shows the output:

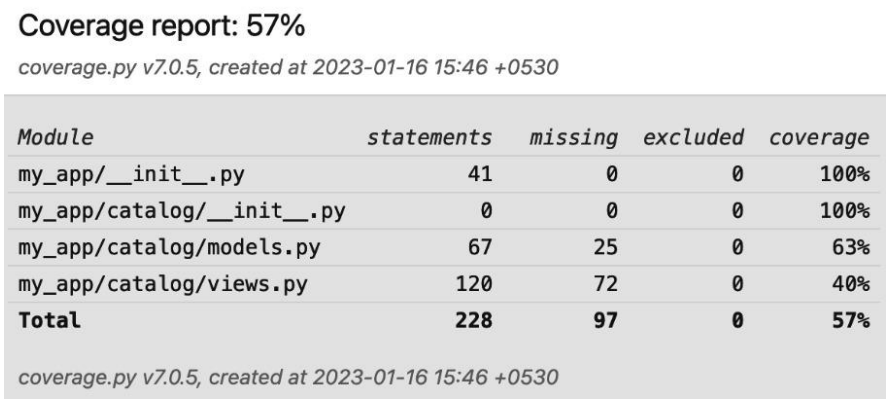
```
Name                          Stmts   Miss  Cover
-----------------------------------------------
my_app/__init__.py               41      0   100%
my_app/catalog/__init__.py        0      0   100%
my_app/catalog/models.py         67     25    63%
my_app/catalog/views.py         120     72    40%
-----------------------------------------------
TOTAL                           228     97    57%
```

Figure 10.5 – The test coverage report

3. To get a nice HTML output of the coverage report, run the following command:

```
$ coverage html
```

This will create a new folder named `htmlcov` in your current working directory. Inside this, just open up `index.html` in a browser, and the full detailed view will be available.



Coverage report: 57%

coverage.py v7.0.5, created at 2023-01-16 15:46 +0530

Module	statements	missing	excluded	coverage
my_app/__init__.py	41	0	0	100%
my_app/catalog/__init__.py	0	0	0	100%
my_app/catalog/models.py	67	25	0	63%
my_app/catalog/views.py	120	72	0	40%
Total	**228**	**97**	**0**	**57%**

coverage.py v7.0.5, created at 2023-01-16 15:46 +0530

Figure 10.6 – The test coverage report web view

Alternatively, we can include a piece of code in our test file and get the coverage report every time the tests are run. We just add the following code snippets to `test_app.py`:

1. Before anything else, add the following code to start the coverage assessment process:

```
import coverage

cov = coverage.coverage(
    omit = [
        '/Users/apple/workspace/flask-cookbook-3/
          Chapter-10/lib/python3.10/site-packages/*',
        'test_app.py'
    ]
)
cov.start()
```

Here, we imported the `coverage` library and created an object for it. This tells the library to omit all `site-packages` instances (because we do not want to evaluate the code that we did not write) and the test file itself. Then, we started the process to determine the coverage.

2. At the end of the code, modify the last block to the following:

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

```
        cov.stop()
        cov.save()
        cov.report()
        cov.html_report(directory = 'coverage')
        cov.erase()
```

In the preceding code, we first put `unittest.main()` inside a `try..finally` block. This is because `unittest.main()` exits after all the tests are executed. Now, the coverage-specific code is forced to run after this method completes. We stopped the coverage report, saved it, printed the report on the console, and then generated the HTML version of it before deleting the temporary `.coverage` file (this is created automatically as part of the process).

How it works...

If we run our tests after including the coverage-specific code, then we can run the following command:

```
$ python test_app.py
```

The output will be very similar to the one in *Figure 10.5*.

See also

It is also possible to determine coverage using the `nose2` library, which we discussed in the *Integrating the nose2 library* recipe. I will leave it to you to explore this by yourself. Refer to `https://docs.nose2.io/en/latest/plugins/coverage.html` for a head start.

Using profiling to find bottlenecks

Profiling is an important and handy tool to measure performance when we decide to scale an application. Before scaling, we want to know whether any process is a bottleneck and affects the overall performance. Python has a built-in profiler, `cProfile`, that can do the job for us, but to make life easier, `werkzeug` has `ProfilerMiddleware`, which is written over `cProfile`. In this recipe, we will use `ProfilerMiddleware` to determine whether there is anything that affects performance.

Getting ready

We will use the application from the previous recipe and add `ProfilerMiddleware` to a new file named `generate_profile.py`.

How to do it...

Create a new file, `generate_profile.py`, alongside `run.py`, which works like `run.py` itself but with `ProfilerMiddleware`:

```
from werkzeug.middleware.profiler import ProfilerMiddleware
from my_app import app

app.wsgi_app = ProfilerMiddleware(app.wsgi_app,
  restrictions = [10])
app.run(debug=True)
```

Here, we imported `ProfilerMiddleware` from `werkzeug` and then modified `wsgi_app` on our Flask app to use it, with a restriction of the top 10 calls to be printed in the output.

How it works...

Now, we can run our application using `generate_profile.py`:

```
$ python generate_profile.py
```

We can then create a new product. Then, the output for that specific call will be like the following screenshot:

```
PATH: '/en/product-create'
         12364 function calls (11825 primitive calls) in 0.054 seconds

   Ordered by: internal time, call count
   List reduced from 1490 to 10 due to restriction <10>

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
        1    0.019    0.019    0.020    0.020 /Users/apple/workspace/flask-cookbook-3/Chapter-10/lib/python3.10/site-packages/maxminddb/reader.py:39(__init__)
        4    0.004    0.001    0.004    0.001 {method 'execute' of 'sqlite3.Cursor' objects}
      104    0.003    0.000    0.003    0.000 /Users/apple/workspace/flask-cookbook-3/Chapter-10/lib/python3.10/site-packages/maxminddb/reader.py:190(_read_node)
        2    0.002    0.001    0.002    0.001 {built-in method posix.open}
       14    0.002    0.000    0.002    0.000 {method 'recv_into' of '_socket.socket' objects}
        3    0.002    0.001    0.003    0.001 {built-in method io.open}
        1    0.001    0.001    0.001    0.001 {method 'commit' of 'sqlite3.Connection' objects}
        5    0.001    0.000    0.001    0.000 {built-in method builtins.exec}
        1    0.001    0.001    0.001    0.001 {built-in method unicodedata.normalize}
        2    0.001    0.000    0.001    0.000 {built-in method _sqlite3.connect}


--------------------------------------------------------------------------------

127.0.0.1 - - [18/Jan/2023 11:53:38] "POST /en/product-create HTTP/1.1" 302 -
--------------------------------------------------------------------------------
```

Figure 10.7 – The profiler output

It is evident from the preceding screenshot that the most intensive call in this process is the call made to the `geoip` database. Even though it is a single call, it takes the most amount of time. So, if we decide to improve performance sometime down the line, this is something that needs to be looked at first.

11
Deployment and Post-Deployment

So far, we have learned how to write Flask applications in different ways. Deploying an application and managing the application post-deployment is as important as developing it. There can be various ways of deploying an application and choosing the best way depends on the requirements. Deploying an application correctly is very important from a security and performance point of view. There are multiple ways of monitoring an application after deployment, of which some are paid and others are free to use. Using them depends on the requirements and features that are offered by them.

In this chapter, we will talk about various application deployment techniques, followed by some monitoring tools that are used post-deployment.

Each of the tools and techniques we will cover has a set of features. For example, adding too much monitoring to an application can prove to be an extra overhead to the application and the developers. Similarly, missing out on monitoring can lead to undetected user errors and overall user dissatisfaction.

> **Note**
> In this chapter, I will be focusing on deployment to **Ubuntu 22.04** servers. This should cover most cases. I will try to cover any special steps needed for macOS and Windows but do not treat those as exhaustive.

Hence, we should choose the tools that we use wisely, which, in turn, will ease our lives as much as possible.

In terms of post-deployment monitoring tools, we will discuss New Relic. Sentry is another tool that will prove to be the most beneficial of all from a developer's perspective. We covered this in the *Using Sentry to monitor exceptions* recipe in *Chapter 10*, *Debugging, Error Handling, and Testing*.

Tip

Several topics will be covered in this chapter and all of them can be followed/implemented independently of each other. You can club some of them together to make use of multiple features and I have mentioned this wherever I felt best. As a software developer, feel free to use your judgment about which library to use for what purpose.

In this chapter, we will cover the following recipes:

- Deploying with Apache
- Deploying with uWSGI and Nginx
- Deploying with Gunicorn and Supervisor
- Deploying with Tornado
- Using S3 storage for file uploads
- Managing and monitoring application performance with New Relic
- Infrastructure and application monitoring with Datadog

Deploying with Apache

In this recipe, we will learn how to deploy a Flask application with `Apache`, which is, arguably, the most popular HTTP server. For Python web applications, we will use `mod_wsgi`, which implements a simple Apache module that can host any Python applications that support the WSGI interface.

Note

Remember that `mod_wsgi` is not the same as Apache and needs to be installed separately.

Getting ready

We will start with the catalog application from the previous chapter. There is no need to make any changes to the existing code.

For deploying with Apache, it is important to make sure that the latest version of the Apache `httpd` server is installed on the machine on which you intend to deploy. Usually, the versions of Apache shipped with the operating systems (especially macOS) might be older and will not be supported by the `mod_wsgi` library.

Note

`httpd` stands for **Hypertext Transfer Protocol Daemon**, which refers to a program that waits for requests from web clients and serves them. In the context of Apache, `httpd` refers to the web server that implements the daemon created by Apache Software Foundation. `apache` and `httpd` are mostly used interchangeably.

For macOS, `httpd` can be installed using Homebrew:

```
$ brew install httpd
```

For Ubuntu, `httpd` is provided by default. Just simply upgrade it:

```
$ sudo apt update
$ sudo apt install python3-dev
$ sudo apt install apache2 apache2-dev
```

For Windows operating systems, please follow the official documentation at `https://httpd.apache.org/docs/trunk/platform/`.

Once Apache has been successfully installed/updated, the next step is to install the `mod_wsgi` library. It can simply be installed inside your virtual environment:

```
$ pip install mod_wsgi
```

How to do it...

In stark contrast to the previous editions of this book, `mod_wsgi` now ships with a modern `mod_wsgi-express` command, which removes all the complexity of writing the Apache `httpd` configuration.

The only argument to the `mod_wsgi-express` command is a file containing the Flask application object. So, create a file called `wsgi.py` with the following content:

```
from my_app import app as application
```

Important

The `app` object needs to be imported as `application` since `mod_wsgi` expects the `application` keyword.

How it works...

Run the following command to invoke the web server using `mod_wsgi`:

```
$ mod_wsgi-express start-server wsgi.py --processes 4
```

Now, visit `http://localhost:8000/` to see the application in action.

You can also run your application on privileged ports such as `80` or `443` by providing the `--port` parameter. Just make sure that the shell user/group running the command has permission to access the port(s). If not, you can change the user/group to the relevant ones by passing the `--user` and `--group` parameters.

See also

Refer to `http://httpd.apache.org/` to read more about Apache.

The latest documentation on `mod_wgsi` can be found at `https://modwsgi.readthedocs.io/en/develop`.

You can read about WSGI in general at `http://wsgi.readthedocs.org/en/latest/`.

Deploying with uWSGI and Nginx

For those who are already aware of the usefulness of uWSGI and Nginx, not much needs to be explained. uWSGI is a protocol as well as an application server and provides a complete stack so that you can build hosting services. Nginx is a reverse proxy and HTTP server that is very lightweight and capable of handling virtually unlimited requests. Nginx works seamlessly with uWSGI and provides many under-the-hood optimizations for better performance. In this recipe, we will use uWSGI and Nginx together to facilitate the deployment of our application.

Getting ready

We will use our application from the previous recipe, *Deploying with Apache*, and use the same `wsgi.py` file.

Now, install Nginx and uWSGI. On Debian-based distributions such as Ubuntu, they can be easily installed using the following commands:

```
$ sudo apt-get install nginx
$ pip install pyuwsgi
```

These installation instructions are OS-specific, so please refer to the respective documentation as per the OS that you're using.

Make sure that you have a `sites-enabled` folder for Nginx since this is where we will keep our site-specific configuration files. Usually, it is already present in most installations in the `/etc/` folder. If not, please refer to the OS-specific documentation for your OS to figure this out.

How to do it...

Follow these steps to deploy the application using uWSGI first and then combine it with Nginx as a reverse proxy:

1. The first step is to create a file named `wsgi.py`:

   ```
   from my_app import app as application
   ```

   This is needed because `uwsgi` expects to find an executable named `application`, so we just import our `app` as `application`.

2. Next, create a file named `uwsgi.ini` in our application root folder:

   ```
   [uwsgi]
   http-socket    = :9090
   wsgi-file = /home/ubuntu/cookbook3/Chapter-11/wsgi.py
   processes   = 3
   ```

   Here, we have configured `uwsgi` to run the `wsgi-file` provided at the HTTP address mentioned with the number of workers, as specified in `processes`.

   To test whether uWSGI is working as expected, run the following command:

   ```
   $ uwsgi --ini uwsgi.ini
   ```

   Now, point your browser to `http://127.0.0.1:9090/`; this should open the home page of the application.

3. Before moving on, edit the preceding file to replace `http-socket` with `socket`. This will change the protocol from HTTP to uWSGI (you can read more about this at `https://uwsgi-docs.readthedocs.io/en/latest/Protocol.html`).

Important

You must keep the `uwsgi` process running. Right now, we have run this as a foreground process.

You might want to keep the uWSGI process running automatically in the background as a headless service rather than having it run manually in the foreground. There are multiple tools to do this, such as `supervisord`, `circus`, and so on. We will touch on `supervisord` in the next recipe for a different purpose, but that can be replicated here as well. I will leave it to you to try this out for yourself.

4. Now, create a new file called `nginx-wsgi.conf`. This will contain the Nginx configuration that's needed to serve our application and the static content:

```
server {
  location / {
    include uwsgi_params;
    uwsgi_pass 0.0.0.0:9090;
  }
  location /static/uploads/ {
    alias /home/ubuntu/cookbook3/Chapter-
      11/flask_test_uploads/;
  }
}
```

   In the preceding code block, `uwsgi_pass` specifies the uWSGI server that needs to be mapped to the specified location.

> **Tip**
>
> The `nginx-wsgi.conf` file can be created anywhere. It can be created with your code bundle so that it can be version controlled, or it can be placed at `/etc/nginx/sites-available` for easier maintenance if you have multiple `.conf` files.

5. Create a soft link from this file to the `sites-enabled` folder we mentioned earlier using the following command:

```
$ sudo ln -s ~/cookbook3/Chapter-11/nginx-wsgi.conf /etc/nginx/
sites-enabled/
```

6. By default, Nginx comes with a site configuration named `default` in the `sites-available` folder with a symlink to the `sites-enabled` folder. Unlink the same to serve our application; otherwise, the default will block our application from being loaded:

```
$ sudo unlink /etc/nginx/sites-enabled/default
```

7. After all of this, reload the Nginx server using the following command:

```
$ sudo systemctl reload nginx.service
```

Point your browser to `http://127.0.0.1/` or `http://<your server IP or domain address>` to see the application that serves via Nginx and uWSGI.

See also

Refer to `https://uwsgi-docs.readthedocs.org/en/latest/` for more information on uWSGI.

Refer to `https://www.nginx.com/` for more information on Nginx.

There is a good article by DigitalOcean on Nginx and uWSGI. I advise you to go through it so that you have a better understanding of the topic. It is available at `https://www.digitalocean.com/community/tutorials/how-to-serve-flask-applications-with-uwsgi-and-nginx-on-ubuntu-22-04`.

To get an insight into the differences between Apache and Nginx, I think an article by Anturis, which can be found at `https://anturis.com/blog/nginx-vs-apache/`, is pretty good.

Deploying with Gunicorn and Supervisor

Gunicorn is a WSGI HTTP server for Unix. It is very simple to implement, ultra-light, and fairly speedy. Its simplicity lies in its broad compatibility with various web frameworks.

Supervisor is a monitoring tool that controls various child processes and handles starting/restarting these child processes when they exit abruptly, or due to some other reason. It can be extended to control processes via the XML-RPC API over remote locations without you having to log into the server (we won't discuss this here as it is beyond the scope of this book).

One thing to remember is that these tools can be used along with the other tools mentioned in the applications in the previous recipe, such as using Nginx as a proxy server. This is left to you to try out.

Getting ready

We will start by installing both the packages – that is, `gunicorn` and `supervisor`. Both can be directly installed using `pip`:

```
$ pip install gunicorn
$ pip install supervisor
```

How to do it...

Follow these steps:

1. To check whether the `gunicorn` package works as expected, just run the following command from inside our application folder:

   ```
   $ gunicorn -w 4 -b 0.0.0.0:8000 my_app:app
   ```

   After this, point your browser to `http://0.0.0.0:8000/` or `http://<IP address or domain name>:8000/` to see the application's home page.

2. Now, we need to do the same as in the previous step using Supervisor so that this process runs as a daemon that will be controlled by Supervisor itself rather than through human intervention. First of all, we need a Supervisor configuration file. This can be achieved by running the following command inside your virtual environment. Supervisor, by default, looks for an `etc` folder that has a file named `supervisord.conf`. In system-wide installations, this folder is `/etc/`, while in a virtual environment, it will look for an `etc` folder in the virtual environment root folder and then fall back to `/etc/`. Hence, it is suggested that you create a folder named `etc` in your virtual environment to maintain separation of concerns:

```
$ mkdir etc
$ echo_supervisord_conf > etc/supervisord.conf
```

The last command will create a configuration file named `supervisord.conf` in the `etc` folder. This file houses all the configurations for the processes that would be run using the Supervisor daemon.

Information

The `echo_supervisord_conf` program is provided by Supervisor; it prints a sample config file to the location specified. If you run into permission issues while running the command, try using `sudo`.

3. Now, add the following configuration block in the file you created previously:

```
[program:flask_catalog]
command=<path to virtual environment>/bin/gunicorn -w
  4 -b 0.0.0.0:8000 my_app:app
directory=<path to application directory>
user=someuser # some user with relevant permissions
autostart=true
autorestart=true
stdout_logfile=/tmp/app.log
stderr_logfile=/tmp/error.log
```

Here, we specified the `gunicorn` process as the command to run, along with the directory and user to be used for the process. Other settings specify the behavior at the start or restart of the Supervisor daemon and the locations to save respective log files in.

Tip

Note that you should never run the applications as a `root` user. This is a huge security flaw in itself as the application may crash or the flaws may harm the OS itself.

4. After the setup is complete, run `supervisord` by using the following command:

```
$ supervisord
```

How it works...

To check the status of the application, run the following command:

```
$ supervisorctl status
flask_catalog            RUNNING   pid 112039, uptime 0:00:06
```

This command provides a status for all of the child processes.

> **Tip**
> The tools that were discussed in this recipe can be coupled with Nginx to serve as a reverse proxy server. I suggest that you try this out for yourself.

Every time you make a change to your application and then wish to restart Gunicorn for it to reflect the changes that have been made, run the following command:

```
$ supervisorctl restart all
```

You can also specify specific processes instead of restarting everything:

```
$ supervisorctl restart flask_catalog
```

See also

You can read more about Gunicorn at `http://gunicorn-docs.readthedocs.org/en/latest/index.html`.

For more information on Supervisor, please refer to `http://supervisord.org/index.html`.

Deploying with Tornado

Tornado is a complete web framework and a standalone web server in itself. Here, we will use Flask to create our application, which is a combination of URL routing and templating, and leave the server part to Tornado. Tornado is built to hold thousands of simultaneous standing connections and makes applications very scalable.

Information

Tornado has limitations while working with WSGI applications, so choose wisely! You can read more about this at `http://www.tornadoweb.org/en/stable/wsgi.html#running-wsgi-apps-on-tornado-servers`.

Getting ready

Installing Tornado can be done using `pip`:

```
$ pip install tornado
```

How to do it...

Let's create a file named `tornado_server.py` and put the following code in it:

```
from tornado.wsgi import WSGIContainer
from tornado.httpserver import HTTPServer
from tornado.ioloop import IOLoop
from my_app import app

http_server = HTTPServer(WSGIContainer(app))
http_server.listen(8000)
IOLoop.instance().start()
```

Here, we created a WSGI container for our application; this container is then used to create an HTTP server, and the application is hosted on port `8000`.

How it works...

Run the Python file we created in the previous section using the following command:

```
$ python tornado_server.py
```

Point your browser to `http://0.0.0.0:8000/` or `http://<IP address or domain name>:8000/` to see the home page being served.

Tip

We can couple Tornado with Nginx (as a reverse proxy to serve static content) and Supervisor (as a process manager) for the best results. This is left for you as an exercise.

Using S3 storage for file uploads

Amazon Web Services (**AWS**) explains S3 as the storage for the internet that is designed to make web-scale computing easier for developers. S3 provides a very simple interface via web services; this makes storing and retrieving any amount of data very simple at any time from anywhere on the internet. Until now, in our catalog application, we saw that there were issues in managing the product images that were uploaded as a part of the creation process. This whole headache will go away if the images are stored somewhere globally and are easily accessible from anywhere. We will use S3 for the same purpose.

Getting ready

Amazon offers **boto3**, a complete Python library that interfaces with AWS via web services. Almost all of the AWS features can be controlled using `boto3`. It can be installed using `pip`:

```
$ pip install boto3
```

How to do it...

Now, make some changes to our existing catalog application to accommodate support for file upload and retrieval from S3:

1. First, we need to store the AWS-specific configuration to allow `boto3` to make calls to S3. Add the following statements to the application's configuration file – that is, `my_app/__init__.py`. Make sure that you group the following configuration values along with other pre-existing configuration values:

   ```
   app.config['AWS_ACCESS_KEY'] = 'AWS Access Key'
   app.config['AWS_SECRET_KEY'] = 'AWS Secret Key'
   app.config['AWS_BUCKET'] = 'Name of AWS Bucket'
   ```

   You can get these values from AWS IAM. Ensure that the user associated with these credentials has access to create and get objects from S3.

2. Next, we need to change our `views.py` file:

   ```
   import boto3
   ```

   This is the import that we need from `boto3`. Next, we need to replace the following line in `create_product()`:

   ```
   image.save(os.path.join(current_app.config['UPLOAD_FOL
     DER'], filename))
   ```

We must replace this with the following block of code:

```
            session = boto3.Session(
                aws_access_key_id=current_app
                  .config['AWS_ACCESS_KEY'],
                aws_secret_access_key=current_app
                  .config['AWS_SECRET_KEY']
            )
            s3 = session.resource('s3')
            bucket = s3.Bucket(current_app
              .config['AWS_BUCKET'])
            if bucket not in list(s3.buckets.all()):
                bucket = s3.create_bucket(
                    Bucket=current_app
                      .config['AWS_BUCKET'],
                    CreateBucketConfiguration={
                        'LocationConstraint':
                          'ap-south-1'
                    },
                )
            bucket.upload_fileobj(
                image, filename,
                ExtraArgs={'ACL': 'public-read'})
```

With this code change, we are essentially changing how we save files. Earlier, the image was being saved locally using `image.save`. Now, this is done by creating an S3 connection and uploading the image to a bucket there. First, we create a `session` connection with AWS using `boto3.Session`. We use this session to access S3 resources and then create a `bucket` (if it doesn't exist; otherwise, use the same) with a location constraint to `'ap-south-1'`. This location constraint isn't necessary and can be used as needed. Finally, we upload our image to the bucket.

3. The last change will be made to our `product.html` template, where we need to change the image's `src` path. Replace the original `img src` statement with the following statement:

```
<img src="{{ 'https://s3.ap-south-
  1.amazonaws.com/' + config['AWS_BUCKET']
  + '/' + product.image_path }}"/>
```

How it works...

Now, run the application as usual and create a product. When the created product is rendered, the product image will take a bit of time to come up as it is now being served from S3 (and not from a local machine). If this happens, then the integration with S3 has been successful.

Managing and monitoring application performance with New Relic

New Relic is an analytics software that provides near real-time operational and business analytics related to your application. It provides deep analytics on the behavior of the application from various aspects. It does the job of a profiler, as well as eliminates the need to maintain extra moving parts in the application. It works in the data push principle, where our application sends data to New Relic rather than New Relic asking for statistics from our application.

Getting ready

We will use the catalog application that we have built throughout this book. In essence, the application to be used does not matter here; it should just be a running Flask application.

The first step will be to sign up with New Relic for an account. Follow the simple sign-up process and, upon completion and email verification, you will be sent to your dashboard. Here, choose **Application monitoring** as the product that we need to use from the suite of offerings from New Relic and choose **Python** as the tech stack:

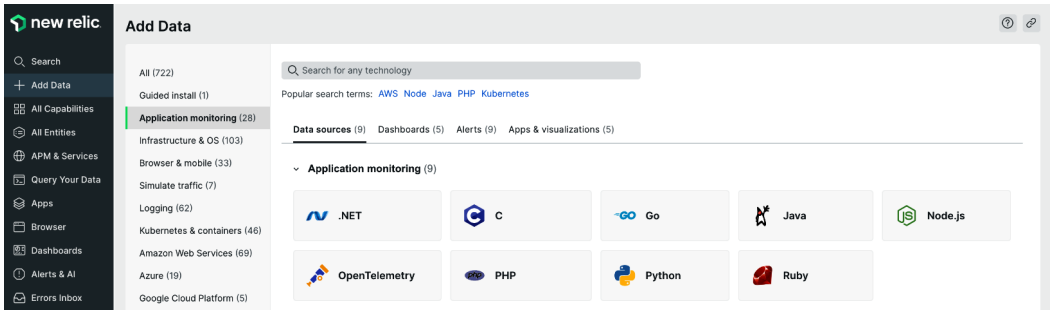


Figure 11.1 – New Relic stack selection

This guided install widget will ask about the operating system being used before handing out the commands to be run:

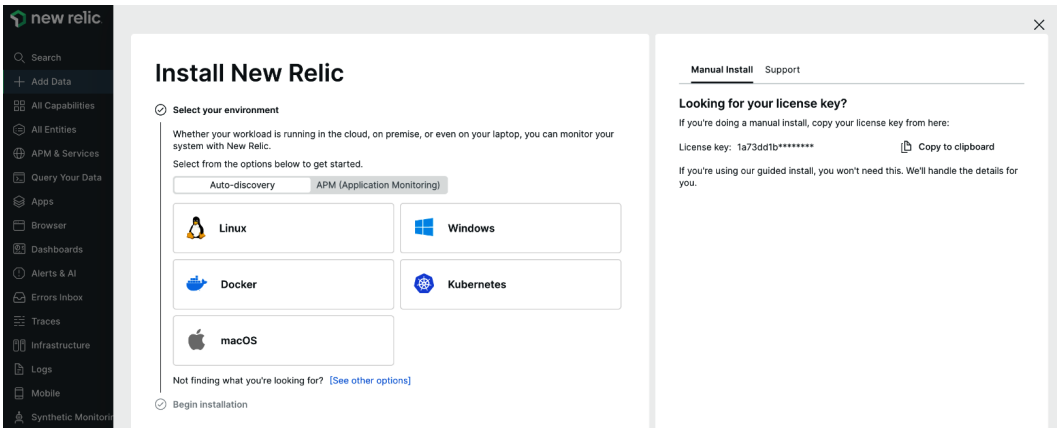


Figure 11.2 – New Relic install configuration

Following this, you can choose to do the configuration and setup manually or just follow the steps that are outlined by New Relic. I will discuss both approaches in the following section.

For the manual method, make sure to copy the license key, as shown in the preceding screenshot.

How to do it...

You can choose either guided or manual configuration.

Guided configuration

The following screenshot lists all the steps that you need to follow to make your application work with New Relic for APM:

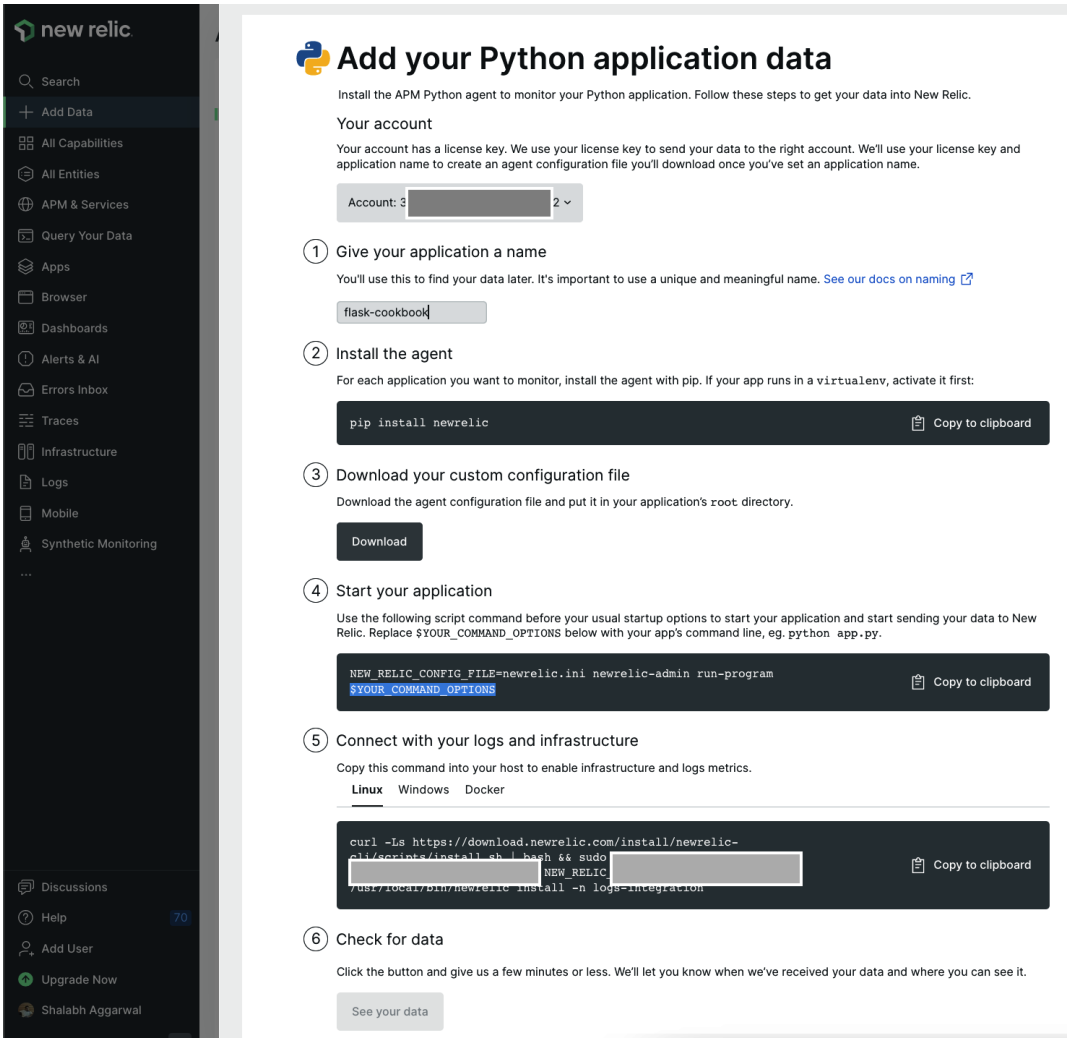


Figure 11.3 – New Relic guided configuration

Manual configuration

Once we have the license key, we need to install the `newrelic` Python library:

```
$ pip install newrelic
```

Now, we need to generate a file called `newrelic.ini`, which will contain details regarding the license key, the name of our application, and so on. This can be done using the following command:

```
$ newrelic-admin generate-config <LICENSE-KEY> newrelic.ini
```

In the preceding command, replace `LICENSE-KEY` with the actual license key of your account. Now, we have a new file called `newrelic.ini`. Open and edit the file in terms of the application name and anything else, as needed.

To check whether the `newrelic.ini` file is working successfully, run the following command:

```
$ newrelic-admin validate-config newrelic.ini
```

This will tell us whether the validation was successful or not. If not, then check the license key and its validity.

Now, add the following lines at the top of the application's configuration file, which is `my_app/__init__.py` in our case. Make sure that you add these lines before anything else is imported:

```
import newrelic.agent
newrelic.agent.initialize('newrelic.ini')
```

How it works...

Now, when you run your application, it will start sending statistics to New Relic, and the dashboard will have a new application added to it. In the following screenshot, there are two applications, where one corresponds to the application that we are working on and the other is the test that we ran a while back to validate whether New Relic is working correctly:

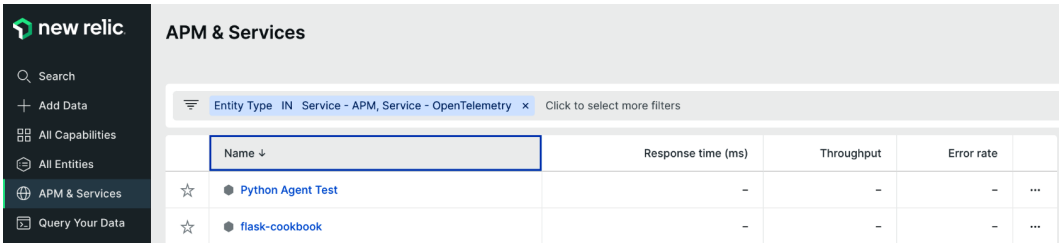


Figure 11.4 – New Relic application list

Open the application-specific page; a whole lot of statistics will appear. It will also show you which calls have taken the most amount of time and how the application is performing. You will also see multiple menu items, where each one will correspond to a different type of monitoring to cover all the necessary aspects.

See also

You can read more about New Relic and its configuration at `https://docs.newrelic.com/`.

Infrastructure and application monitoring with Datadog

Datadog is an observability service that provides detailed analytics for infrastructure, databases, applications, and services. Just like New Relic, Datadog is a full-stack platform that allows all-around monitoring that provides great insights into the health of an application and infrastructure.

Although both Datadog and New Relic are similar in almost all aspects, both of them have some benefits over each other. For example, a popular opinion is that while New Relic is great at **Application Performance Monitoring** (**APM**), Datadog is stronger at infrastructure monitoring.

In short, both these platforms are great for most purposes and you can choose to use any of them or maybe some other tool/platform based on your needs.

Getting ready

Just like in the previous recipe, we will use the catalog application that we have built throughout this book. In essence, the application to be used does not matter here; it should just be a running Flask application.

The first step is to create a new account with Datadog. They have a free tier that would suffice for testing, as in our case. Once you've signed up and logged in, the first step is to enable/install the Python integration in the Datadog console:

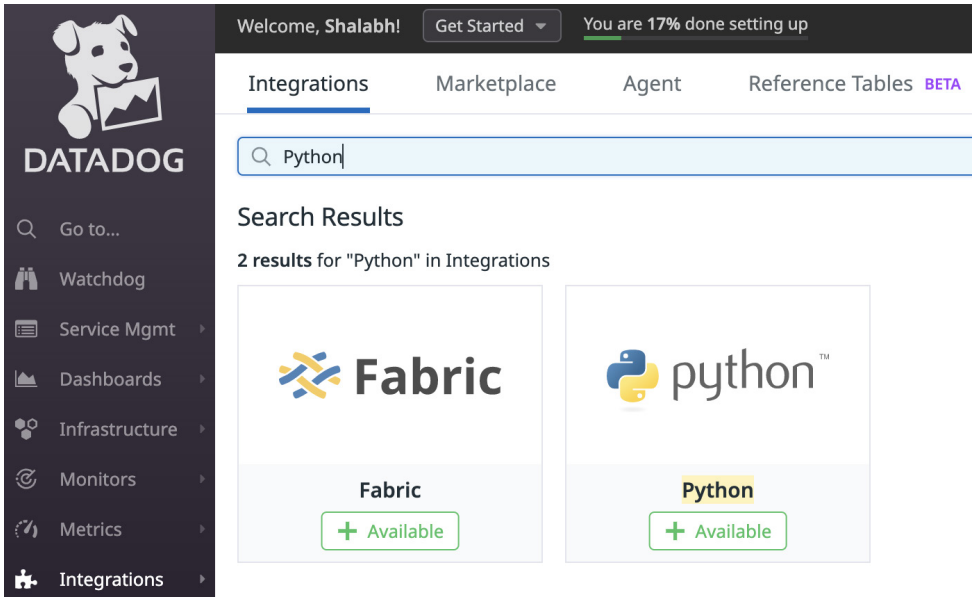


Figure 11.5 – Installing the Python integration

As shown in the preceding screenshot, click on the **Python** tile and install the integration.

As soon as you create an account on Datadog, it creates an API key by default. This API key will be needed in all further steps to make sure that monitoring statistics from your machine/server and application are sent to the correct Datadog account. Navigate to **Your account | Organization Settings | API Keys** to get your API key or just go to `https://app.datadoghq.com/organization-settings/api-keys`:

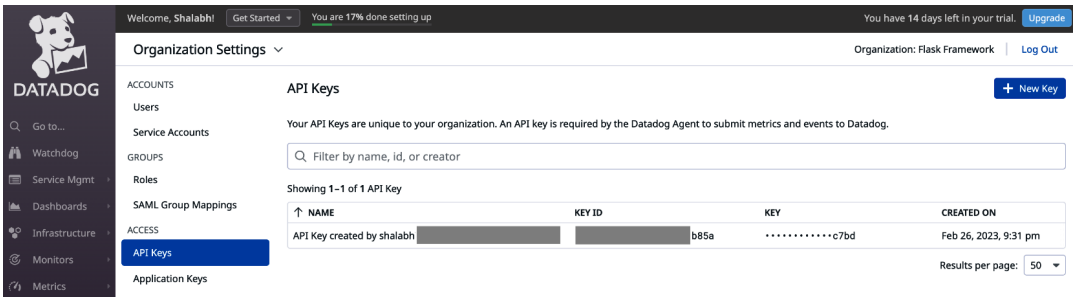


Figure 11.6 – Fetching the API key

How to do it...

Go through the following steps to set up infrastructure and application monitoring with Datadog:

1. Once you get the API key, the next step is to install the Datadog agent on your operating system to allow for infrastructure monitoring. Follow the instructions according to your OS or infrastructure by navigating to **Integrations | Agent**:

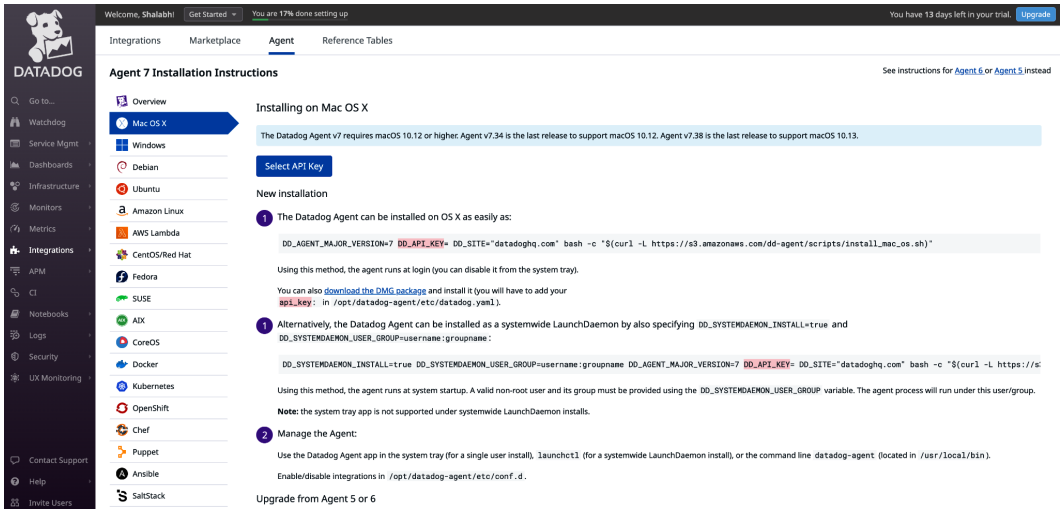


Figure 11.7 – Installing the Datadog agent

As shown in the preceding screenshot, select your OS and follow the instructions accordingly. Your OS might ask for some permissions, which you will need to grant for Datadog to work properly.

2. Once you've installed the agent, navigate to **Infrastructure | Infrastructure List** to validate that your infrastructure is being monitored:

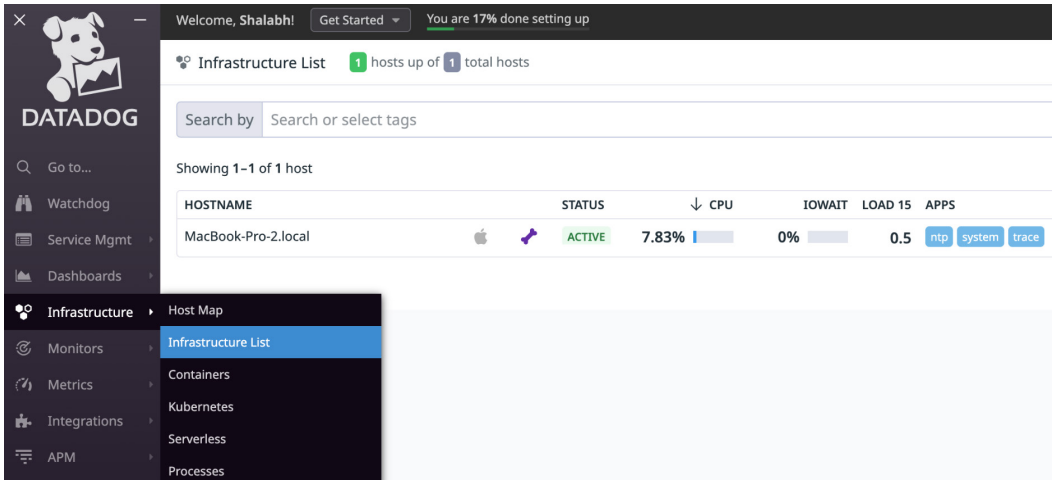


Figure 11.8 – Infrastructure monitoring validation

Feel free to explore other options or drill down into the details here to see more analytics.

3. The next step is to install the `ddtrace` utility, which is Datadog's Python APM client and allows you to profile code, requests, and trace data to flow to Datadog:

```
$ pip install ddtrace
```

Important

If your application is running on port 5000, make sure you change the port to something else – ports 5000 to 5002 are used by Datadog for its agent and other utilities.

4. Following the installation of `ddtrace`, run your Flask application using the following command:

```
$ DD_SERVICE="<your service name>" DD_ENV="<your environment
name>" ddtrace-run python run.py
```

Note the `DD_SERVICE` and `DD_ENV` environment variables. These are important for Datadog to decide how to segregate and group your application logs.

If you get an error, as shown in the following screenshot, just set `DD_REMOTE_CONFIGURATION_ENABLED=false`:

```
Agent is down or Remote Config is not enabled in the Agent
Check your Agent version, you need an Agent running on 7.39.1 version or above.
Check Your Remote Config environment variables on your Agent:
DD_REMOTE_CONFIGURATION_ENABLED=true
DD_REMOTE_CONFIGURATION_KEY=<YOUR-KEY>
```

Figure 11.9 – Handling configuration errors

Hence, in my case, the command looks like this:

```
$ DD_SERVICE="flask-cookbook" DD_ENV="stage" DD_REMOTE_
CONFIGURATION_ENABLED=false ddtrace-run python run.py
```

5. Now, just wait for a few minutes – your application statistics should start reflecting on Datadog:

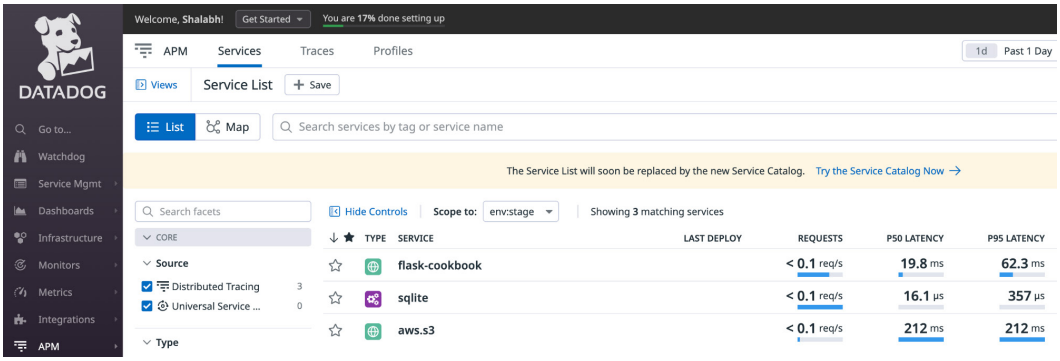


Figure 11.10 – APM in action

Feel free to play around and dig into more details to understand how Datadog works and what kind of statistics it provides.

See also

You can read more about Datadog and `ddtrace` at the following links:

- Flask configuration for `ddtrace`: `https://ddtrace.readthedocs.io/en/stable/integrations.html#flask`
- Datadog documentation: `https://docs.datadoghq.com/`

12
Microservices and Containers

Up until now, we have been developing the complete application as one block of code (usually known as a **monolith**), which is typically designed, tested, and deployed as a single unit. Scaling also occurs in a similar manner, where either the whole application is scaled or not. However, as the application grows in size, it is natural to want to break the monolith into smaller chunks that can be separately managed and scaled. A solution to this is microservices. This chapter is all about microservices, and we will look at a few methodologies for creating and managing them.

Microservices comprise a method of developing and architecting software applications as a collection of multiple loosely coupled services. These services are designed and developed to help build single-function modules that have clear and fine-grained interfaces. The benefit of this modularity, if designed and architected properly, is that the overall application becomes easier to understand, develop, maintain, and test. Multiple small autonomous teams can work in parallel on multiple microservices, so the time to develop and deliver an application is effectively reduced. Each microservice can now be deployed and scaled separately, which allows for less downtime and cost-effective scaling since only the high-traffic services can be scaled based on predefined criteria. Other services can operate as usual.

This chapter will start with some of the common terminologies that you might hear whenever microservices are talked about – that is, containers and Docker. First, we will look at how to deploy a Flask application using Docker containers. Then, we will look at how multiple containers are scaled and managed effectively using Kubernetes, which is one of the best container orchestration tools available. Then, we will look at how to create fully-managed microservices using some cloud platforms such as **AWS Lambda** and **GCP Cloud Run**. Finally, we will look at how to stitch everything together into a seamless deployment pipeline using **GitHub Actions**.

In this chapter, we will cover the following recipes:

- Containerization with Docker
- Orchestrating containers with Kubernetes
- Going serverless with Google Cloud Run
- Continuous deployment with GitHub Actions

Containerization with Docker

A container can be thought of as a standardized package of code that is needed to run the application and all its dependencies, which allows the application to run uniformly across multiple environments and platforms. **Docker** is a tool that allows for a standard and easy method of creating, distributing, deploying, and running applications using containers.

Docker is essentially a virtualization software, but instead of visualizing the whole operating system, it allows the application to use the underlying host OS and requires applications to package additional dependencies and components as needed. This makes Docker container images very lightweight and easy to distribute.

Getting ready

The first step is to install Docker. Docker's installation steps vary in terms of the operating system you use. The detailed steps for each operating system can be found at `https://docs.docker.com/install/`.

> **Tip**
> Docker is a fast-evolving software and has had multiple major releases in the last few years, where a lot of older releases have been deprecated. I would suggest that you always read the documentation thoroughly to avoid installing any legacy versions of Docker.

Once Docker has been successfully installed, head over to the Terminal and run the following command:

```
$ docker ps
CONTAINER ID   IMAGE   COMMAND   CREATED   STATUS   PORTS   NAMES
```

The preceding command is used to list all the running containers. If it runs without any errors and shows a row of headers that start with `CONTAINER ID`, then Docker has been successfully installed.

> **Information**
> Different versions of Docker, whether old or current, have been called Docker Toolbox, Docker Machine, Docker Engine, Docker Desktop, and so on. These names will appear multiple times across the documentation and other resources on the internet. There is a great probability that these might change or evolve in the future as well. For the sake of simplicity, I will just call everything **Docker**.

A more fun way to verify the Docker installation would be to try out a `hello-world` container. Just run the following command:

```
$ docker run hello-world
```

The preceding command should give you the following output. It lists the steps that Docker took to execute this command. I recommend reading through this:

```
Unable to find image 'hello-world:latest' locally
latest: Pulling from library/hello-world
2db29710123e: Pull complete
Digest: sha256:6e8b6f026e0b9c419ea0fd02d3905dd0952ad1feea67543f525c73a0a790fefb
Status: Downloaded newer image for hello-world:latest

Hello from Docker!
This message shows that your installation appears to be working correctly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
    (amd64)
 3. The Docker daemon created a new container from that image which runs the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which sent it
    to your terminal.

To try something more ambitious, you can run an Ubuntu container with:
 $ docker run -it ubuntu bash

Share images, automate workflows, and more with a free Docker ID:
 https://hub.docker.com/

For more examples and ideas, visit:
 https://docs.docker.com/get-started/
```

Figure 12.1 – Testing Docker

How to do it...

We will start with the catalog application from the *Managing and monitoring application performance with New Relic* recipe from *Chapter 11*:

1. The first step toward creating a container is to create an image for it. A Docker image can easily be created in a scripted manner by creating a file named `Dockerfile`. This file contains the steps that Docker needs to perform to build an image for our application's container. A basic `Dockerfile` for our application would be as follows:

```
FROM python:3

WORKDIR /usr/src/app

COPY requirements.txt requirements.txt
RUN pip install -r requirements.txt
```

```
COPY . .

ENTRYPOINT [ "python" ]
CMD [ "run.py" ]
```

Each line in the preceding file is a command that is executed in a linear top-down approach. `FROM` specifies the base container image over which the new image for our application container will be built. I have taken the base image as `python:3`, which is a Linux image with `Python 3.11` installed.

Information

The `python:3` Docker base images come with `Python 3.11` pre-installed at the time of writing this book. This will change over time.

`WORKDIR` indicates the default directory where the application will be installed. I have set it to `/usr/src/app`. Any commands that are run after this will be executed from inside this folder.

`COPY` simply copies the files specified on the local machine to the container filesystem. I have copied `requirements.txt` to `/usr/src/app`.

This is followed by `RUN`, which executes the command provided. Here, we have installed all the requirements from `requirements.txt` using `pip`. Then, I simply copied all the files from my current local folder, which is essentially my application root folder, to `/usr/src/app`.

Finally, an `ENTRYPOINT` is defined that indicates the default `CMD` command, which should be run when a container is started. Here, I have simply run my application by running `python run.py`.

Information

A Dockerfile provides many other keywords, all of which can be used to create powerful scripts. Refer to `https://docs.docker.com/engine/reference/builder/` for more information.

Tip

There are multiple ways of running the application, as outlined in *Chapter 11*, *Deployment and Post-Deployment*. I would urge you to use those methods while dockerizing the application.

2. For the Dockerfile to run, you must have a `requirements.txt` file in your application's root folder. If you don't have one, you can simply generate a `requirements.txt` file using the following command:

```
$ pip freeze > requirements.txt
```

The following is my `requirements.txt` file. I encourage you to generate your own instead of using the one that follows because the Python package versions will evolve and you will want to use the latest and most relevant ones:

```
aiohttp==3.8.4
aiosignal==1.3.1
async-timeout==4.0.2
attrs==22.2.0
Babel==2.11.0
blinker==1.5
boto3==1.26.76
botocore==1.29.76
certifi==2022.12.7
charset-normalizer==3.0.1
click==8.1.3
Flask==2.2.3
flask-babel==3.0.1
Flask-SQLAlchemy==3.0.3
Flask-WTF==1.1.1
frozenlist==1.3.3
geoip2==4.6.0
greenlet==2.0.2
gunicorn==20.1.0
idna==3.4
itsdangerous==2.1.2
Jinja2==3.1.2
jmespath==1.0.1
MarkupSafe==2.1.2
maxminddb==2.2.0
multidict==6.0.4
python-dateutil==2.8.2
pytz==2022.7.1
requests==2.28.2
s3transfer==0.6.0
sentry-sdk==1.15.0
six==1.16.0
SQLAlchemy==2.0.4
tornado==6.2
typing_extensions==4.5.0
urllib3==1.26.14
Werkzeug==2.2.3
WTForms==3.0.1
yarl==1.8.2
newrelic==8.7.0
```

> **Tip**
> If you have `mod_wsgi` in your `requirements.txt` file, you can remove it from the file unless you specifically want to run your application in a Docker container using `Apache`. `mod_wsgi` is an OS-specific package and the OS on your development machine might not match that on the Docker image, which would lead to installation failure.

3. A small change needs to be made to `run.py`, after which it will look as follows:

```
from my_app import app
app.run(debug=True, host='0.0.0.0', port='8000')
```

I have added the `host` parameter to `app.run`. This allows the application to be accessed outside the Docker container.

4. The creation of `Dockerfile` is followed by building a Docker container image, which can then be run like so:

```
$ docker build -t cookbook .
```

Here, we asked Docker to build an image using the Dockerfile at the same location. The `-t` argument sets the name/tag for the image that will be built. The final argument is a dot (`.`), which indicates that everything in the current folder needs to be packaged in the build. This command might take a while to process when it's run for the first time because it will download the base image and then all of our application dependencies.

Let's check the created image:

```
$ docker images
REPOSITORY     TAG      IMAGE ID       CREATED          SIZE
cookbook    latest   bceac988395a   48 seconds ago   1.13GB
```

5. Next, run this image to create a container:

```
$ docker run -d -p 8000:8000 cookbook:latest
```

```
92a7ee37e044cf59196f5ec4472d9ffb540c7f48ee3f4f1e5f978f7f93b301ba
```

Here, we have asked Docker to run the container using the commands that were specified in the `Dockerfile` at the bottom. The `-d` argument asks Docker to run the container in detached mode in the background; otherwise, it will block control to the current shell window. `-p` maps the port from the host machine to the Docker container port. This means that we have asked Docker to map port `8000` on the local machine to port `8000` on the container. `8000` is the port on which we are running our Flask app (see `run.py`). The last argument is the name of the container image, which is a combination of `REPOSITORY` and `TAG`, as indicated by the `docker images` command. Alternatively, you can just provide an `IMAGE ID`.

How it works...

Head over to your browser and open `http://localhost:8000/` to see the application running.

Now, run `docker ps` again to see the details of the running container:

```
$ docker ps
CONTAINER ID   IMAGE              COMMAND            CREATED          STA
TUS          PORTS                    NAMES
92a7ee37e044   cookbook:latest    "python run.py"    7 seconds ago    Up
6 seconds    0.0.0.0:8000->8000/tcp   beautiful_ritchie
```

See also

- You can learn more about Dockerfiles at `https://docs.docker.com/engine/reference/builder/`.
- The definition of a container by Docker can be read at `https://www.docker.com/resources/what-container`.
- You can read about microservices in general at `https://en.wikipedia.org/wiki/Microservices`.
- One of the first articles on microservices by Martin Fowler can be found at `https://martinfowler.com/articles/microservices.html`.

Orchestrating containers with Kubernetes

Docker containers are pretty easy and powerful, as we saw from the previous recipe, but without a strong container orchestration system, managing containers can become pretty intensive. **Kubernetes** (also written as **K8s**) is an open source container orchestration system that automates the management, deployment, and scaling of containerized applications. It was originally developed at Google and, over the years, has become the most popular container orchestration software. It is widely available across all major cloud providers.

Getting ready

In this recipe, we will see how we can leverage Kubernetes to automate the deployment and scaling of our application container, which we created in the previous recipe.

Kubernetes is packaged along with the newer versions of the Docker Desktop installation and works in a pretty straightforward manner. However, we will be using **minikube**, which is a standard distribution that's provided by Kubernetes itself. It's quite popular and good for getting started. For this recipe, I will use Minikube, which will allow a single-node Kubernetes cluster to be run inside a VM on our local machine. You can choose to use other distributions of Kubernetes; refer to `https://kubernetes.io/docs/setup/` for more details.

To install Minikube, follow the instructions outlined at `https://minikube.sigs.k8s.io/docs/start/` for your operating system.

> **Information**
>
> Kubernetes is a huge topic that spans multiple dimensions. There are multiple books dedicated just to Kubernetes, and many more are being written. In this recipe, we will cover a very basic implementation of Kubernetes, just to get you acquainted with it.

How to do it...

Follow these steps to understand how a local Kubernetes cluster can be created and used:

1. After Minikube has been installed, create a Minikube cluster on your local machine:

```
$ minikube start
😄  minikube v1.29.0 on Darwin 13.0
✨  Automatically selected the docker driver. Other choices:
hyperkit, ssh
📌  Using Docker Desktop driver with root privileges
👍  Starting control plane node minikube in cluster minikube
🚜  Pulling base image …

. . . .
Downloading and installing images
. . .

🔎  Verifying Kubernetes components...
🌟  Enabled addons: storage-provisioner, default-storageclass
🏄  Done! kubectl is now configured to use "minikube" cluster
and "default" namespace by default
```

   As you can see, the preceding command downloads a bunch of images to set up and run Minikube, which creates a VM on your local machine. After creating a VM using these images, a simple Kubernetes cluster with only one node will be launched. This process might take a bit of time when it's run for the first time.

   Minikube provides a browser dashboard view as well. This can be initiated by running the following command:

```
$ minikube dashboard
🔌  Enabling dashboard ...
▪ Using image docker.io/kubernetesui/metrics-scraper:v1.0.8
▪ Using image docker.io/kubernetesui/dashboard:v2.7.0

🤔  Verifying dashboard health ...
🚀  Launching proxy ...
```

```
🤔  Verifying proxy health ...
🎉  Opening http://127.0.0.1:57206/api/v1/namespaces/
kubernetes-dashboard/services/http:kubernetes-dashboard:/proxy/
in your default browser...
```

Visit the URL mentioned in the output of the preceding command to view the dashboard.

In Kubernetes, containers are deployed in pods, where a pod can be defined as a group of one or more containers that are tied together for sharing resources and networking. In this recipe, we will have only one container inside a pod.

2. Whenever a deployment is created using Minikube, it will look for the Docker image on some cloud-based registries such as Docker Hub or Google Cloud Registry, or something custom. For this recipe, we intend to make a deployment using a local Docker image. Therefore, we will run the following command, which sets the `docker` environment to `minikube docker`:

```
$ eval $(minikube -p minikube docker-env)
```

3. Now, rebuild the Docker image using the preceding `docker` environment set:

```
$ docker build -t cookbook .
```

For more details on building Docker images, refer to the previous recipe, *Containerization with Docker*.

4. Next, create a file named `cookbook-deployment.yaml` in your application root folder:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  creationTimestamp: null
  labels:
    app: cookbook-recipe
  name: cookbook-recipe
spec:
  replicas: 1
  selector:
    matchLabels:
      app: cookbook-recipe
  strategy: {}
  template:
    metadata:
      creationTimestamp: null
      labels:
        app: cookbook-recipe
    spec:
      containers:
      - image: cookbook:latest
        name: cookbook
```

```
        resources: {}
        imagePullPolicy: Never
status: {}
```

In this file, we created a deployment named `cookbook-recipe`, which uses the `cookbook:latest` image. Take note of `imagePullPolicy`, which is set to `Never` – this signifies that kubectl should not try to fetch the image from online Docker repositories (such as Docker Hub or **Google Container Registry** (**GCR**); instead, it should always search for this image locally.

5. Now, `apply` the preceding file to create a Kubernetes deployment using kubectl:

```
$ kubectl apply -f cookbook-deployment.yaml
deployment.apps/cookbook-recipe created
```

You can verify and get the status of the deployment that's been created by running the following:

```
$ kubectl get deployments
NAME              READY   UP-TO-DATE   AVAILABLE   AGE
cookbook-recipe   1/1     1            1           26s
```

Check the values for the `READY`, `UP-TO-DATE`, and `AVAILABLE` columns. These values represent the number of replicas of our application in the cluster.

6. Our application is now running but is currently not accessible outside the cluster. To expose the application outside the Kubernetes cluster, create a `LoadBalancer` type service:

```
$ kubectl expose deployment cookbook-recipe --type=LoadBalancer
--port=8000
service/cookbook-recipe exposed
```

The deployment that we created in the last step exposed our application on port `8000`, which was internal to the cluster. The preceding command has exposed this internal `8000` port to any random port that can be accessed outside the cluster and hence via a browser.

How it works...

To open the application in a browser, run the following command:

```
$ minikube service cookbook-recipe
```

```
|-----------|-----------------|-------------|---------------------------|
| NAMESPACE |      NAME       | TARGET PORT |            URL            |
|-----------|-----------------|-------------|---------------------------|
| default   | cookbook-recipe |        8000 | http://192.168.49.2:31473 |
|-----------|-----------------|-------------|---------------------------|
🏃  Starting tunnel for service cookbook-recipe.
|-----------|-----------------|-------------|------------------------|
| NAMESPACE |      NAME       | TARGET PORT |          URL           |
|-----------|-----------------|-------------|------------------------|
| default   | cookbook-recipe |             | http://127.0.0.1:58764 |
|-----------|-----------------|-------------|------------------------|
🎉  Opening service default/cookbook-recipe in default browser...
```

Figure 12.2 – Service deployed using Kubernetes

Running the preceding command will open the application in a browser on a random port, such as `58764`.

Scaling a deployment is very easy with Kubernetes. It is as simple as running a single command. By doing this, the application will be replicated in multiple pods:

```
$ kubectl scale --replicas=3 deployment/cookbook-recipe
deployment.apps/cookbook-recipe scaled
```

Now, look at the status of deployment again:

```
$ kubectl get deployments
NAME              READY   UP-TO-DATE   AVAILABLE   AGE
cookbook-recipe   3/3     3            3           90s
```

Check the replica values in the `READY`, `UP-TO-DATE`, and `AVAILABLE` columns, which will have increased from `1` to `3`.

There's more...

You can look at the YAML configurations that Kubernetes automatically creates for the deployment and service:

```
apiVersion: v1
kind: Service
metadata:
  creationTimestamp: "2023-03-06T08:23:24Z"
  labels:
    app: cookbook-recipe
  name: cookbook-recipe
  namespace: default
```

```
    resourceVersion: "5991"
    uid: 1253962c-f3d5-4a1f-b997-c11a4abd2b33
  spec:
    allocateLoadBalancerNodePorts: true
    clusterIP: 10.105.38.134
    clusterIPs:
    - 10.105.38.134
    externalTrafficPolicy: Cluster
    internalTrafficPolicy: Cluster
    ipFamilies:
    - IPv4
    ipFamilyPolicy: SingleStack
    ports:
    - nodePort: 31473
      port: 8000
      protocol: TCP
      targetPort: 8000
    selector:
      app: cookbook-recipe
    sessionAffinity: None
    type: LoadBalancer
  status:
    loadBalancer: {}
```

The preceding code is the config for the service. You can choose to create/save and `apply` this config (instead of specifying configuration values in command lines) just like we did earlier for the deployment in *Step 5*.

> **Information**
>
> What I have shown in this recipe is a very basic implementation of Kubernetes. The purpose of this is to get you acquainted with Kubernetes. This recipe does not intend to be a production-grade implementation. Ideally, the config files need to be created, and then the overall Kubernetes deployment can be built around them. I would urge you to build on the knowledge from this recipe and strive toward production-grade techniques with Kubernetes.

See also

To learn more, check out the following resources:

- Start getting to know about Kubernetes at `https://kubernetes.io/docs/concepts/overview/`

- The basics of Kubernetes are available at `https://kubernetes.io/docs/tutorials/kubernetes-basics/`
- A Minikube tutorial can be followed at `https://kubernetes.io/docs/tutorials/hello-minikube/`
- You can learn about the details of Minikube's installation at `https://minikube.sigs.k8s.io/docs/start/`
- The complete Kubernetes documentation can be found at `https://kubernetes.io/docs/home/`

Going serverless with Google Cloud Run

Serverless computing is a cloud computing model where the cloud provider runs the server and dynamically manages the allocation of machine resources by scaling the resources up or down, depending on the consumption. Pricing is done based on the actual resources that are used. It also simplifies the overall process of deploying code, and it becomes relatively easy to maintain different executions for different environments, such as development, testing, staging, and production. These properties of serverless computing make this model a perfect candidate for developing and deploying tons of microservices without worrying about managing the overhead.

> **Trivia**
>
> Why is this model called "serverless" even though there is a server involved?
>
> Even though there is a server involved that hosts your application and serves the requests coming into your application, the lifespan of the server is as small as a single request. So, you can think of a server as something that lives to serve a single request. Hence, the lifespan of a server is typically in milliseconds.

As Google explains, **Cloud Run** is a managed compute platform that lets you run containers directly on top of Google's scalable infrastructure. Also, since Google Cloud provides loads of other services with which Cloud Run integrates very well, it allows us to build full-featured applications without a lot of moving parts from different cloud vendors.

> **Note**
>
> Throughout this recipe, I will interchangeably use the terms **Google Cloud**, **Google Cloud Platform**, and **GCP**.

> **Tip**
>
> Deploying with serverless tools allows developers to focus more on writing code rather than worrying about the infrastructure.

Getting ready

Before you can deploy with Cloud Run, you need to set up the `gcloud` CLI on your machine from where you would deploy your application to Cloud Run. Go through the following steps:

1. First, create an account on Google Cloud Platform. Head over to `https://console.cloud.google.com/getting-started` and create a new account if you don't already have one. Then, create a project under which you will deploy your application.

   Once you've created your account, make sure you have a billing account activated. Even though you will not be charged for the use case of this recipe, Google mandates you to have a billing account activated and linked to your project.

2. Next, install the `gcloud` CLI. This is highly OS-specific, so look for appropriate instructions here: `https://cloud.google.com/sdk/docs/install`.

   The `gcloud` CLI uses Python versions 3.5 to 3.9 for its installation. If you have a later version of Python such as 3.10 or 3.11, you don't need to worry about it as `gcloud` will download its own Python version and create a virtual environment for itself.

3. Once the `gcloud` installation is done, run the following command to initialize `gcloud` and go over some basic settings:

   ```
   $ gcloud init
   ```

   The execution of this command will ask you for some details, such as which GCP account you would want to use to link to your `gcloud` CLI. On a desktop, it will open a browser and ask you to log into your GCP account. Make sure the user who logs in has enough permissions to deploy to Cloud Run. For this recipe, the `owner` permission should handle everything.

   Then, you will be asked about the GCP project that you want to use.

   You can always change this configuration by running the same command again.

How to do it...

Follow these steps:

1. After setting up and initializing `gcloud`, the next step is to create and upload the container of your application to GCR. You can also use other container registries such as Docker Hub, but that is outside the scope of this recipe.

> **Important**
>
> Cloud Run expects the application to run on port `8080`. So, update your `run.py` to run on `8080` instead of `8000` or `5000` like we have done so far in this book.

Run the following command from the root of your application where your `Dockerfile` is located:

```
$ gcloud builds submit --tag "gcr.io/<Your project
  ID>/<Name of your container image>"
```

The preceding command created a Docker container using `Dockerfile`. Then, it uploaded the Docker container to GCR at the path provided in the command. On successful execution, you will get a response similar to the following:

```
ID: [redacted]81b6a
CREATE_TIME: 2023-03-09T04:43:02+00:00
DURATION: 1M11S
SOURCE: gs://flask-cookbook-240711_cloudbuild/source/16783[redacted]213cc5102da238.tgz
IMAGES: gcr.io/flask-[redacted] (+1 more)
STATUS: SUCCESS
```

Figure 12.3 – GCR image creation

2. Now, use the image you created to deploy your application to Cloud Run. Run the following command for the same:

```
$ gcloud run deploy "your-application-name" –image
  "gcr.io/<Your project ID>/<Name of your container
  image>" --allow-unauthenticated --platform "managed"
```

This command will ask for a region of deployment if one hasn't been set already; then, it will take a few minutes to deploy the application successfully to Cloud Run. Once done, it will provide the Service URL on which the application can be accessed. See the following screenshot:

```
Deploying container to Cloud Run service [flask-cookbook] in project [flask-[redacted]] region [asia-south1]
OK Deploying... Done.
  OK Creating Revision...
  OK Routing traffic...
  OK Setting IAM Policy...
Done.
Service [flask-cookbook] revision [flask-[redacted]-qus] has been deployed and is serving 100 percent of traffic.
Service URL: https://flask-cookbook-[redacted]a.run.app
```

Figure 12.4 – Deployment on Cloud Run

How it works...

To check whether the application deployment is successful and is running as expected, open the Service URL provided, as shown in the previous screenshot. It should open the application home page.

See also

To learn more, check out the following resources:

- You can read more about Cloud Run at `https://cloud.google.com/run/docs/overview/what-is-cloud-run`.
- There are other serverless tools and platforms such as Serverless, Zappa, AWS Beanstalk, AWS Lambda, and others. I urge you to explore them on your own. The underlying concept remains the same.

Continuous deployment with GitHub Actions

Continuous deployment is a deployment strategy that enables the deployment and release of software to its relevant environment (production, in most cases) whenever there is a committed code change. Usually, this is preceded by automated test cases; when those pass, the code is deployed automatically.

GitHub Actions is a continuous deployment platform provided by GitHub that allows you to trigger workflows on certain actions (such as code commit/merge/pull request). These workflows can be used to deploy to your choice of cloud provider. The best thing about GitHub Actions is that it integrates seamlessly with GitHub.

Other tools can be used to perform continuous deployment but I will be focusing on GitHub Actions because it is one of the easiest ones to understand and adopt.

Getting ready

For this recipe, I am assuming that you have a GitHub account and know the basics of managing code and repositories on GitHub.

In this recipe, we will be building upon the application from the previous recipe.

Two steps need to be done to get ready for this recipe:

1. In the previous recipe, the authentication step for Google Cloud was performed during `gcloud init`, where you were asked to log in to GCP. But when deploying from GitHub Actions, you won't have this liberty; hence, you need to create a service account on Google Cloud that has permission to create a container image on GCR and then deploy it to Cloud Run.

   To create a service account, head over to your GCP console and open **IAM & Admin**. Next, create a service account and give it relevant permissions/roles. To test this recipe, **owner** permission should do. Once you have created and configured a service account, it should look like this:

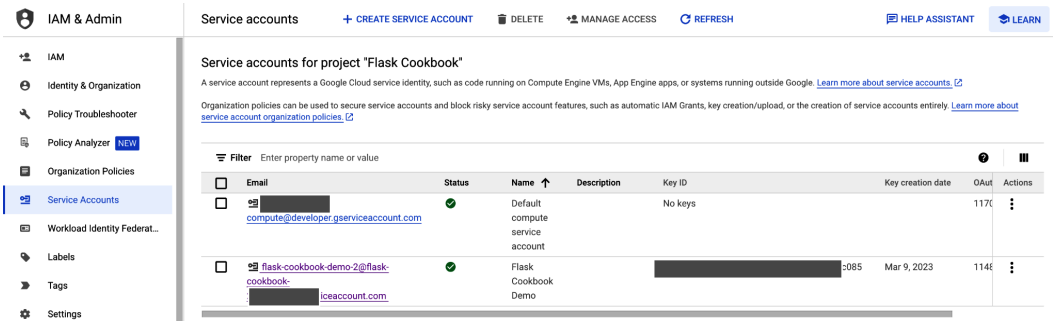


Figure 12.5 – Service account on GCP

Download the service account file in JSON format when given the option. It cannot be downloaded again.

2. Next, configure your GitHub repository so that it stores secrets that will be read when the deployment runs. Head over to your GitHub repository by going to **Settings | Secrets and variables | Actions**. Here, create two repository secrets called `RUN_PROJECT` and `RUN_SA_KEY`.

   `RUN_PROJECT` is the project ID of your GCP project, while `RUN_SA_KEY` is the content of the service account JSON file that you downloaded in the previous step:

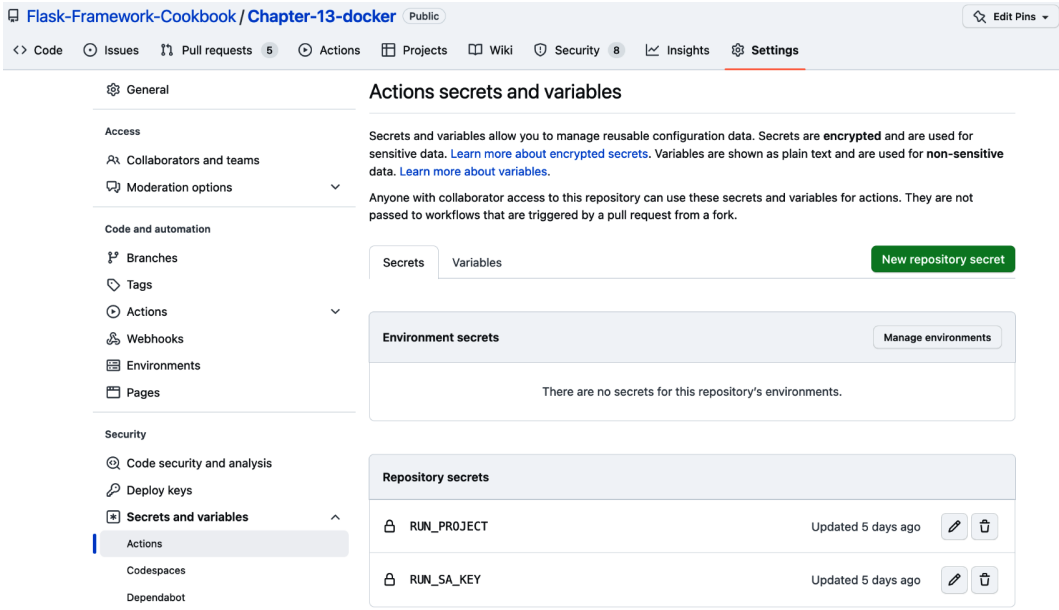


Figure 12.6 – GitHub repository secrets

How to do it...

Now, create a file called `.github/workflows/main.yml` in your application's root folder. Make sure the path for the file is created properly. You will need to create two folders called `.github` and `workflows` inside it, followed by the `main.yml` file in the latter. The following is the content of the file:

```
name: Build and Deploy to Cloud Run

on:
  push:
    branches:
    - vol-3

env:
  PROJECT_ID: ${{ secrets.RUN_PROJECT }}
  RUN_REGION: asia-south1
  SERVICE_NAME: flask-cookbook-git

jobs:
  setup-build-deploy:
    name: Setup, Build, and Deploy
    runs-on: ubuntu-latest

    steps:
    - name: Checkout
      uses: actions/checkout@v3

    # Setup gcloud CLI
    - uses: 'google-github-actions/auth@v1'
      with:
        credentials_json: ${{ secrets.RUN_SA_KEY }}
        project_id: ${{ secrets.RUN_PROJECT }}

    # Build and push image to Google Container Registry
    - name: Build
      run: |-
        gcloud builds submit \
          --quiet \
          --tag "gcr.io/$PROJECT_ID/$SERVICE_NAME"

    # Deploy image to Cloud Run
    - name: Deploy
      run: |-
        gcloud run deploy "$SERVICE_NAME" \
```

```
            --quiet \
            --region "$RUN_REGION" \
            --image "gcr.io/$PROJECT_ID/$SERVICE_NAME" \
            --platform "managed" \
            --allow-unauthenticated
```

In this file, first, we specified the branch on which the GitHub action is triggered on code push. Then, we have some environment variables that will be used in the next steps in the file. A job named `Setup, Build, and Deploy` is then created that specifies the operating system, which is Ubuntu in our case. The job consists of four steps:

1. **Checkout**: Checks out code from the GitHub branch that was specified earlier.
2. **Set up the gcloud CLI**: Sets up `gcloud` and authenticates using the service account credentials file.
3. **Build**: Builds the Docker image and pushes it to GCR using `gcloud submit`.
4. **Deploy the image to Cloud Run**: Deploys the Docker image created in the preceding step to Cloud Run.

Now, just commit and push your code to the relevant branch.

How it works...

When the code is pushed to GitHub on the correct branch, the GitHub action is triggered. A successful GitHub action looks like this:

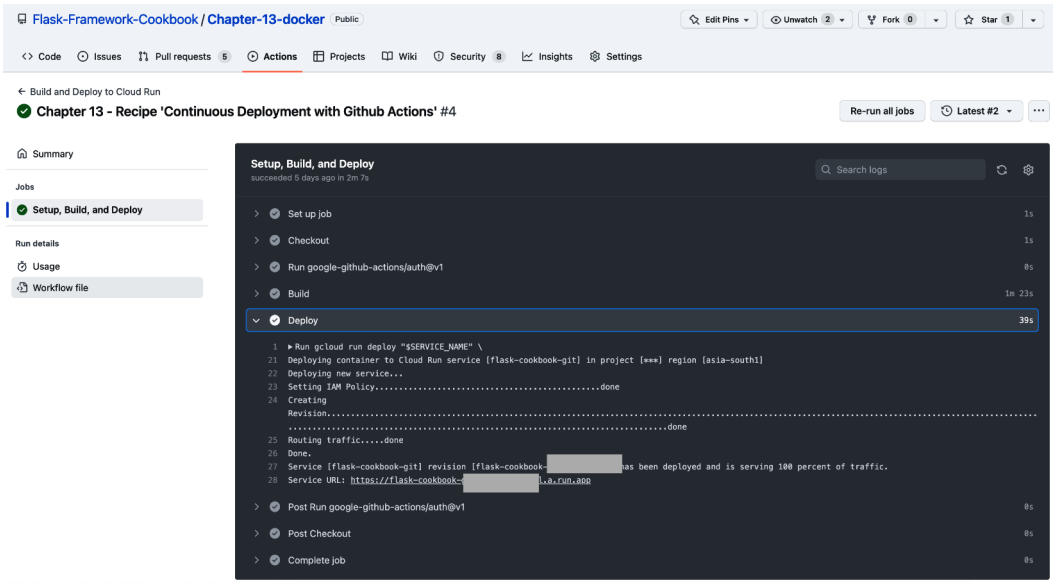


Figure 12.7 – Successful GitHub action execution

To see your application running, copy the service URL, as shown in the preceding screenshot, and open it in your browser.

> **Tip**
>
> If you have followed this book since the beginning, this recipe would be a good place to think about how all the major pieces fall into place to complete the puzzle. We learned about creating a Flask application, then built more complexity into it, which was followed by unit test cases and, last but not least, deployment.
>
> In this recipe, we automated deployment on code commits known as **continuous deployment**.
>
> You can also modify your GitHub workflow to run test cases before building the image and exit on failure. This is called **continuous integration**.

See also

You can read more about GitHub Actions at `https://docs.github.com/en/actions/deployment/about-deployments/deploying-with-github-actions`.

13
GPT with Flask

GPT, the latest buzzword of today (which stands for **Generative Pre-trained Transformer**), is a state-of-the-art language model developed by **OpenAI**. It is based on the Transformer architecture and uses unsupervised learning to generate natural language text. GPT was first introduced in 2018 with the release of GPT-1, followed by GPT-2 and GPT-3 in 2019 and 2020, respectively.

One of the most well-known applications of GPT is text completion, where it can generate coherent and grammatically correct sentences based on a given prompt. This has led to its use in various writing assistance tools, such as autocomplete and auto-correction features in text editors and messaging apps.

Another popular application of GPT is in the development of chatbots, such as ChatGPT. With its ability to generate natural language responses, GPT can create chatbots that simulate human conversation, making them useful for customer service and other applications.

GPT has also been used for image generation, where it generates images based on textual descriptions. This has opened up new possibilities for creative applications such as art and design.

Information

In this chapter, we will touch upon some new terminology that is mostly specific to GPT. One of the most important of these new terms would be **prompt**.

In simple terms, a prompt in GPT is a starting point or a partial sentence that is given to the model. It's like giving a suggestion or a hint to the model so that it can generate the rest of the sentence or paragraph based on that hint.

For example, if you want to generate a review for a restaurant, you could start with a prompt such as "The food was..." and let GPT generate the rest of the sentence. The generated text could be something like "The food was delicious, with a perfect balance of spices and flavors. The portions were generous, and the presentation was beautiful."

By providing a prompt, you are giving GPT some context to work with and guiding it toward generating text that fits that context. This can be useful in various natural language processing tasks, such as text completion, summarization, and more.

GPT is a powerful language model that has been applied to various natural language processing tasks, such as text completion, chatbots, and image generation. Its ability to generate human-like text has made it a valuable tool for developers, especially in the Python community who are interested in natural language processing and related web applications, such as those developed using Flask.

In this chapter, we will look at how to implement GPT for the use cases we have mentioned. There can be innumerable other applications of GPT as it is open to imagination and creativity, but in this chapter, I will limit it to some basic yet powerful examples applicable to web applications.

In this chapter, we will cover the following recipes:

- Automating text completion using GPT
- Implementing chat using GPT (ChatGPT)
- Generating images using GPT

Technical requirements

For all the recipes in this chapter, the following steps are common and mandatory:

- We will use a library called `openai`, which is the official Python library provided by OpenAI for working with GPT:

```
$ pip install openai
```

- We will also need an API key from the OpenAI website, which is necessary to make any API call for using GPT. For this, simply create an account at `platform.openai.com` and then navigate to **Settings** to create your API key. The following is a screenshot demonstrating the same:

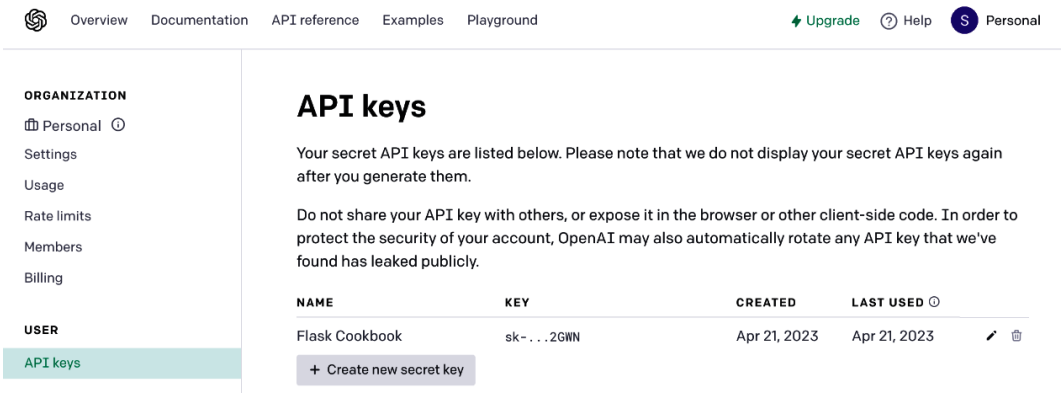


Figure 13.1 – API keys on OpenAI for using GPT

Tip

Be mindful that GPT by OpenAI is a paid tool and, as of writing this book, there is a small grant of 5 USD given with each account for a period of 3 months to experiment and get acquainted with the APIs. Once the limit is exhausted, you would have to opt for a paid plan. Read more about pricing at `https://openai.com/pricing`.

Automating text completion using GPT

Text completion using GPT involves providing a prompt or starting sentence to the model, which then generates a coherent and relevant continuation. GPT's capabilities in this area are impressive, as it can generate complex and contextually relevant text with a high degree of accuracy. This makes it an ideal tool for web applications that involve writing, such as content creation, auto-correction, and messaging. By incorporating GPT's text completion abilities into these applications, developers can enhance the user experience by automating tedious or time-consuming tasks, improving the quality of written content, and providing more natural and responsive communication.

If we talk in the context of an e-commerce website, one of the most important features is effective search. In addition to effectiveness, if the search is made interactive and intuitive, then it becomes highly engaging for the users. In this recipe, we will implement text completion using GPT to build intuitive and user-friendly search queries on an e-commerce website.

Getting ready

Refer to the *Technical requirements* section at the beginning of this chapter for details on setting up GPT.

To demonstrate the complete context of this recipe, I will be using a JavaScript library called **Awesomplete** for autocomplete functionality on a demo search field. Head over to `https://projects.verou.me/awesomplete/` to download the static files and learn more about this library.

To demonstrate this recipe, we will start with the code base that was developed in *Chapter 4*.

How to do it...

Follow these steps to perform the setup of autocomplete functionality and then use GPT for text completion:

1. Start by adding the static files from **Awesomplete** to your `my_app/templates/base.html`:

```
<!-- Group with other CSS files -->
<link href="https://cdnjs.cloudflare.com/
ajax/libs/awesomplete/1.1.5/awesomplete.min.css"
rel="stylesheet">

<!-- Group with other JS files -->
```

```
<script src="https://cdnjs.cloudflare.com/
ajax/libs/awesomplete/1.1.5/awesomplete.min.js">
</script>
```

I have used the link to the static files directly from CDN. You can alternatively choose to download these files to your static files folder and refer from there.

2. Next, add the API key provided by OpenAI to your application configuration in `my_app/__init__.py`:

```
app.config['OPENAI_KEY'] = 'Your own API Key'
```

3. Next, create a new method to handle the user search term and convert it to GPT-generated search queries in `my_app/catalog/views.py`:

```
import openai

@catalog.route('/product-search-
  gpt',methods=['GET','POST'])
def product_search_gpt():
 if request.method == 'POST':
  query = request.form.get('query')

  openai.api_key = app.config['OPENAI_KEY']

  prompt = """Context: Ecommerce electronics website\n
  Operation: Create search queries for a product\n
            Product: """ + query

        response = openai.Completion.create(
            model="text-davinci-003",
            prompt=prompt,
            temperature=0.2,
            max_tokens=60,
            top_p=1.0,
            frequency_penalty=0.5,
            presence_penalty=0.0
        )

        return response['choices'][0][
            'text'].strip('\n').split('\n')[1:]
return render_template('product-search-gpt-demo.html')
```

In the preceding code, first, `openai` is imported. Then a new endpoint is created under the `catalog` blueprint with the relative path, `/product-search-gpt`. This endpoint serves both `GET` and `POST` requests.

On a `GET` request, it will simply render the `product-search-gpt-demo.html` template, which we have created to demonstrate this recipe.

On a `POST` request, it expects a form field with the name `query`, which is then used to make an API request to the `openai.Completion` module with a relevant prompt. Look carefully at the prompt where I have specified the `Context` followed by the `Operation` that needs to be performed. There is no defined format in which you can provide the prompt; it just needs to be something that GPT can understand and work upon. The response returned by GPT needs a bit of formatting before it can be sent to the JS library for interpretation.

Information

Notice the multiple parameters that have been provided in the API request that we made to the `openai.Completion` module. You can read more about all of them at `https://platform.openai.com/docs/api-reference/completions/create`.

4. Finally, the template that we referenced in the last step needs to be created. Create a new template file at `my_app/templates/product-search-gpt-demo.html`:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <form
        class="form-horizontal"
        role="form">
      <div class="form-group">
        <label for="name" class="col-sm-2 control-
          label">Query</label>
        <div class="col-sm-10">
          <input type="text" class="form-control
            awesomplete" id="query" name="query">
        </div>
      </div>
    </form>
  </div>
{% endblock %}
```

```
{% block scripts %}
<script>
$(document).ready(function(){

  const input = document.querySelector(
    'input[name="query"]' );

  const awesomplete = new Awesomplete( input, {
    tabSelect: true, minChars: 5 } );

function ajaxResults() {
  $.ajax({
   url: '{{ url_for("catalog.product_search_gpt") }}',
        type: 'POST',
        dataType: "json",
        data: {
            query: input.value
        }
    })
    .done(function(data) {
        awesomplete.list = data;
    });
  };

  input.addEventListener( 'keyup', ajaxResults );
});
</script>
{% endblock %}
```

In the preceding code, I have created a simple HTML form with just one field. It is intended to demonstrate the search field on an e-commerce store. Here, you can enter any product of choice and the value entered will be sent to GPT to create search queries that will help users make more targeted searches.

How it works...

Open `http://127.0.0.1:5000/product-search-gpt` in your browser. In the query field, enter the product value of choice and see how GPT provides more helpful search queries. This is demonstrated in the following screenshot.

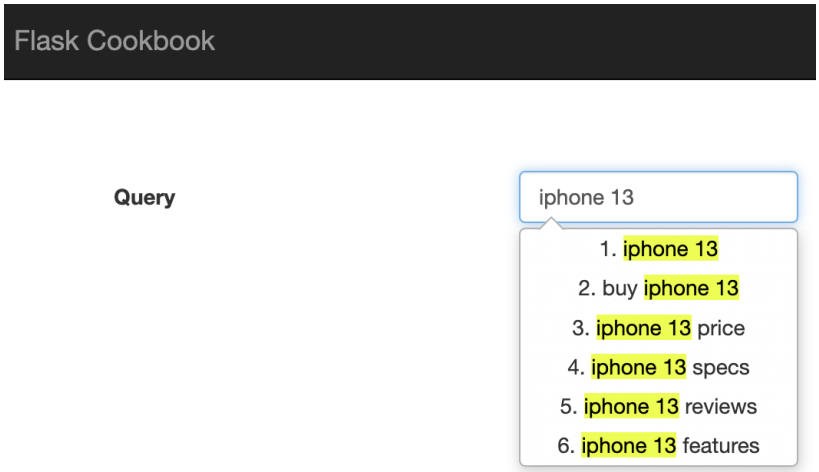


Figure 13.2 – Text completion using GPT

See also

- Read about the usage and capabilities of text completion using GPT at `https://platform.openai.com/docs/guides/completion/introduction`
- Check out the detailed API reference specific to text completion at `https://platform.openai.com/docs/api-reference/completions/create`

Implementing chat using GPT (ChatGPT)

Arguably, chat using GPT, or more popularly, **ChatGPT**, is the most widely used application of GPT. Chat using GPT involves using the model to generate natural language responses to user input in a conversational setting. GPT's capabilities in this area are impressive, as it can generate coherent and contextually relevant responses that simulate human conversation. This makes it an ideal tool for web applications that involve chatbots, virtual assistants, or other conversational interfaces.

With GPT's ability to generate human-like responses, chatbots developed using this technology can provide a more personalized and engaging experience for users. By understanding the context of the conversation and providing relevant responses, these chatbots can be used for a wide range of applications, such as customer service, scheduling appointments, and more.

If we talk in the context of an e-commerce website or any web application, one of the common features in recent times is chatbots. All businesses want to remain connected to their users but, at the same time, might not want to hire many customer support executives. In such a scenario, ChatGPT becomes very helpful. I will demonstrate this with some basic examples in this recipe.

Getting ready

Refer to the *Technical requirements* section at the beginning of this chapter for details on setting up GPT.

We will build this recipe on top of the previous recipe, *Text completion using GPT*. Refer to the same for the `openai` configuration settings.

How to do it...

Go through the following steps to implement a basic chatbot on your Flask-powered web application using ChatGPT:

1. First, create a handler to receive user chat messages and respond to them using ChatGPT. This should be done in `my_app/catalog/views.py` as follows:

```
@catalog.route('/chat-gpt', methods=['GET', 'POST'])
def chat_gpt():
  if request.method == 'POST':
      msg = request.form.get('msg')

      openai.api_key = app.config['OPENAI_KEY']

      messages = [
          {
              "role": "system",
              "content": "You are a helpful chat
                assistant for a generic electronics
                Ecommerce website"
          },
          {"role": "user", "content": msg}
        ]

        response = openai.ChatCompletion.create(
            model="gpt-3.5-turbo",
            messages=messages
        )

        return jsonify(
            message=response[
                'choices'][0]['message']['content']
        )

    return render_template('chatgpt-demo.html')
```

In the preceding code, a new endpoint is created under the `catalog` blueprint with the relative path, `/chat-gpt`. This endpoint serves both `GET` and `POST` requests.

On a `GET` request, it will simply render the `chatgpt-demo.html` template, which we have created to demonstrate this recipe.

On a `POST` request, it expects a form field with the name `msg`, which should refer to the message entered by the user while talking to the chatbot. The message is then used to make an API request to the `openai.ChatCompletion` module with a relevant set of messages.

If you look carefully at the `messages` provided in the `ChatCompletion` API, you will notice that the first message has a `system` role. It essentially prepares the context for ChatGPT in which it will address the messages from the actual user that will be in the `msg` variable.

2. Next, the template that we referenced in the last step needs to be created. Create a new template file at `my_app/templates/chatgpt-demo.html`:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <ul class="list-group" id="chat-list">
      <li class="list-group-item">
        <span class="badge">GPT</span>
        How can I help you?
      </li>
    </ul>
    <div class="input-group">
      <input type="text" class="form-control"
        name="message" placeholder="Enter your
        message" aria-describedby="chat-input">
      <span class="input-group-btn">
        <button class="btn btn-success" type="button"
          data-loading-text="Loading..." id="send-
          message">Send</button>
      </span>
    </div>
  </div>
{% endblock %}

{% block scripts %}
<script>

function appendToChatList(mode, message) {
  $( "#chat-list" ).append( '<li class="list-
    group-item"><span class="badge">' + mode +
```

```
    '</span>' + message + '</li>' );
}
$(document).ready(function(){
  $('button#send-message').click(function() {
    var send_btn = $(this).button('loading');
    const inputChat = document.querySelector
      ( 'input[name="message"]' );
    var message = inputChat.value;

    appendToChatList('Human', message);

    inputChat.value = '';

    $.ajax({
      url: '{{ url_for("catalog.chat_gpt") }}',
      type: 'POST',
      dataType: "json",
      data: {
          msg: message
      }
    })
    .done(function(data) {
      appendToChatList('GPT', data.message);
      send_btn.button('reset');
    });

  });
});
</script>
{% endblock %}
```

In the preceding code file, I have created a very simple chatbot using a JS list. Here, a simple `textfield` takes the user input and sends it to the API endpoint that we created in the first step for GPT to respond.

How it works...

Open `http://127.0.0.1:5000/chat-gpt` in your browser. In the message field, enter the message that you want to send to the chatbot and it will respond with a relevant response in the context of an e-commerce website. See the following screenshot for a demonstration:

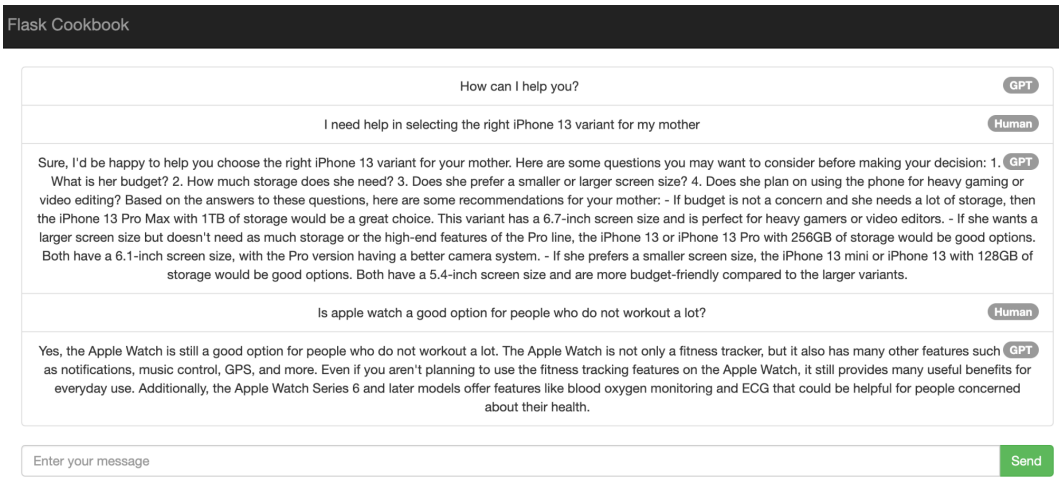


Figure 13.3 – Chat assistant/bot using GPT

See also

- Read about the usage and capabilities of ChatGPT at `https://platform.openai.com/docs/guides/chat`
- Check out the detailed API reference specific to ChatGPT at `https://platform.openai.com/docs/api-reference/chat`

Generating images using GPT

Image generation using GPT involves using the model to generate images based on textual descriptions. GPT's capabilities in this area have shown promising results, although image generation is not its primary function. By providing a textual description, GPT can generate images that attempt to match the given description.

While the quality of the generated images may not be as high as specialized image generation models, GPT's ability to produce visual representations opens up new possibilities for creative applications in web development. Possible applications include generating placeholder images, creating visual representations based on user input, or even assisting in the design process by providing visual suggestions based on textual descriptions. However, it's important to note that for advanced image generation tasks, dedicated image generation models such as GANs or VAEs are typically preferred.

In this recipe, we will generate an image using GPT for a product listing on an e-commerce store. With a clear enough prompt, GPT should generate a custom image suited to our needs.

Getting ready

Refer to the *Technical requirements* section at the beginning of this chapter for details on setting up GPT.

To demonstrate this recipe, we will start with the code base that was developed in *Chapter 5*.

Refer to the first recipe in this chapter, *Text completion using GPT*, for the `openai` configuration settings.

We will also be using the `requests` library to download the image. It can simply be installed via `pip`:

```
$ pip install requests
```

How to do it...

Go through the following steps to generate an image while creating the product automatically and using the same on the product view page:

1. The first change is a very trivial one. In this recipe, we are creating a product without uploading the product image as the image will be generated using GPT. Hence, the requirement for an `image` field in the product creation form becomes obsolete. Accordingly, a new form should be created as follows in `my_app/catalog/models.py`:

```
class ProductGPTForm(NameForm):
    price = DecimalField('Price', validators=[
        InputRequired(),
          NumberRange(min=Decimal('0.0'))
  ])
  category = CategoryField(
  'Category', validators=[InputRequired()], coerce=int
    )
```

   In the preceding code, a new form named `ProductGPTForm` is created with just the `price` and `category` fields. The `name` field will be provided by `NameForm`, which the newly created form inherits from.

2. Next, a new product creation handler and endpoint need to be created that will use GPT to generate images in the `my_app/catalog/views.py` file:

```
import openai
import requests
from my_app.catalog.models import ProductGPTForm

@catalog.route('/product-create-
  gpt',methods=['GET','POST'])
def create_product_gpt():
    form = ProductGPTForm()
```

```
    if form.validate_on_submit():
        name = form.name.data
        price = form.price.data
        category = Category.query.get_or_404(
            form.category.data
        )

        openai.api_key = app.config['OPENAI_KEY']

        prompt = "Generate an image for a " + name + \
            " on a white background for a classy
              e-commerce store listing"

        response = openai.Image.create(
            prompt=prompt,
            n=1,
            size="512x512"
        )

        image_url = response['data'][0]['url']
        filename = secure_filename(name + '.png')
        response = requests.get(image_url)
        open(os.path.join(
            app.config['UPLOAD_FOLDER'], filename
            ), "wb").write(response.content)

        product = Product(name, price, category,
          filename)
        db.session.add(product)
        db.session.commit()
        flash('The product %s has been created' %
          name, 'success')
        return redirect(url_for('catalog.product',
          id=product.id))

    if form.errors:
        flash(form.errors, 'danger')

    return render_template('product-create-gpt.html',
      form=form)
```

In the preceding code snippet, on a `GET` request, the `product-create-gpt.html` template is rendered, which is a newly created template.

In the case of a `POST` request, once the form is validated, the relevant data for the `name`, `price`, and `category` fields is captured. Then, a request is made to GPT using the `create` method of the `openai.Image` module to generate an image using the given `prompt`. Notice the other parameters provided to the `create()` method – that is, `n` and `size`, which refer to the number of images to be generated and the size in pixels, respectively. The `image_url` is captured from the response of `create()` and then the image is downloaded using `requests.get()`. The downloaded image content is then saved to `UPLOAD_FOLDER`, which is configured during the initialization of the application. Then, the rest of the product creation continues, as discussed throughout *Chapter 5*.

3. Finally, the template that we referenced in the last step needs to be created. Create a new template file at `my_app/templates/product-create-gpt.html`:

```
{% extends 'home.html' %}

{% block container %}
  <div class="top-pad">
    <form method="POST"
        action="{{
          url_for('catalog.create_product_gpt') }}"
        role="form"
        enctype="multipart/form-data">
      {{ form.csrf_token }}
      <div class="form-group">{{ form.name.label }}:
        {{ form.name() }}</div>
      <div class="form-group">{{ form.price.label }}:
        {{ form.price() }}</div>
      <div class="form-group">{{ form.category.label
        }}: {{ form.category() }}</div>
      <button type="submit" class="btn btn-
        default">Submit</button>
    </form>
  </div>
{% endblock %}
```

The preceding code snippet is a simple HTML form that takes the product name, price, and category as input before making a `POST` request for product creation.

How it works...

First, run your application and create some categories using this URL: `http://127.0.0.1:5000/category-create`. Then, head over to `http://127.0.0.1:5000/product-create-gpt` to create a new product using the GPT image generation logic that was described earlier in this recipe. The screen should look like the following screenshot:

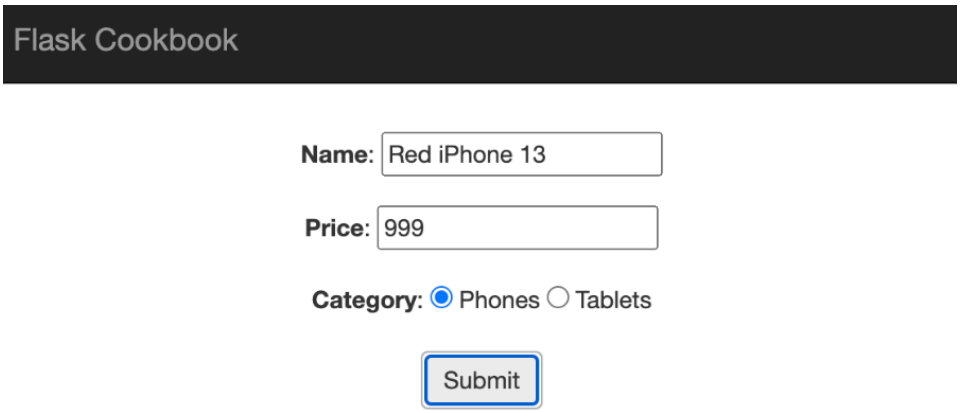


Figure 13.4 – Product creation form without image field

Once you have filled in the details, submit the form and see the image getting generated automatically using GPT in accordance with the product name provided. Check the following screenshot:

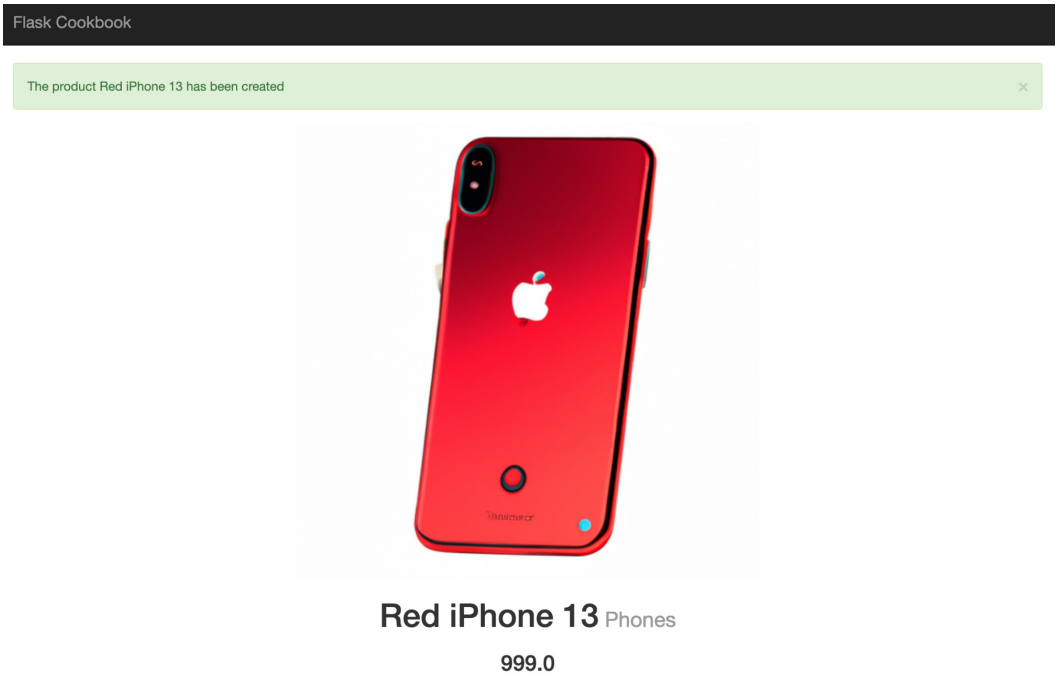


Figure 13.5 – The newly created product with an image generated using GPT

Important

The preceding example is just a demonstration of how to use GPT for image generation. The images generated might not be exactly accurate or use exact product logos because of image copyright issues. You can choose to be more creative in your approach while defining the prompt as per your use cases.

See also

- Read about the usage and capabilities of image generation using GPT at `https://platform.openai.com/docs/guides/images/introduction`
- Check out the detailed API reference specific to GPT image generation at `https://platform.openai.com/docs/api-reference/images`
- Refer to *Chapter 5* to get more details and context about product creation APIs and forms

14
Additional Tips and Tricks

This book has covered almost all the areas that need to be known for the creation of a web application using Flask. Much has been covered, and a lot more needs to be explored. In this final chapter, we will go through some additional recipes that can be used to add value to a Flask-based web application if and when needed.

We will learn how to implement full-text search using Elasticsearch. Full-text search becomes important for a web application that offers a lot of content and options, such as an e-commerce site. Next, we will catch up on signals that help decouple applications by sending notifications (signals) when an action is performed somewhere in the application. This signal is caught by a subscriber/receiver that can perform an action accordingly. This is followed by implementing caching for our Flask application.

We will also see how email support is added to our application and how emails can be sent directly from the application by performing different actions. We will then see how we can make our application asynchronous. By default, WSGI applications are synchronous and blocking – that is, by default, they do not serve multiple simultaneous requests together. We will see how to deal with this via a small example. We will also integrate Celery with our application and see how a task queue can be used to our application's benefit.

In this chapter, we will cover the following recipes:

- Implementing full-text search with Elasticsearch
- Working with signals
- Using caching with your application
- Implementing email support
- Understanding asynchronous operations
- Working with Celery

Implementing full-text search with Elasticsearch

Full-text search is an essential part of almost all use cases that are catered to via web applications. It becomes much more crucial if you intend to build an e-commerce platform or something similar where search plays a central role. Full-text search means an ability to search some text inside a large amount of textual data where the search results can contain full or partial matches as per configuration.

Elasticsearch is a search server based on Lucene, which is an open source information-retrieval library. Elasticsearch provides a distributed full-text search engine with a RESTful web interface and schema-free JSON documents. In this recipe, we will implement full-text search using Elasticsearch for our Flask application.

Getting ready

We will use a Python library called `elasticsearch`, which makes dealing with Elasticsearch a lot easier:

```
$ pip install elasticsearch
```

We also need to install the Elasticsearch server itself. This can be downloaded from `https://www.elastic.co/downloads/elasticsearch`. Unpack the package at any location of your choice on your machine and run the following command:

```
$ bin/elasticsearch
```

This will start the Elasticsearch server on `http://localhost:9200/` by default. There are a couple of details that you need to make note of before moving ahead:

- When you run the `elasticsearch` server using the preceding command, you will see some details as shown in the following screenshot:

```
✅ Elasticsearch security features have been automatically configured!
✅ Authentication is enabled and cluster connections are encrypted.

🔑 Password for the elastic user (reset with `bin/elasticsearch-reset-password -u elastic`):
  8oJ7C3U8ipo0PE+-n1Ff

🔏 HTTP CA certificate SHA-256 fingerprint:
  1f50e662c11e8bf370b00ca5c26091271b9218fb52fa2f500c7a4101acfb33f8

🎟️  Configure Kibana to use this cluster:
• Run Kibana and click the configuration link in the terminal when Kibana starts.
• Copy the following enrollment token and paste it into Kibana in your browser (valid for the next 30 minutes):
  eyJ2ZXIiOiI4LjYuMiIsImFkciI6WyIxOTIuMTY4LjEuNjo5MjAwIl0sImZnciI6IjFmNTBlNjYyYzExZThiZjM3MGIwMGNhNWMyNjA5MTI3MWI5MjE4ZmI1

🎟️  Configure other nodes to join this cluster:
• On this node:
  - Create an enrollment token with `bin/elasticsearch-create-enrollment-token -s node`.
  - Uncomment the transport.host setting at the end of config/elasticsearch.yml.
  - Restart Elasticsearch.
• On other nodes:
  - Start Elasticsearch with `bin/elasticsearch --enrollment-token <token>`, using the enrollment token that you generated.
```

Figure 14.1 – Elasticsearch security details

Make note of the password for the elastic user here. You can also choose to reset the password using the command specified in the preceding screenshot.

- When you run the `elasticsearch` server, it generates an HTTP CA certificate, which needs to be used while establishing a connection via our Flask application. You can find this certificate file in the `config/certs` folder of your `elasticsearch` server folder. In most cases, it should be `<path to your elasticsearch folder>/config/certs/http_ca.crt`.

How to do it...

Follow these steps to perform the integration between Elasticsearch and our Flask application:

1. Start by adding the `elasticsearch` object to the application's configuration – that is, `my_app/__init__.py`:

```
from elasticsearch import Elasticsearch

es = Elasticsearch(
    'https://192.168.1.6:9200/',
    ca_certs='Users/apple/workspace/elasticsearch-
      8.6.2/config/certs/http_ca.crt',
    verify_certs=False,
    basic_auth=("elastic", '8oJ7C3U8ipo0PE+-n1Ff')
)
es.indices.create(index='catalog', ignore=400)
```

Tip

You will notice that several configuration settings are used in the preceding code. I have used them directly while instantiating an `es` object to make it easier for you to understand. In actual applications, these should come from configuration settings or configuration files.

Here, we have created an `es` object from the `Elasticsearch` class, which accepts the server URL, HTTP CA certificate, and basic authentication using the username and password. The HTTP CA certificate and password were sourced in the steps outlined in the *Getting ready* section of this recipe. `verify_certs=False` is required because my application is running on HTTP, while Elasticsearch runs on HTTPS. If your app also runs on HTTPS, then this flag would not be needed. `ignore=400` will ignore any errors related to `resource_already_exists_exception` that are raised, as this index has been created already.

2. Next, we need to add a document to our Elasticsearch index. This can be done in views or models; however, in my opinion, the best way will be to add it in the model layer because it is more closely related to data rather than how it is displayed. We will do this in the `my_app/catalog/models.py` file:

```
from my_app import es

class Product(db.Model):

    def add_index_to_es(self):
        es.index(index='catalog', document={
            'name': self.name,
            'category': self.category.name
        }, id=self.id)
        es.indices.refresh(index='catalog')

class Category(db.Model):

    def add_index_to_es(self):
        es.index('catalog', document={
            'name': self.name,
        }, id=self.id)
        es.indices.refresh(index='catalog')
```

Here, in each of the models, we added a new method called `add_index_to_es()`, which will add the document that corresponds to the current `Product` or `Category` object to the `catalog` index. You might want to index different types of data in separate indexes to make the search more accurate. Finally, we refreshed our index so that the newly created index is available for searching.

The `add_index_to_es()` method can be called when we create, update, or delete a product or category.

3. Next, for demonstration, just add the statement to index a document (product) to the `elasticsearch` index while creating the product in `my_app/catalog/views.py`:

```
from my_app import es

@catalog.route('/product-create', methods=['GET',
  'POST'])
def create_product():
#... normal product creation logic … #
        db.session.commit()
        product.add_index_to_es()
#... normal post product creation logic … #

@catalog.route('/product-search-es')
```

```
@catalog.route('/product-search-es/<int:page>')
def product_search_es(page=1):
    q = request.args.get('q')
    products = es.search(index="catalog", query={
        "query_string": {
            "query": '*' + q + '*'
        }
    })
    return products['hits']
```

In the preceding code, we have also added a `product_search_es()` method to allow for searching on the Elasticsearch index we just created. Do the same in the `create_category()` method as well.

Tip

The search query we sent to Elasticsearch in the preceding code is pretty basic and open-ended. I would urge you to read about Elasticsearch query building and apply it to your program. Refer to the following: `https://www.elastic.co/guide/en/elasticsearch/reference/current/query-dsl.html`.

How it works...

Now, let's say we created a few categories and products in each of the categories. If we open `http://127.0.0.1:5000/product-search-es?q=phone`, we will get a response similar to the following:

```
{
  "hits": [
    {
      "_id": "5",
      "_index": "catalog",
      "_score": 1.0,
      "_source": {
        "category": "Phones",
        "name": "iPhone 14"
      }
    },
    {
      "_id": "6",
      "_index": "catalog",
      "_score": 1.0,
      "_source": {
        "category": "Phones",
        "name": "Motorola razr"
```

```
        }
      }
    ],
    "max_score": 1.0,
    "total": {
      "relation": "eq",
      "value": 2
    }
  }
```

I encourage you to try and enhance the formatting and display of the output.

See also

- You can learn more about connecting to the elasticsearch server at `https://www.elastic.co/guide/en/elasticsearch/client/python-api/current/connecting.html`
- More about the Python Elasticsearch client can be read at `https://elasticsearch-py.readthedocs.io/en/v8.6.2/index.html`

Working with signals

Signals can be thought of as events that happen in our application. These events can be subscribed by certain receivers who then invoke a function whenever the event occurs. The occurrence of events is broadcasted by senders who can specify the arguments that can be used by the function, which will be triggered by the receiver.

> **Important**
> You should refrain from modifying any application data in the signals because signals aren't executed in a specified order and can easily lead to data corruption.

Getting ready

We will use a Python library called `blinker`, which provides the signals feature. Flask has built-in support for `blinker` and uses signaling itself to a good extent. There are certain core signals provided by Flask.

In this recipe, we will use the application from the *Implementing full-text search with Elasticsearch* recipe and add the `product` and `category` documents to make indexes work via signals.

How to do it...

Follow these steps to implement and understand how signaling works:

1. First, create signals for the `product` and `category` creation. This can be done in `my_app/catalog/models.py`. However, you can use any file you want since signals are created on a global scope:

```
from blinker import Namespace

catalog_signals = Namespace()
product_created = catalog_signals.signal('product-
  created')
category_created = catalog_signals.signal('category-
  created')
```

   We have used `Namespace` to create signals, which will create them in a custom namespace rather than in the global namespace, thereby helping with the clean management of signals. We created two signals, `product-created` and `category-created`, where the intent of both is clear by their names.

2. Then, we will create subscribers to these signals and attach functions to them. For this, the `add_index_to_es()` methods have to be removed (if you are building over the code from the previous recipe), and new functions on the global scope have to be created in `my_app/catalog/models.py`:

```
def add_product_index_to_es(sender, product):
    es.index(index='catalog', document={
        'name': product.name,
        'category': product.category.name
    }, id=product.id)
    es.indices.refresh(index='catalog')

product_created.connect(add_product_index_to_es, app)

def add_category_index_to_es(sender, category):
    es.index(index='catalog', document={
        'name': category.name,
    }, id=category.id)
    es.indices.refresh('catalog')

category_created.connect(add_category_index_to_es,
  app)
```

In the preceding code snippet, we created subscribers for the signals we created in *step 1* using `.connect()`. This method accepts the function that should be called when the event occurs; it also accepts the sender as an optional argument. The `app` object is provided as the sender because we don't want our function to be called every time the event is triggered anywhere in any application. This specifically holds true in the case of extensions, which can be used by multiple applications. The function that gets called by the receiver (in this case, `add_product_index_to_es` and `add_category_index_to_es`) gets the sender as the first argument, which defaults to `None` if the sender is not provided. We provided the product/category as the second argument for which the record needs to be added to the `elasticsearch` index.

3. Now, emit the signal that can be caught by the receiver. This needs to be done in `my_app/catalog/views.py`. For this, just remove the calls to the `add_index_to_es()` methods and replace them with the `.send()` methods:

```
From my_app.catalog.models import product_created,
  category_created

@catalog.route('/product-create', methods=['GET',
  'POST'])
def create_product():
    #... normal product creation logic … #
        db.session.commit()
        product_created.send(app, product=product)
    #... normal post product creation logic … #
```

Do the same in the `create_category()` method as well.

How it works...

Whenever a product is created, the `product_created` signal is emitted, with the `app` object as the sender and the `product` as the keyword argument. This is then caught in `models.py` and the `add_product_index_to_es()` function is called, which adds the document to the catalog index.

The functionality of this recipe is exactly the same as the last recipe, *Implementing full-text search with Elasticsearch*.

See also

- Read the *Implementing full-text search with Elasticsearch* recipe for a background on this recipe
- You can read about the `blinker` library at `https://pypi.python.org/pypi/blinker`
- You can view the list of core signals that are supported by Flask at `https://flask.palletsprojects.com/en/2.2.x/api/#core-signals-list`

- You can view the signals that are provided by Flask-SQLAlchemy for tracking modifications to models at `https://flask-sqlalchemy.palletsprojects.com/en/3.0.x/api/#module-flask_sqlalchemy.track_modifications`

Using caching with your application

Caching becomes an important and integral part of any web application when scaling or increasing the response time of your application becomes a question. Caching is the first thing that is implemented in these cases. Flask, by itself, does not provide any caching support by default, but **Werkzeug** does. Werkzeug has some basic support to cache with multiple backends, such as Memcached and Redis. This caching support of Werkzeug is implemented by a package called **Flask-Caching**, which we will use in this recipe.

Getting ready

We will install a Flask extension called `flask-caching`, which simplifies the process of caching a lot:

```
$ pip install flask-caching
```

We will use our catalog application for this purpose and implement caching for some methods.

How to do it...

Implementing basic caching is pretty easy. Go through the following steps to do so:

1. First, initialize `Cache` to work with our application. This is done in the application's configuration – that is, `my_app/__init__.py`:

   ```
   from flask_caching import Cache

   cache = Cache(app, config={'CACHE_TYPE': 'simple'})
   ```

   Here, we used `simple` as the `Cache` type, where the cache is stored in the memory. This is not advised for production environments. For production, we should use something such as Redis, Memcached, filesystem cache, and so on. Flask-Caching supports all of them with a couple more backends.

2. Next, add caching to the methods that need to be cached. Just add a `@cache.cached(timeout=<time in seconds>)` decorator to the view methods. A simple target can be the list of categories (we will do this in `my_app/catalog/views.py`):

   ```
   @catalog.route('/categories')
   @cache.cached(timeout=120)
   def categories():
   ```

```
    categories = Category.query.all()
    return render_template('categories.html',
      categories=categories)
```

This way of caching stores the value of the output of this method in the cache in the form of a key-value pair, with the key as the request path.

How it works...

After adding the preceding code, to check whether the cache works as expected, fetch the list of categories by pointing the browser to `http://127.0.0.1:5000/categories`. This will save a key-value pair for this URL in the cache. Now, create a new category quickly and navigate to the same category list page. You will notice that the newly added category is not listed. Wait for a couple of minutes and then reload the page. The newly added category will be shown now. This is because the first time the category list was cached, it expired after 2 minutes (120 seconds).

This might seem to be a fault with the application but, in the case of large applications, this becomes a boon where the hits to the database are reduced, and the overall application experience improves. Caching is usually implemented for those handlers whose results don't get updated frequently.

There's more...

Many of us might think that such caching will fail in the case of a single category or product page, where each record has a separate page. The solution to this is **memoization**. It is similar to caching, with the difference being that it stores the result of a method in the cache, along with the information on the parameters that were passed. So, when a method is created with the same parameters multiple times, the result is loaded from the cache rather than making a database hit. Implementing memoization is quite simple:

```
@catalog.route('/product/<id>')
@cache.memoize(120)
def product(id):
    product = Product.query.get_or_404(id)
    return render_template('product.html', product=product)
```

Now, if we open a URL (say, `http://127.0.0.1:5000/product/1`) in our browser for the first time, it will be loaded after making calls to the database. However, if we make the same call again, the page will be loaded from the cache. On the other hand, if we open another product (say, `http://127.0.0.1:5000/product/2`), then it will be loaded after fetching the product details from the database when accessed for the first time.

See also

- Flask-Caching at `https://flask-caching.readthedocs.io/en/latest/`
- Memoization at `http://en.wikipedia.org/wiki/Memoization`

Implementing email support

The ability to send emails is usually one of the most basic functions of any web application. It is usually easy to implement with any application. With Python-based applications, it is quite simple to implement with the help of `smtplib`. In the case of Flask, this is further simplified by an extension called `Flask-Mail`.

Getting ready

`Flask-Mail` can be easily installed via `pip`:

```
$ pip install Flask-Mail
```

Let's look at a simple case where an email will be sent to a catalog manager in the application whenever a new category is added.

How to do it...

First, instantiate the `Mail` object in our application's configuration – that is, `my_app/__init__.py`:

```
from flask_mail import Mail

app.config['MAIL_SERVER'] = 'smtp.gmail.com'
app.config['MAIL_PORT'] = 587
app.config['MAIL_USE_TLS'] = True
app.config['MAIL_USERNAME'] = 'gmail_username'
app.config['MAIL_PASSWORD'] = 'gmail_password'
app.config['MAIL_DEFAULT_SENDER'] = ('Sender name', 'sender
  email')
mail = Mail(app)
```

We also need to do some configuration to set up the email server and sender account. The preceding code is a sample configuration for Gmail accounts (without two-factor authentication enabled). Any SMTP server can be set up like this. There are several other options provided; they can be found in the `Flask-Mail` documentation at `https://pythonhosted.org/Flask-Mail`.

To send an email on category creation, we need to make the following changes in `my_app/catalog/views.py`:

```
from my_app import mail
from flask_mail import Message

@catalog.route('/category-create', methods=['POST',])
def create_category():
    # ... Create a category ... #
    message = Message(
        "New category added",
        recipients=['shalabh7777@gmail.com']
    )
    message.body = 'New category "%s" has been created'
      % category.name
    message.html = render_template(
        "category-create-email-html.html",
        category=category
    )
    mail.send(message)
    # ... Rest of the process ... #
```

Here, a new email will be sent to the list of recipients from the default sender configuration that we did. You will notice that the category creation takes one or two seconds to execute. That is the time taken to send the email.

How it works...

Create a new category by simply making a post request to `http://127.0.0.1:5000/category-create`. You can do it using the `requests` library from the `Python` prompt:

```
>>> requests.post('http://127.0.0.1:5000/category-create',
data={'name': 'Headphone'})
```

You should receive an email on the recipient email ID(s) provided.

There's more...

Now, let's assume that we need to send a large email with a lot of HTML content. Writing all of this in our Python file will make the overall code ugly and unmanageable. A simple solution to this is to create templates and render their content while sending emails. Here, I created two templates: one for the HTML content and one simply for text content.

The `category-create-email-text.html` template will look like this:

```
A new category has been added to the catalog.

The name of the category is {{ category.name }}.
Click on the URL below to access the same:
{{ url_for('catalog.category', id=category.id, _external =
  True) }}

This is an automated email. Do not reply to it.
```

The `category-create-email-html.html` template will look like this:

```
<p>A new category has been added to the catalog.</p>

<p>The name of the category is <a href="{{
  url_for('catalog.category', id=category.id, _external =
  True) }}">
      <h2>{{ category.name }}</h2>
    </a>.
</p>

<p>This is an automated email. Do not reply to it.</p>
```

After this, we need to modify the email message creation procedure that we created earlier:

```
    message.body = render_template(
        "category-create-email-text.html",
        category=category
    )
    message.html = render_template(
        "category-create-email-html.html",
        category=category
    )
```

See also

The next recipe, *Understanding asynchronous operations*, will show us how we can delegate the time-consuming email-sending process to an asynchronous thread and speed up our application experience.

Understanding asynchronous operations

Some of the operations in a web application can be time-consuming and make the overall application feel slow for the user, even though it's not actually slow. This hampers the user experience significantly. To deal with this, the simplest way to implement the asynchronous execution of operations is with the help of threads. In this recipe, we will implement this using the `threading` libraries of Python. In Python 3, the `thread` package has been deprecated. Although it is still available as `_thread`, it is highly recommended to use `threading`.

Getting ready

We will use the application from the *Implementing email support for Flask applications* recipe. Many of us will have noticed that, while the email is being sent, the application waits for the whole process to finish, which is unnecessary. Email sending can be easily done in the background, and our application can become available to the user instantaneously.

How to do it...

Doing an asynchronous execution with the `threading` package is very simple. Just add the following code to `my_app/catalog/views.py`:

```
from threading import Thread

def send_mail(message):
    with app.app_context():
        mail.send(message)

# Replace the line below in create_category()
# mail.send(message)
# by
t = Thread(target=send_mail, args=(message,))
t.start()
```

As you can see, the sending of an email happens in a new thread, which sends the message as a parameter to the newly created method. We need to create a new `send_mail()` method because our email templates contain `url_for`, which can only be executed inside an application context; this won't be available in the newly created thread by default. It provides the flexibility of starting the thread whenever it's needed instead of creating and starting the thread at the same time.

How it works...

It is pretty simple to observe how this works. Compare the performance of sending an email in this recipe with that of the application in the previous recipe, *Implementing email support for Flask applications*. You will notice that the application is more responsive. Another way can be to monitor the debug logs, where the newly created category page will load before the email is sent.

See also

- Since I have mentioned multithreading and asynchronous operations, many of you must be thinking about Python's built-in `asyncio` library and its potential here. Although it is possible to write Flask methods using `async..await` and they would work in a non-blocking fashion, there are no obvious performance gains as WSGI would still need to run in a single worker to handle a request. See `https://flask.palletsprojects.com/en/2.2.x/async-await/` for more details.
- You can look at **Quart** (`https://pgjones.gitlab.io/quart/`), which is an `asyncio` implementation of Flask or **Fast API** (`https://fastapi.tiangolo.com/`), which is a different framework built using `asyncio` with a very similar syntax to Flask.

Working with Celery

Celery is a task queue for Python. There used to be an extension to integrate Flask and Celery but, with Celery 3.0, it became obsolete. Now, Celery can be directly used with Flask by just using a bit of configuration. In the *Understanding asynchronous operations* recipe, we implemented asynchronous processing to send an email. In this recipe, we will implement the same using Celery.

Getting ready

Celery can be installed simply from PyPI:

```
$ pip install celery
```

To make Celery work with Flask, we will need to modify our Flask app config file a bit. In order to do its job, Celery needs a broker to receive and deliver tasks. Here, we will use Redis as the broker (thanks to its simplicity).

> **Information**
>
> Make sure that you run the Redis server for the connection to happen. To install and run a Redis server, refer to `https://redis.io/docs/getting-started/`.
>
> You would also need to install the Redis client in your virtual environment:
>
> `$ pip install Redis`

We will use the application from the previous recipe and implement Celery in the same manner.

How to do it...

Follow these steps to understand Celery's integration with the Flask application:

1. First, we need to do a bit of configuration in the application's configuration – that is, `my_app/__init__.py`:

```
from celery import Celery

app.config['SERVER_NAME'] = '127.0.0.1:5000'
app.config.update(
    CELERY_BROKER_URL='redis://127.0.0.1:6379',
    CELERY_RESULT_BACKEND='redis://127.0.0.1:6379'
)

def make_celery(app):
    celery = Celery(
        app.import_name,
          broker=app.config['CELERY_BROKER_URL']
    )
    celery.conf.update(app.config)
    TaskBase = celery.Task
    class ContextTask(TaskBase):
        abstract = True
        def __call__(self, *args, **kwargs):
            with app.app_context():
                return TaskBase.__call__(self, *args,
                  **kwargs)
    celery.Task = ContextTask
    return celery

celery = make_celery(app)
```

   The preceding snippet comes directly from the Flask website and can be used as is in your application in most cases. Here, we are essentially configuring a task in Celery to have the application context.

2. To run the Celery process, execute the following command:

```
$ celery --app=my_app.celery worker -l INFO
```

   Here, `-app` points to the `celery` object that is created in the configuration file, and `-l` is the log level that we want to observe.

Important
Make sure that Redis is also running on the broker URL, as specified in the configuration.

3. Now, use this `celery` object in the `my_app/catalog/views.py` file to send emails asynchronously:

```
from my_app import db, app, es, cache, mail, celery

@celery.task()
def send_mail(category_id, category_name):
    with app.app_context():
        category = Category(category_name)
        category.id = category_id
        message = Message(
            "New category added",
            recipients=['some-receiver@domain.com']
        )
        message.body = render_template(
            "category-create-email-text.html",
            category=category
        )
        message.html = render_template(
            "category-create-email-html.html",
            category=category
        )
        mail.send(message)

# Add this line wherever the email needs to be sent
  send_mail.apply_async(args=[category.id,
  category.name])
```

We add the `@celery.task` decorator to any method that we wish to use as a Celery task. The Celery process will detect these methods automatically.

How it works...

Now, when we create a category and an email is sent, we can see a task being run on the Celery process logs, which will look like this:

```
[2023-03-22 15:24:21,838: INFO/MainProcess] Task my_app.catalog.views.
send_mail[1e869100-5bee-4d99-a4cc-6a3dca92e120] received
[2023-03-22 15:24:25,927: INFO/ForkPoolWorker-8] Task my_app.catalog.
views.send_mail[1e869100-5bee-4d99-a4cc-6a3dca92e120] succeeded in
4.086294061969966s: None
```

See also

- Read the *Understanding asynchronous operations* recipe to see how threads can be used for various purposes – in our case, to send emails
- You can read more about Celery at `http://docs.celeryproject.org/en/latest/index.html`

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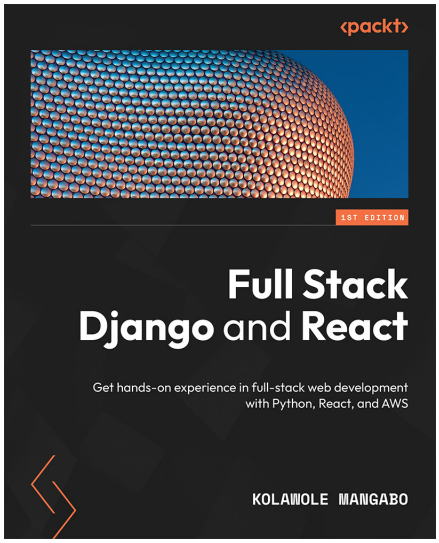

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