EXPERT INSIGHT

Django 5 By Example

Build powerful and reliable Python web applications from scratch

Foreword by:
Paolo Melchiorre
Django contributor

Fifth Edition

Antonio Melé

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Fifth Editon

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To my mother, Lola.

Foreword

“Django is a high-level Python web framework that encourages rapid development and clean, pragmatic design.”

This is the description of Django that you find on its website and in its Git repository, and I think it defines it in a concise but complete way.

In the almost 20 years since the first Django release, there have been many new web frameworks that have arisen and grown rapidly, based on Python and other languages, occupying their specific niches and exploiting new technologies.

Despite everything, Django has continued its growth. It has improved its functionality, ensured its stability, and innovated in an iterative but inexorable way, version after version, all the way up to its latest release.

I started using Django from version 1.3, after having used Zope and Plone, and I was immediately impressed by how much it helped me build real-world applications in a fast yet effective way. Over the years, the characteristics of the web applications I have created have changed, but Django has always remained a valid tool for responding to technical challenges.

Over the years, I have tried writing down my experiences of the Django features that I appreciate most, trying to demonstrate them with examples. When I discovered this book, I immediately saw myself in Antonio’s approach, which supplements your discovery of Django with concrete applications that you create along the way.

In addition to the many commonly used Django features, I appreciate how this book presents useful packages, such as Django REST framework and the Django Debug Toolbar, and that there are also examples of using more advanced features, such as full-text search with PostgreSQL (which I’m very fond of) and cache integration with Redis.

Furthermore, in this new edition, you will find many of the new features introduced in Django 5.0, such as database-computed default values, admin facets, and simplified templates for form field rendering.

The projects from the old edition have also been revisited with Python 3.12, updated third-party packages, and updated setup instructions. I found nice additions like explanatory diagrams and advanced DRF functionality.

When I was young, I started learning HTML, trying to edit web pages I visited with a text editor, and I have remained fond of a hands-on approach to learning technologies. I like getting my hands dirty before studying a technology and I like doing it by trying to create something concrete. I recommend this approach to you, too.

This book will take you on a similar journey, in which you will alternate between the study of Django functionalities and their use in concrete examples. Get ready to get your hands dirty!

– *Paolo Melchiorre*

Python developer / Django contributor

www.paulox.net

Contributors

About the author

Antonio Melé serves as Engineering Director at Backbase, a fintech leader in digital transformation for financial institutions. He joined Backbase in 2023, following its acquisition of Nucoro, a digital wealth management platform that he co-founded.

Antonio has been developing Django projects since 2006 for clients across several industries. In 2009 Antonio founded Zenx IT, a development company specialized in building digital products. He has been working as a CTO and technology consultant for multiple technology-based startups and he has managed development teams building projects for large digital businesses. Antonio holds an MSc in Computer Science from Universidad Pontificia Comillas and completed the Advanced Management Program at MIT Sloan. His father inspired his passion for computers and coding.

I couldn't have done this without an incredible group of Python enthusiasts and experts who took the time to dive into the early versions of this book. A huge thanks to everyone who reviewed the book and read the beta drafts. Your insights, corrections, and enthusiasm really brought this project to life.

About the reviewer

Mark Walker has previously developed e-learning software in the government and defense sectors. Beginning Django development with a niche offline application, he moved on to develop projects for the world's biggest running events. He then branched out into DevOps, load testing, and securing applications for penetration testing. In recent years, he has become the technical lead for the Django CMS Association and a Django Software Foundation member. He has also worked for fantasy sports games, shifting from AWS to GCP. Over the years Mark has become a maintainer for several packages and a navigator of the Djangonaut space program, which aims to mentor developers who want to become contributors in the Django ecosystem.

About the beta readers

The following list comprises readers from our beta program who kindly guided the development of this edition through their feedback. We would like to thank the following individuals for their valuable assistance reviewing this edition:

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`https://packt.link/Django5ByExample`

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Preface

Django is an open-source Python web framework that encourages rapid development and clean, pragmatic design. It takes care of much of the hassle of web development and presents a relatively shallow learning curve for beginner programmers. Django follows Python's "batteries included" philosophy, shipping with a rich and versatile set of modules that solve common web-development problems. The simplicity of Django, together with its powerful features, makes it attractive to both novice and expert programmers. Django has been designed for simplicity, flexibility, reliability, and scalability.

Nowadays, Django is used by countless start-ups and large organizations such as Instagram, Spotify, Pinterest, Udemy, Robinhood, and Coursera. It is not by coincidence that, over the last few years, Django has consistently been chosen by developers worldwide as one of the most loved web frameworks in Stack Overflow's annual developer survey.

This book will guide you through the entire process of developing professional web applications with Django. The book focuses on explaining how the Django web framework works by building multiple projects from the ground up. This book not only covers the most relevant aspects of the framework but also explains how to apply Django to very diverse real-world situations.

This book not only teaches Django but also presents other popular technologies, such as PostgreSQL, Redis, Celery, RabbitMQ, and Memcached. You will learn how to integrate these technologies into your Django projects throughout the book to create advanced functionalities and build complex web applications.

Django 5 By Example will walk you through the creation of real-world applications, solving common-problems, and implementing best practices, using a step-by-step approach that is easy to follow.

After reading this book, you will have a good understanding of how Django works and how to build full-fledged Python web applications.

Who this book is for

This book should serve as a primer for programmers newly initiated to Django. The book is intended for developers with Python knowledge who wish to learn Django in a pragmatic manner. Perhaps you are completely new to Django, or you already know a little but you want to get the most out of it. This book will help you to master the most relevant areas of the framework by building practical projects from scratch. You need to have familiarity with programming concepts in order to read this book. In addition to basic Python knowledge, some previous knowledge of HTML and JavaScript is assumed.

What this book covers

This book encompasses a range of topics of web application development with Django. The book will guide you through building four different fully-featured web applications, that are built over the course of 17 chapters.

- A blog application (chapters 1 to 3)
- An image bookmarking website (chapters 4 to 7)
- An online shop (chapters 8 to 11)
- An e-learning platform (chapters 12 to 17)

Each chapter covers several Django features.

Chapter 1, Building a Blog Application, will introduce you to the framework through a blog application. You will create the basic blog models, views, templates, and URLs to display blog posts. You will learn how to build QuerySets with the Django **object-relational mapper** (**ORM**), and you will configure the Django administration site.

Chapter 2, Enhancing Your Blog with Advanced Features, will teach you how to add pagination to your blog, and how to implement Django class-based views. You will learn to send emails with Django, and handle forms and model forms. You will also implement a comment system for blog posts.

Chapter 3, Extending Your Blog Application, explores how to integrate third-party applications. This chapter will guide you through the process of creating a tagging system, and you will learn how to build complex QuerySets to recommed similar posts. The chapter will teach you how to create custom template tags and filters. You will also learn how to use the sitemap framework and create an RSS feed for your posts. You will complete your blog application by building a search engine using PostgreSQL's full-text search capabilities.

Chapter 4, Building a Social Website, explains how to build a social website. You will learn how to implement user authentication views and learn to use the Django authentication framework. You will implement user registration and extend the user model with a custom profile model.

Chapter 5, Implementing Social Authentication, covers implementing social authentication and using the messages framework. You will create a custom authentication backend and you will integrate social authentication with Google, using OAuth 2. You will learn how to use `django-extensions` to run the development server through HTTPS and customize the social authentication pipeline to automate the user profile creation.

Chapter 6, Sharing Content on Your Website, will teach you how to transform your social application into an image bookmarking website. You will define many-to-many relationships for models, and you will create a JavaScript bookmarklet that integrates into your project. The chapter will show you how to generate image thumbnails. You will also learn how to implement asynchronous HTTP requests using JavaScript and Django and you will implement infinite scroll pagination.

Chapter 7, Tracking User Actions, will show you how to build a follower system for users. You will complete your image bookmarking website by creating a user activity stream application. You will learn how to create generic relations between models and optimize QuerySets.

You will work with signals and implement denormalization. You will use Django Debug Toolbar to obtain relevant debug information. Finally, you will integrate Redis into your project to count image views and you will create a ranking of the most viewed images with Redis.

Chapter 8, Building an Online Shop, explores how to create an online shop. You will build models for a product catalog, and you will create a shopping cart using Django sessions. You will build a context processor for the shopping cart and will learn how to manage customer orders. The chapter will teach you how to send asynchronous notifications using Celery and RabbitMQ. You will also learn to monitor Celery using Flower.

Chapter 9, Managing Payments and Orders, explains how to integrate a payment gateway into your shop. You will integrate Stripe Checkout and receive asynchronous payment notifications in your application. You will implement custom views in the administration site and you will also customize the administration site to export orders to CSV files. You will also learn how to generate PDF invoices dynamically.

Chapter 10, Extending Your Shop, will teach you how to create a coupon system to apply discounts to the shopping cart. You will update the Stripe Checkout integration to implement coupon discounts and you will apply coupons to orders. You will use Redis to store products that are usually bought together, and use this information to build a product recommendation engine.

Chapter 11, Adding Internationalization to Your Shop, will show you how to add internationalization to your project. You will learn how to generate and manage translation files and translate strings in Python code and Django templates. You will use Rosetta to manage translations and implement per-language URLs. You will learn how to translate model fields using `django-parler` and how to use translations with the ORM. Finally, you will create a localized form field using `django-localflavor`.

Chapter 12, Building an E-Learning Platform, will guide you through creating an e-learning platform. You will add fixtures to your project, and create initial models for the content management system. You will use model inheritance to create data models for polymorphic content. You will learn how to create custom model fields by building a field to order objects. You will also implement authentication views for the CMS.

Chapter 13, Creating a Content Management System, will teach you how to create a CMS using class-based views and mixins. You will use the Django groups and permissions system to restrict access to views and implement formsets to edit the content of courses. You will also create a drag-and-drop functionality to reorder course modules and their content using JavaScript and Django.

Chapter 14, Rendering and Caching Content, will show you how to implement the public views for the course catalog. You will create a student registration system and manage student enrollment on courses. You will create the functionality to render different types of content for the course modules. You will learn how to cache content using the Django cache framework and configure the Memcached and Redis cache backends for your project. Finally, you will learn how to monitor Redis using the administration site.

Chapter 15, Building an API, explores building a RESTful API for your project using Django REST framework. You will learn how to create serializers for your models and build custom API views. You will handle API authentication and implement permissions for API views.

You will learn how to build API viewsets and routers. The chapter will also teach you how to consume your API using the Requests library.

Chapter 16, Building a Chat Server, explains how to use Django Channels to create a real-time chat server for students. You will learn how to implement functionalities that rely on asynchronous communication through WebSockets. You will create a WebSocket consumer with Python and implement a WebSocket client with JavaScript. You will use Redis to set up a channel layer and you will learn how to make your WebSocket consumer fully asynchronous. You will also implement a chat history by persisting chat messages into the database.

Chapter 17, Going Live, will show you how to create settings for multiple environments and how to set up a production environment using PostgreSQL, Redis, uWSGI, NGINX, and Daphne with Docker Compose. You will learn how to serve your project securely through HTTPS and use the Django system check framework. The chapter will also teach you how to build a custom middleware and create custom management commands.

To get the most out of this book

- You must possess a good working knowledge of Python.
- You should be comfortable with HTML and JavaScript.
- It is recommended that you go through parts 1 to 3 of the tutorial in the official Django documentation at `https://docs.djangoproject.com/en/5.0/intro/tutorial01/`.

Download the example code files

The code bundle for the book is hosted on GitHub at `https://github.com/PacktPublishing/Django-5-by-Example`. 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/diagrams used in this book. You can download it here: `https://packt.link/gbp/9781805125457`.

Conventions used

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

`CodeInText`: Indicates code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles. For example: "Edit the `models.py` file of the `shop` application."

A block of code is set as follows:

```
from django.contrib import admin
from .models import Post

admin.site.register(Post)
```

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

```
INSTALLED_APPS = [
'django.contrib.admin',
'django.contrib.auth',
'django.contrib.contenttypes',
'django.contrib.sessions',
'django.contrib.messages',
'django.contrib.staticfiles',
'blog.apps.BlogConfig',
]
```

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

```
python manage.py runserver
```

Bold: Indicates a new term, an important word, or words that you see on the screen. For instance, words in menus or dialog boxes appear in the text like this. For example: "Select **System info** from the **Administration** panel."

Warnings or important notes appear like this.

Tips and tricks appear like this.

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1

Building a Blog Application

In this book, you will learn how to build professional-grade web projects using Django. This initial chapter will guide you through the essential building blocks of a Django application, from installation to deployment. If you haven't set up Django on your machine yet, the *Installing Django* section will walk you through the installation process.

Before starting our first Django project, let's go over what you are about to learn. This chapter will give you a general overview of the framework. It will guide you through the different major components to create a fully functional web application: models, templates, views, and URLs. You will gain an understanding of how Django works and how the different framework components interact.

You will also learn the difference between Django projects and applications, and you will learn about the most important Django settings. You will build a simple blog application that allows users to navigate through all published posts and read individual posts. You will also create a simple administration interface to manage and publish posts. In the next two chapters, you will extend the blog application with more advanced functionalities.

Consider this chapter as your roadmap for constructing a fully-fledged Django application. Don't be concerned if some components or concepts appear unclear at first. The different framework components will be explored in detail throughout this book.

This chapter will cover the following topics:

- Installing Python
- Creating a Python virtual environment
- Installing Django
- Creating and configuring a Django project
- Building a Django application
- Designing data models
- Creating and applying model migrations
- Setting up an administration site for your models
- Working with QuerySets and model managers

- Building views, templates, and URLs
- Understanding the Django request/response cycle

You will start by installing Python on your machine.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter01`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all the requirements at once with the command `python -m pip install -r requirements.txt`.

Installing Python

Django 5.0 supports Python 3.10, 3.11, and 3.12. In the examples in this book, we will use Python 3.12.

If you're using Linux or macOS, you probably have Python installed. If you're using Windows, you can download a Python installer from the `python.org` website. You can download Python for your OS from `https://www.python.org/downloads/`.

Open the command-line shell prompt of your machine. If you are using macOS, press *Command* + *spacebar* to open Spotlight and write **Terminal** to open `Terminal.app`. If you are using Windows, open the **Start** menu and type `powers` into the search box. Then, click on the **Windows PowerShell** application to open it. Alternatively, you can use the more basic command prompt by typing `cmd` into the search box and clicking on the **Command Prompt** application to open it.

Verify that Python 3 is installed on your machine by typing the following command in the shell prompt:

```
python3 --version
```

If you see the following, then Python 3 is installed on your computer:

```
Python 3.12.3
```

If you get an error, try the `python` command instead of `python3`. If you use Windows, it's recommended that you replace `python` with the `py` command.

If your installed Python version is lower than 3.12, or if Python is not installed on your computer, download Python 3.12 from `https://www.python.org/downloads/` and follow the instructions to install it. On the download site, you can find Python installers for Windows, macOS, and Linux.

Throughout this book, when Python is referenced in the shell prompt, we will use the `python` command, though some systems may require using `python3`. If you are using Linux or macOS and your system's Python is Python 2, you will need to use `python3` to use the Python 3 version you installed. Note that Python 2 reached end-of-life in January 2020 and shouldn't be used anymore.

In Windows, `python` is the Python executable of your default Python installation, whereas `py` is the Python launcher. The Python launcher for Windows was introduced in Python 3.3. It detects what Python versions are installed on your machine and it automatically delegates to the latest version.

If you use Windows, you should use the py command. You can read more about the Windows Python launcher at https://docs.python.org/3/using/windows.html#launcher.

Next, you are going to create a Python environment for your project and install the necessary Python libraries.

Creating a Python virtual environment

When you write Python applications, you will usually use packages and modules that are not included in the standard Python library. You may have Python applications that require a different version of the same module. However, only a specific version of a module can be installed system-wide. If you upgrade a module version for an application, you might end up breaking other applications that require an older version of that module.

To address this issue, you can use Python virtual environments. With virtual environments, you can install Python modules in an isolated location rather than installing them system-wide. Each virtual environment has its own Python binary and can have its own independent set of installed Python packages in its site-packages directory.

Since version 3.3, Python comes with the venv library, which provides support for creating lightweight virtual environments. By using the Python venv module to create isolated Python environments, you can use different package versions for different projects. Another advantage of using venv is that you won't need any administrative privileges to install Python packages.

If you are using Linux or macOS, create an isolated environment with the following command:

```
python -m venv my_env
```

Remember to use python3 instead of python if your system comes with Python 2 and you installed Python 3.

If you are using Windows, use the following command instead:

```
py -m venv my_env
```

This will use the Python launcher in Windows.

The previous command will create a Python environment in a new directory named my_env. Any Python libraries you install while your virtual environment is active will go into the my_env/lib/python3.12/site-packages directory.

If you are using Linux or macOS, run the following command to activate your virtual environment:

```
source my_env/bin/activate
```

If you are using Windows, use the following command instead:

```
.\my_env\Scripts\activate
```

The shell prompt will include the name of the active virtual environment enclosed in parentheses, like this:

```
(my_env) zenx@pc:~ zenx$
```

You can deactivate your environment at any time with the `deactivate` command. You can find more information about `venv` at `https://docs.python.org/3/library/venv.html`.

Installing Django

If you have already installed Django 5.0, you can skip this section and jump directly to the *Creating your first project* section.

Django comes as a Python module and thus can be installed in any Python environment. If you haven't installed Django yet, the following is a quick guide to installing it on your machine.

Installing Django with pip

The `pip` package management system is the preferred method of installing Django. Python 3.12 comes with `pip` preinstalled, but you can find `pip` installation instructions at `https://pip.pypa.io/en/stable/installation/`.

Run the following command at the shell prompt to install Django with `pip`:

```
python -m pip install Django~=5.0.4
```

This will install Django's latest 5.0 version in the Python `site-packages` directory of your virtual environment.

Now we will check whether Django has been successfully installed. Run the following command in a shell prompt:

```
python -m django --version
```

If you get an output that starts with `5.0`, Django has been successfully installed on your machine. If you get the message `No module named Django`, Django is not installed on your machine. If you have issues installing Django, you can review the different installation options described at `https://docs.djangoproject.com/en/5.0/intro/install/`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter, mentioned above. You can follow the instructions to install each Python package in the following sections, or you can install all requirements at once with the command `pip install -r requirements.txt`.

Django overview

Django is a framework consisting of a set of components that solve common web development problems. Django components are loosely coupled, which means they can be managed independently. This helps separate the responsibilities of the different layers of the framework; the database layer knows nothing about how the data is displayed, the template system knows nothing about web requests, and so on.

Django offers maximum code reusability by following the **DRY** (**don't repeat yourself**) principle. Django also fosters rapid development and allows you to use less code by taking advantage of Python's dynamic capabilities, such as introspection.

You can read more about Django's design philosophies at `https://docs.djangoproject.com/en/5.0/misc/design-philosophies/`.

Main framework components

Django follows the **MTV** (**Model-Template-View**) pattern. It is a slightly similar pattern to the well-known **MVC** (**Model-View-Controller**) pattern, where the template acts as the view and the framework itself acts as the controller.

The responsibilities in the Django MTV pattern are divided as follows:

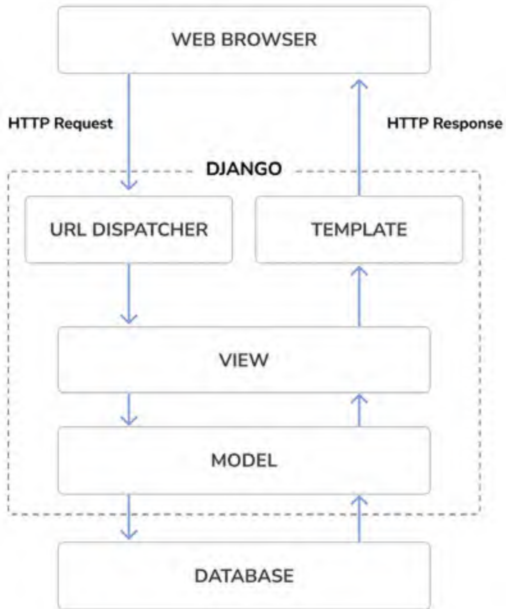
- **Model**: This defines the logical data structure and is the data handler between the database and the view.
- **Template**: This is the presentation layer. Django uses a plain-text template system that keeps everything that the browser renders.
- **View**: This communicates with the database via the model and transfers the data to the template for viewing.

The framework itself acts as the controller. It sends a request to the appropriate view, according to the Django **URL** configuration.

When developing any Django project, you will always work with models, views, templates, and URLs. In this chapter, you will learn how they fit together.

The Django architecture

Figure 1.1 shows how Django processes requests and how the request/response cycle is managed with the different main Django components – URLs, views, models, and templates:



This is how Django handles HTTP requests and generates responses:

1. A web browser requests a page by its URL and the web server passes the HTTP request to Django.
2. Django runs through its configured URL patterns and stops at the first one that matches the requested URL.
3. Django executes the view that corresponds to the matched URL pattern.
4. The view potentially uses data models to retrieve information from the database.
5. Data models provide data definitions and behaviors. They are used to query the database.
6. The view renders a template (usually HTML) to display the data and returns it with an HTTP response.

We will get back to the Django request/response cycle at the end of this chapter in the *The request/response cycle* section.

Django also includes hooks in the request/response process, which are called middleware. Middleware has been intentionally left out of this diagram for the sake of simplicity. You will use middleware in different examples of this book, and you will learn how to create custom middleware in *Chapter 17, Going Live*.

We have covered the foundational elements of Django and how it processes requests. Let's explore the new features introduced in Django 5.

New features in Django 5

Django 5 introduces several key features that you will use in the examples of this book. This version also deprecates certain features and eliminates previously deprecated functionalities. Django 5.0 presents the following new major features:

- **Facet filters in the administration site**: Facet filters can be added now to the administration site. When enabled, facet counts are displayed for applied filters in the admin object list. This feature is presented in the *Added facet counts to filters* section of this chapter.
- **Simplified templates for form field rendering**: Form field rendering has been simplified with the capability to define field groups with associated templates. This aims to make the process of rendering related elements of a Django form field, such as labels, widgets, help text, and errors, more streamlined. An example of using field groups can be found in the *Creating templates for the comment form* section of *Chapter 2, Enhancing Your Blog and Adding Social Features*.
- **Database-computed default values:** Django adds database-computed default values. An example of this feature is presented in the *Adding datetime fields* section of this chapter.
- **Database-generated model fields**: This is a new type of field that enables you to create database-generated columns. An expression is used to automatically set the field value each time the model is changed. The field value is set using the `GENERATED ALWAYS` SQL syntax.
- **More options for declaring model field choices**: Fields that support choices no longer require accessing the `.choices` attribute to access enumeration types. A mapping or callable instead of an iterable can be used directly to expand enumeration types. Choices with enumeration types in this book have been updated to reflect these changes. An instance of this can be found in the *Adding a status field* section of this chapter.

Django 5 also comes with some improvements in asynchronous support. **Asynchronous Server Gateway Interface** (**ASGI**) support was first introduced in Django 3 and improved in Django 4.1 with asynchronous handlers for class-based views and an asynchronous ORM interface. Django 5 adds asynchronous functions to the authentication framework, provides support for asynchronous signal dispatching, and adds asynchronous support to multiple built-in decorators.

Django 5.0 drops support for Python 3.8 and 3.9.

You can read the complete list of changes in the Django 5.0 release notes at `https://docs.djangoproject.com/en/5.0/releases/5.0/`.

As a time-based release, there are no drastic changes in Django 5, making it straightforward to upgrade Django 4 applications to the 5.0 release.

If you want to quickly upgrade an existing Django project to the 5.0 release, you can use the `django-upgrade` tool. This package rewrites the files of your project by applying fixers up to a target version. You can find instructions to use `django-upgrade` at `https://github.com/adamchainz/django-upgrade`.

The `django-upgrade` tool is inspired by the `pyupgrade` package. You can use `pyupgrade` to automatically upgrade syntax for newer versions of Python. You can find more information about `pyupgrade` at `https://github.com/asottile/pyupgrade`.

Creating your first project

Your first Django project will consist of a blog application. This will offer you a solid introduction to Django's capabilities and functionalities.

Blogging is the perfect starting point to build a complete Django project, given its wide range of required features, from basic content management to advanced functionalities like commenting, post sharing, search, and post recommendations. The blog project will be covered in the first three chapters of this book.

In this chapter, we will start by creating the Django project and a Django application for the blog. We will then create our data models and synchronize them to the database. Finally, we will create an administration site for the blog, and we will build the views, templates, and URLs.

Figure 1.2 shows a representation of the blog application pages that you will create:

Figure 1.2: Diagram of functionalities built in Chapter 1

The blog application will consist of a list of posts including the post title, publishing date, author, a post excerpt, and a link to read the post. The post list page will be implemented with the `post_list` view. You will learn how to create views in this chapter.

When readers click on the link of a post in the post list page, they will be redirected to a single (detail) view of a post. The detail view will display the title, publishing date, author, and the complete post body.

Let's start by creating the Django project for our blog. Django provides a command that allows you to create an initial project file structure.

Run the following command in your shell prompt:

```
django-admin startproject mysite
```

This will create a Django project with the name `mysite`.

Avoid naming projects after built-in Python or Django modules in order to prevent conflicts.

Let's take a look at the generated project structure:

```
mysite/
    manage.py
    mysite/
      __init__.py
      asgi.py
      settings.py
      urls.py
      wsgi.py
```

The outer `mysite/` directory is the container for our project. It contains the following files:

- `manage.py`: This is a command-line utility used to interact with your project. You won't usually need to edit this file.
- `mysite/`: This is the Python package for your project, which consists of the following files:
    - `__init__.py`: An empty file that tells Python to treat the `mysite` directory as a Python module.
    - `asgi.py`: This is the configuration to run your project as an ASGI application with ASGI-compatible web servers. ASGI is the emerging Python standard for asynchronous web servers and applications.
    - `settings.py`: This indicates settings and configuration for your project and contains initial default settings.
    - `urls.py`: This is the place where your URL patterns live. Each URL defined here is mapped to a view.

- `wsgi.py`: This is the configuration to run your project as a **Web Server Gateway Interface** (**WSGI**) application with WSGI-compatible web servers.

Applying initial database migrations

Django applications require a database to store data. The `settings.py` file contains the database configuration for your project in the `DATABASES` setting. The default configuration is a SQLite3 database. SQLite comes bundled with Python 3 and can be used in any of your Python applications. SQLite is a lightweight database that you can use with Django for development. If you plan to deploy your application in a production environment, you should use a full-featured database, such as PostgreSQL, MySQL, or Oracle. You can find more information about how to get your database running with Django at `https://docs.djangoproject.com/en/5.0/topics/install/#database-installation`.

Your `settings.py` file also includes a list named `INSTALLED_APPS` that contains common Django applications that are added to your project by default. We will go through these applications later in the *Project settings* section.

Django applications contain data models that are mapped to database tables. You will create your own models in the *Creating the blog data models* section. To complete the project setup, you need to create the tables associated with the models of the default Django applications included in the `INSTALLED_APPS` setting. Django comes with a system that helps you manage database migrations.

Open the shell prompt and run the following commands:

```
cd mysite
python manage.py migrate
```

You will see an output that ends with the following lines:

```
Applying contenttypes.0001_initial... OK
Applying auth.0001_initial... OK
Applying admin.0001_initial... OK
Applying admin.0002_logentry_remove_auto_add... OK
Applying admin.0003_logentry_add_action_flag_choices... OK
Applying contenttypes.0002_remove_content_type_name... OK
Applying auth.0002_alter_permission_name_max_length... OK
Applying auth.0003_alter_user_email_max_length... OK
Applying auth.0004_alter_user_username_opts... OK
Applying auth.0005_alter_user_last_login_null... OK
Applying auth.0006_require_contenttypes_0002... OK
Applying auth.0007_alter_validators_add_error_messages... OK
Applying auth.0008_alter_user_username_max_length... OK
Applying auth.0009_alter_user_last_name_max_length... OK
Applying auth.0010_alter_group_name_max_length... OK
Applying auth.0011_update_proxy_permissions... OK
Applying auth.0012_alter_user_first_name_max_length... OK
Applying sessions.0001_initial... OK
```

The preceding lines are the database migrations that are applied by Django. By applying the initial migrations, the tables for the applications listed in the `INSTALLED_APPS` setting are created in the database.

You will learn more about the `migrate` management command in the *Creating and applying migrations* section of this chapter.

Running the development server

Django comes with a lightweight web server to run your code quickly, without needing to spend time configuring a production server. When you run the Django development server, it keeps checking for changes in your code. It reloads automatically, freeing you from manually reloading it after code changes. However, it might not notice some actions, such as adding new files to your project, so you will have to restart the server manually in these cases.

Start the development server by typing the following command in the shell prompt:

```
python manage.py runserver
```

You should see something like this:

```
Watching for file changes with StatReloader
Performing system checks...
System check identified no issues (0 silenced).
January 01, 2024 - 10:00:00
Django version 5.0, using settings 'mysite.settings'
Starting development server at http://127.0.0.1:8000/
Quit the server with CONTROL-C.
```

Now, open `http://127.0.0.1:8000/` in your browser. You should see a page stating that the project is successfully running, as shown in *Figure 1.3*:

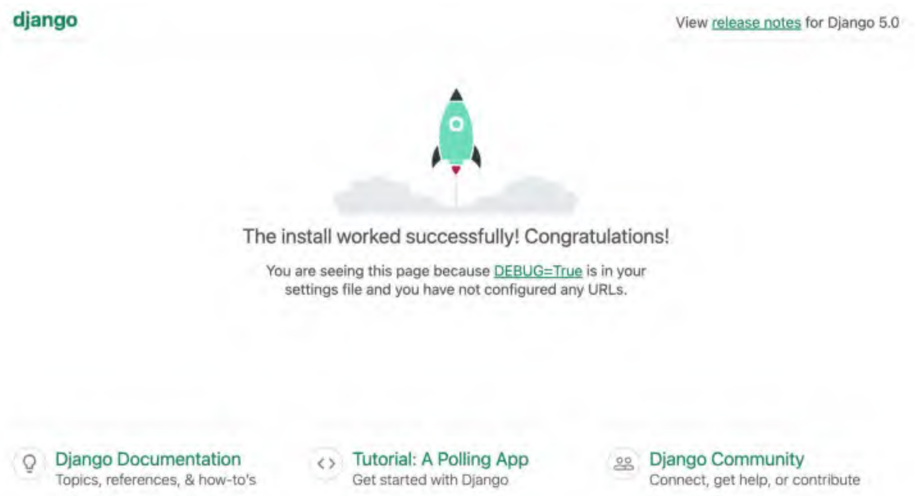


Figure 1.3: The default page of the Django development server

The preceding screenshot indicates that Django is running. If you take a look at your console, you will see the `GET` request performed by your browser:

```
[01/Jan/2024 10:00:15] "GET / HTTP/1.1" 200 16351
```

Each HTTP request is logged in the console by the development server. Any error that occurs while running the development server will also appear in the console.

You can run the Django development server on a custom host and port or tell Django to load a specific settings file, as follows:

```
python manage.py runserver 127.0.0.1:8001 --settings=mysite.settings
```

> When you have to deal with multiple environments that require different configurations, you can create a different settings file for each environment.

This server is only intended for development and is not suitable for production use. To deploy Django in a production environment, you should run it as a WSGI application using a web server, such as Apache, Gunicorn, or uWSGI, or as an ASGI application using a server such as Daphne or Uvicorn. You can find more information on how to deploy Django with different web servers at `https://docs.djangoproject.com/en/5.0/howto/deployment/wsgi/`.

Chapter 17, *Going Live*, explains how to set up a production environment for your Django projects.

Project settings

Let's open the `settings.py` file and take a look at the configuration of the project. There are several settings that Django includes in this file, but these are only part of all the available Django settings. You can see all the settings and their default values at `https://docs.djangoproject.com/en/5.0/ref/settings/`.

Let's review some of the project settings:

- `DEBUG` is a Boolean that turns the debug mode of the project on and off. If it is set to `True`, Django will display detailed error pages when an uncaught exception is thrown by your application. When you move to a production environment, remember that you have to set it to `False`. Never deploy a site into production with `DEBUG` turned on because you will expose sensitive project-related data.
- `ALLOWED_HOSTS` is not applied while debug mode is on or when the tests are run. Once you move your site to production and set `DEBUG` to `False`, you will have to add your domain/host to this setting to allow it to serve your Django site.
- `INSTALLED_APPS` is a setting you will have to edit for all projects. This setting tells Django which applications are active for this site. By default, Django includes the following applications:
    - `django.contrib.admin`: An administration site.
    - `django.contrib.auth`: An authentication framework.

- `django.contrib.contenttypes`: A framework for handling content types.
- `django.contrib.sessions`: A session framework.
- `django.contrib.messages`: A messaging framework.
- `django.contrib.staticfiles`: A framework for managing static files, such as CSS, JavaScript files, and images.

- `MIDDLEWARE` is a list that contains middleware to be executed.
- `ROOT_URLCONF` indicates the Python module where the root URL patterns of your application are defined.
- `DATABASES` is a dictionary that contains the settings for all the databases to be used in the project. There must always be a default database. The default configuration uses a SQLite3 database.
- `LANGUAGE_CODE` defines the default language code for this Django site.
- `USE_TZ` tells Django to activate/deactivate timezone support. Django comes with support for timezone-aware datetimes. This setting is set to `True` when you create a new project using the `startproject` management command.

Don't worry if you don't understand much about what you're seeing here. You will learn more about the different Django settings in the following chapters.

Projects and applications

Throughout this book, you will encounter the terms **project** and **application** over and over. In Django, a project is considered a Django installation with some settings. An application is a group of models, views, templates, and URLs. Applications interact with the framework to provide specific functionalities and may be reused in various projects. You can think of a project as your website, which contains several applications, such as a blog, wiki, or forum, that can also be used by other Django projects.

Figure 1.4 shows the structure of a Django project:

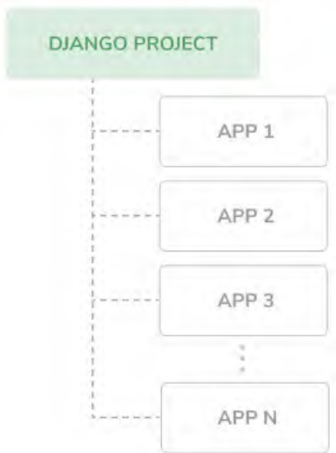


Figure 1.4: The Django project/application structure

Creating an application

Let's create our first Django application. We will build a blog application from scratch.

Run the following command in the shell prompt from the project's root directory:

```
python manage.py startapp blog
```

This will create the basic structure of the application, which will look like this:

```
blog/
    __init__.py
    admin.py
    apps.py
    migrations/
        __init__.py
    models.py
    tests.py
    views.py
```

These files are as follows:

- `__init__.py`: This is an empty file that tells Python to treat the `blog` directory as a Python module.
- `admin.py`: This is where you register models to include them in the Django administration site—using this site is optional.
- `apps.py`: This includes the main configuration of the `blog` application.
- `migrations`: This directory will contain database migrations of the application. Migrations allow Django to track your model changes and synchronize the database accordingly. This directory contains an empty `__init__.py` file.
- `models.py`: This includes the data models of your application; all Django applications need to have a `models.py` file but it can be left empty.
- `tests.py`: This is where you can add tests for your application.
- `views.py`: The logic of your application goes here; each view receives an HTTP request, processes it, and returns a response.

With the application structure ready, we can start building the data models for the blog.

Creating the blog data models

Remember that a Python object is a collection of data and methods. Classes are the blueprint for bundling data and functionality together. Creating a new class creates a new type of object, allowing you to create instances of that type.

A Django model is a source of information about the behaviors of your data. It consists of a Python class that subclasses `django.db.models.Model`. Each model maps to a single database table, where each attribute of the class represents a database field.

When you create a model, Django will provide you with a practical API to query objects in the database easily.

We will define the database models for our blog application. Then, we will generate the database migrations for the models to create the corresponding database tables. When applying the migrations, Django will create a table for each model defined in the `models.py` file of the application.

Creating the Post model

First, we will define a `Post` model that will allow us to store blog posts in the database.

Add the following lines to the `models.py` file of the `blog` application. The new lines are highlighted in bold:

```
from django.db import models

class Post(models.Model):
    title = models.CharField(max_length=250)
    slug = models.SlugField(max_length=250)
    body = models.TextField()

    def __str__(self):
        return self.title
```

This is the data model for blog posts. Posts will have a title, a short label called `slug`, and a body. Let's take a look at the fields of this model:

- `title`: This is the field for the post title. This is a `CharField` field that translates into a `VARCHAR` column in the SQL database.
- `slug`: This is a `SlugField` field that translates into a `VARCHAR` column in the SQL database. A slug is a short label that contains only letters, numbers, underscores, or hyphens. A post with the title *Django Reinhardt: A legend of Jazz* could have a slug like *django-reinhardt-legend-jazz*. We will use the `slug` field to build beautiful, SEO-friendly URLs for blog posts in *Chapter 2, Enhancing Your Blog with Advanced Features*.
- `body`: This is the field for storing the body of the post. This is a `TextField` field that translates into a `TEXT` column in the SQL database.

We have also added a `__str__()` method to the model class. This is the default Python method to return a string with the human-readable representation of the object. Django will use this method to display the name of the object in many places, such as the Django administration site.

Let's take a look at how the model and its fields will be translated into a database table and columns. The following diagram shows the `Post` model and the corresponding database table that Django will create when we synchronize the model to the database:

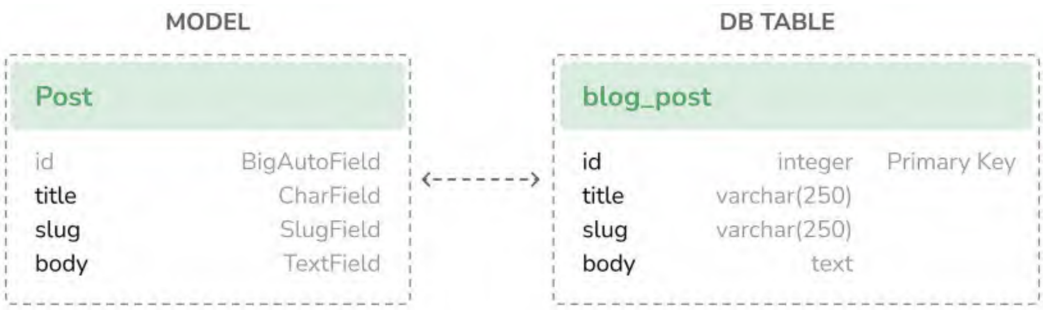


Figure 1.5: Initial Post model and database table correspondence

Django will create a database column for each of the model fields: `title`, `slug`, and `body`. You can see how each field type corresponds to a database data type.

By default, Django adds an auto-incrementing primary key field to each model. The field type for this field is specified in each application configuration or globally in the `DEFAULT_AUTO_FIELD` setting. When creating an application with the `startapp` command, the default value for `DEFAULT_AUTO_FIELD` is `BigAutoField`. This is a 64-bit integer that automatically increments according to available IDs. If you don't specify a primary key for your model, Django adds this field automatically. You can also define one of the model fields to be the primary key by setting `primary_key=True` on it.

We will expand the `Post` model with additional fields and behaviors. Once complete, we will synchronize it to the database by creating a database migration and applying it.

Adding datetime fields

We will continue by adding different datetime fields to the `Post` model. Each post will be published at a specific date and time. Therefore, we need a field to store the publication date and time. We also want to store the date and time when the `Post` object was created and when it was last modified.

Edit the `models.py` file of the `blog` application to make it look like this; the new lines are highlighted in bold:

```
from django.db import models
from django.utils import timezone


class Post(models.Model):
    title = models.CharField(max_length=250)
    slug = models.SlugField(max_length=250)
    body = models.TextField()
    publish = models.DateTimeField(default=timezone.now)

    def __str__(self):
        return self.title
```

We have added a publish field to the Post model. This is a DateTimeField field that translates into a DATETIME column in the SQL database. We will use it to store the date and time when the post was published. We use Django's timezone.now method as the default value for the field. Note that we imported the timezone module to use this method. timezone.now returns the current datetime in a timezone-aware format. You can think of it as a timezone-aware version of the standard Python datetime.now method.

Another method to define default values for model fields is using database-computed default values. Introduced in Django 5, this feature allows you to use underlaying database functions to generate default values. For instance, the following code uses the database server's current date and time as the default for the publish field:

```
from django.db import models
from django.db.models.functions import Now


class Post(models.Model):
    # ...
    publish = models.DateTimeField(db_default=Now())
```

To use database-generated default values, we use the db_default attribute instead of default. In this example, we use the Now database function. It serves a similar purpose to default=timezone.now, but instead of a Python-generated datetime, it uses the NOW() database function to produce the initial value. You can read more about the db_default attribute at https://docs.djangoproject.com/en/5.0/ref/models/fields/#django.db.models.Field.db_default. You can find all available database functions at https://docs.djangoproject.com/en/5.0/ref/models/database-functions/.

Let's continue with the previous version of the field:

```
class Post(models.Model):
    # ...
    publish = models.DateTimeField(default=timezone.now)
```

Edit the models.py file of the blog application and add the following lines highlighted in bold:

```
from django.db import models
from django.utils import timezone


class Post(models.Model):
    title = models.CharField(max_length=250)
    slug = models.SlugField(max_length=250)
    body = models.TextField()
    publish = models.DateTimeField(default=timezone.now)
    created = models.DateTimeField(auto_now_add=True)
```

```
    updated = models.DateTimeField(auto_now=True)

    def __str__(self):
        return self.title
```

We have added the following fields to the `Post` model:

- `created`: This is a `DateTimeField` field. We will use it to store the date and time when the post was created. By using `auto_now_add`, the date will be saved automatically when creating an object.
- `updated`: This is a `DateTimeField` field. We will use it to store the last date and time when the post was updated. By using `auto_now`, the date will be updated automatically when saving an object.

Utilizing the `auto_now_add` and `auto_now` datetime fields in your Django models is highly beneficial for tracking the creation and last modification times of objects.

Defining a default sort order

Blog posts are typically presented in reverse chronological order, showing the newest posts first. For our model, we will define a default ordering. This ordering takes effect when retrieving objects from the database unless a specific order is indicated in the query.

Edit the `models.py` file of the `blog` application as shown below. The new lines are highlighted in bold:

```
from django.db import models
from django.utils import timezone


class Post(models.Model):
    title = models.CharField(max_length=250)
    slug = models.SlugField(max_length=250)
    body = models.TextField()
    publish = models.DateTimeField(default=timezone.now)
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)

    class Meta:
        ordering = ['-publish']

    def __str__(self):
        return self.title
```

We have added a `Meta` class inside the model. This class defines metadata for the model. We use the `ordering` attribute to tell Django that it should sort results by the `publish` field. This ordering will apply by default for database queries when no specific order is provided in the query. We indicate descending order by using a hyphen before the field name, `-publish`. Posts will be returned in reverse chronological order by default.

Adding a database index

Let's define a database index for the `publish` field. This will improve performance for query filtering or ordering results by this field. We expect many queries to take advantage of this index since we are using the `publish` field to order results by default.

Edit the `models.py` file of the `blog` application and make it look like this; the new lines are highlighted in bold:

```
from django.db import models
from django.utils import timezone


class Post(models.Model):
    title = models.CharField(max_length=250)
    slug = models.SlugField(max_length=250)
    body = models.TextField()
    publish = models.DateTimeField(default=timezone.now)
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)

    class Meta:
        ordering = ['-publish']
        indexes = [
            models.Index(fields=['-publish']),
        ]

    def __str__(self):
        return self.title
```

We have added the `indexes` option to the model's `Meta` class. This option allows you to define database indexes for your model, which could comprise one or multiple fields, in ascending or descending order, or functional expressions and database functions. We have added an index for the `publish` field. We use a hyphen before the field name to define the index specifically in descending order. The creation of this index will be included in the database migrations that we will generate later for our blog models.

Index ordering is not supported on MySQL. If you use MySQL for the database, a descending index will be created as a normal index.

You can find more information about how to define indexes for models at `https://docs.djangoproject.com/en/5.0/ref/models/indexes/`.

Activating the application

We need to activate the `blog` application in the project for Django to keep track of the application and be able to create database tables for its models.

Edit the `settings.py` file and add `blog.apps.BlogConfig` to the `INSTALLED_APPS` setting. It should look like this; the new lines are highlighted in bold:

```
INSTALLED_APPS = [
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.staticfiles',
    'blog.apps.BlogConfig',
]
```

The `BlogConfig` class is the application configuration. Now Django knows that the application is active for this project and will be able to load the application models.

Adding a status field

A common functionality for blogs is to save posts as a draft until ready for publication. We will add a `status` field to our model that will allow us to manage the status of blog posts. We will be using the *Draft* and *Published* statuses for posts.

Edit the `models.py` file of the `blog` application to make it look as follows. The new lines are highlighted in bold:

```
from django.db import models
from django.utils import timezone


class Post(models.Model):
    class Status(models.TextChoices):
        DRAFT = 'DF', 'Draft'
```

```
        PUBLISHED = 'PB', 'Published'

    title = models.CharField(max_length=250)
    slug = models.SlugField(max_length=250)
    body = models.TextField()
    publish = models.DateTimeField(default=timezone.now)
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)
    status = models.CharField(
        max_length=2,
        choices=Status,
        default=Status.DRAFT
    )

    class Meta:
        ordering = ['-publish']
        indexes = [
            models.Index(fields=['-publish']),
        ]

    def __str__(self):
        return self.title
```

We have defined the enumeration class `Status` by subclassing `models.TextChoices`. The available choices for the post status are `DRAFT` and `PUBLISHED`. Their respective values are `DF` and `PB`, and their labels or readable names are *Draft* and *Published*.

Django provides enumeration types that you can subclass to define choices simply. These are based on the `enum` object of Python's standard library. You can read more about `enum` at `https://docs.python.org/3/library/enum.html`.

Django enumeration types present some modifications over `enum`. You can learn about those differences at `https://docs.djangoproject.com/en/5.0/ref/models/fields/#enumeration-types`.

We can access `Post.Status.choices` to obtain the available choices, `Post.Status.names` to obtain the names of the choices, `Post.Status.labels` to obtain the human-readable names, and `Post.Status.values` to obtain the actual values of the choices.

We have also added a new `status` field to the model that is an instance of `CharField`. It includes a `choices` parameter to limit the value of the field to the choices in `Status`. We have also set a default value for the field using the `default` parameter. We use `DRAFT` as the default choice for this field.

It's a good practice to define choices inside the model class and use the enumeration types. This will allow you to easily reference choice labels, values, or names from anywhere in your code. You can import the `Post` model and use `Post.Status.DRAFT` as a reference for the *Draft* status anywhere in your code.

Let's take a look at how to interact with status choices.

Run the following command in the shell prompt to open the Python shell:

```
python manage.py shell
```

Then, type the following lines:

```
>>> from blog.models import Post
>>> Post.Status.choices
```

You will obtain the `enum` choices with value-label pairs, like this:

```
[('DF', 'Draft'), ('PB', 'Published')]
```

Type the following line:

```
>>> Post.Status.labels
```

You will get the human-readable names of the `enum` members, as follows:

```
['Draft', 'Published']
```

Type the following line:

```
>>> Post.Status.values
```

You will get the values of the `enum` members, as follows. These are the values that can be stored in the database for the `status` field:

```
['DF', 'PB']
```

Type the following line:

```
>>> Post.Status.names
```

You will get the names of the choices, like this:

```
['DRAFT', 'PUBLISHED']
```

You can access a specific lookup enumeration member with `Post.Status.PUBLISHED` and you can access its `.name` and `.value` properties as well.

Adding a many-to-one relationship

Posts are always written by an author. We will create a relationship between users and posts that will indicate which user wrote which posts. Django comes with an authentication framework that handles user accounts. The Django authentication framework comes in the `django.contrib.auth` package and contains a `User` model. To define the relationship between users and posts, we will use the `AUTH_USER_MODEL` setting, which points to `auth.User` by default. This setting allows you to specify a different user model for your project.

Edit the `models.py` file of the `blog` application to make it look as follows. The new lines are highlighted in bold:

```
from django.conf import settings
from django.db import models
from django.utils import timezone


class Post(models.Model):

    class Status(models.TextChoices):
        DRAFT = 'DF', 'Draft'
        PUBLISHED = 'PB', 'Published'

    title = models.CharField(max_length=250)
    slug = models.SlugField(max_length=250)
    author = models.ForeignKey(
        settings.AUTH_USER_MODEL,
        on_delete=models.CASCADE,
        related_name='blog_posts'
    )
    body = models.TextField()
    publish = models.DateTimeField(default=timezone.now)
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)
    status = models.CharField(
        max_length=2,
        choices=Status,
        default=Status.DRAFT
    )

    class Meta:
        ordering = ['-publish']
        indexes = [
```

```
                models.Index(fields=['-publish']),
            ]

    def __str__(self):
        return self.title
```

We have imported the project's settings and we have added an author field to the Post model. This field defines a many-to-one relationship with the default user model, meaning that each post is written by a user, and a user can write any number of posts. For this field, Django will create a foreign key in the database using the primary key of the related model.

The on_delete parameter specifies the behavior to adopt when the referenced object is deleted. This is not specific to Django; it is a SQL standard. Using CASCADE, you specify that when the referenced user is deleted, the database will also delete all related blog posts. You can take a look at all the possible options at https://docs.djangoproject.com/en/5.0/ref/models/fields/#django.db.models.ForeignKey.on_delete.

We use related_name to specify the name of the reverse relationship, from User to Post. This will allow us to access related objects easily from a user object by using the user.blog_posts notation. We will learn more about this later.

Django comes with different types of fields that you can use to define your models. You can find all field types at https://docs.djangoproject.com/en/5.0/ref/models/fields/.

The Post model is now complete, and we can now synchronize it to the database.

Creating and applying migrations

Now that we have a data model for blog posts, we need to create the corresponding database table. Django comes with a migration system that tracks the changes made to models and enables them to propagate into the database.

The migrate command applies migrations for all applications listed in INSTALLED_APPS. It synchronizes the database with the current models and existing migrations.

First, we will need to create an initial migration for our Post model.

Run the following command in the shell prompt from the root directory of your project:

```
python manage.py makemigrations blog
```

You should get an output similar to the following one:

```
Migrations for 'blog':
    blog/migrations/0001_initial.py
        - Create model Post
        - Create index blog_post_publish_bb7600_idx on field(s)
          -publish of model post
```

Django just created the `0001_initial.py` file inside the `migrations` directory of the `blog` application. This migration contains the SQL statements to create the database table for the `Post` model and the definition of the database index for the `publish` field.

You can take a look at the file contents to see how the migration is defined. A migration specifies dependencies on other migrations and operations to perform in the database to synchronize it with model changes.

Let's take a look at the SQL code that Django will execute in the database to create the table for your model. The `sqlmigrate` command takes the migration names and returns their SQL without executing it.

Run the following command from the shell prompt to inspect the SQL output of your first migration:

```
python manage.py sqlmigrate blog 0001
```

The output should look as follows:

```
BEGIN;
--
-- Create model Post
--
CREATE TABLE "blog_post" (
  "id" integer NOT NULL PRIMARY KEY AUTOINCREMENT,
  "title" varchar(250) NOT NULL,
  "slug" varchar(250) NOT NULL,
  "body" text NOT NULL,
  "publish" datetime NOT NULL,
  "created" datetime NOT NULL,
  "updated" datetime NOT NULL,
  "status" varchar(10) NOT NULL,
  "author_id" integer NOT NULL REFERENCES "auth_user" ("id") DEFERRABLE
INITIALLY DEFERRED);
--
-- Create blog_post_publish_bb7600_idx on field(s) -publish of model post
--
CREATE INDEX "blog_post_publish_bb7600_idx" ON "blog_post" ("publish" DESC);
CREATE INDEX "blog_post_slug_b95473f2" ON "blog_post" ("slug");
CREATE INDEX "blog_post_author_id_dd7a8485" ON "blog_post" ("author_id");
COMMIT;
```

The exact output depends on the database you are using. The preceding output is generated for SQLite. As you can see in the output, Django generates the table names by combining the application name and the lowercase name of the model (`blog_post`), but you can also specify a custom database name for your model in the `Meta` class of the model using the `db_table` attribute.

Django creates an auto-incremental `id` column that is used as the primary key for each model, but you can also override this by specifying `primary_key=True` on one of your model fields. The default `id` column consists of an integer that is incremented automatically. This column corresponds to the `id` field that is automatically added to your model.

The following three database indexes are created:

- An index in descending order on the `publish` column. This is the index we explicitly defined with the `indexes` option of the model's `Meta` class.
- An index on the `slug` column because `SlugField` fields imply an index by default.
- An index on the `author_id` column because `ForeignKey` fields imply an index by default.

Let's compare the `Post` model with its corresponding database `blog_post` table:

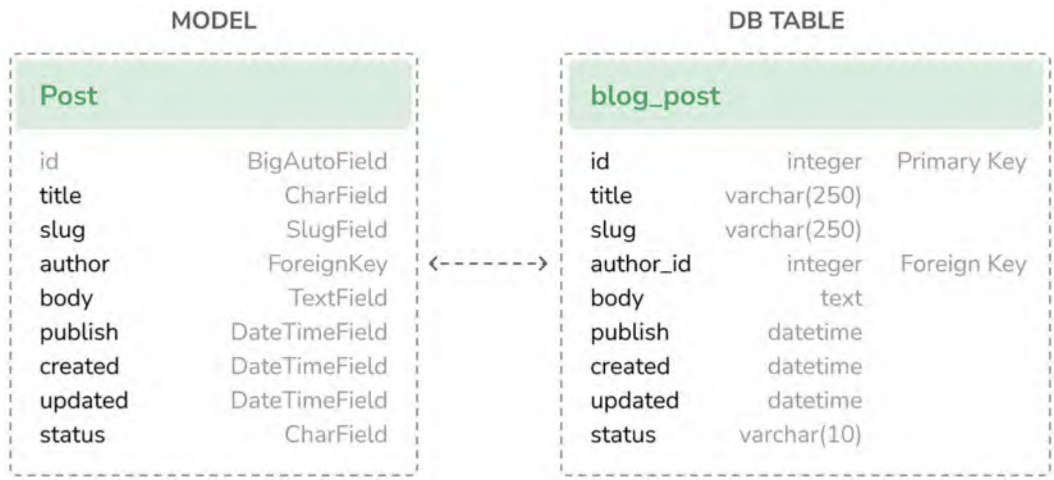


Figure 1.6: Complete Post model and database table correspondence

Figure 1.6 shows how the model fields correspond to database table columns.

Let's sync the database with the new model.

Execute the following command in the shell prompt to apply the existing migrations:

```
python manage.py migrate
```

You will get an output that ends with the following line:

```
Applying blog.0001_initial... OK
```

We just applied migrations for the applications listed in `INSTALLED_APPS`, including the `blog` application. After applying the migrations, the database reflects the current status of the models.

If you edit the `models.py` file in order to add, remove, or change the fields of existing models, or if you add new models, you will have to create a new migration using the `makemigrations` command. Each migration allows Django to keep track of model changes. Then, you will have to apply the migration using the `migrate` command to keep the database in sync with your models.

Creating an administration site for models

Now that the `Post` model is in sync with the database, we can create a simple administration site to manage blog posts.

Django comes with a built-in administration interface that is very useful for editing content. The Django site is built dynamically by reading the model metadata and providing a production-ready interface for editing content. You can use it out of the box, configuring how you want your models to be displayed in it.

The `django.contrib.admin` application is already included in the `INSTALLED_APPS` setting, so you don't need to add it.

Creating a superuser

First, you will need to create a user to manage the administration site. Run the following command:

```
python manage.py createsuperuser
```

You will see the following output. Enter your desired username, email, and password, as follows:

```
Username (leave blank to use 'admin'): admin
Email address: admin@admin.com
Password: ********
Password (again): ********
```

Then, you will see the following success message:

```
Superuser created successfully.
```

We just created an administrator user with the highest permissions.

The Django administration site

Start the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/` in your browser. You should see the administration login page, as shown in *Figure 1.7*:

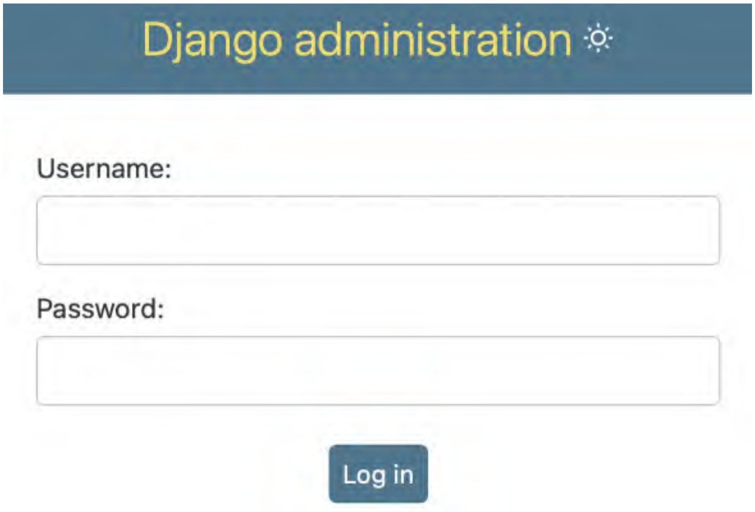


Figure 1.7: The Django administration site login screen

Log in using the credentials of the user you created in the preceding step. You will see the administration site index page, as shown in *Figure 1.8*:

Figure 1.8: The Django administration site index page

The `Group` and `User` models that you can see in the preceding screenshot are part of the Django authentication framework located in `django.contrib.auth`. If you click on **Users**, you will see the user you created previously.

Adding models to the administration site

Let's add your blog models to the administration site. Edit the `admin.py` file of the `blog` application and make it look like this; the new lines are highlighted in bold:

```
from django.contrib import admin
from .models import Post


admin.site.register(Post)
```

Now, reload the administration site in your browser. You should see your `Post` model on the site, as follows:

Figure 1.9: The Post model of the blog application included in the Django administration site index page

That was easy, right? When you register a model in the Django administration site, you get a user-friendly interface generated by introspecting your models that allows you to list, edit, create, and delete objects in a simple way.

Click on the **Add** link beside **Posts** to add a new post. You will note the form that Django has generated dynamically for your model, as shown in *Figure 1.10*:

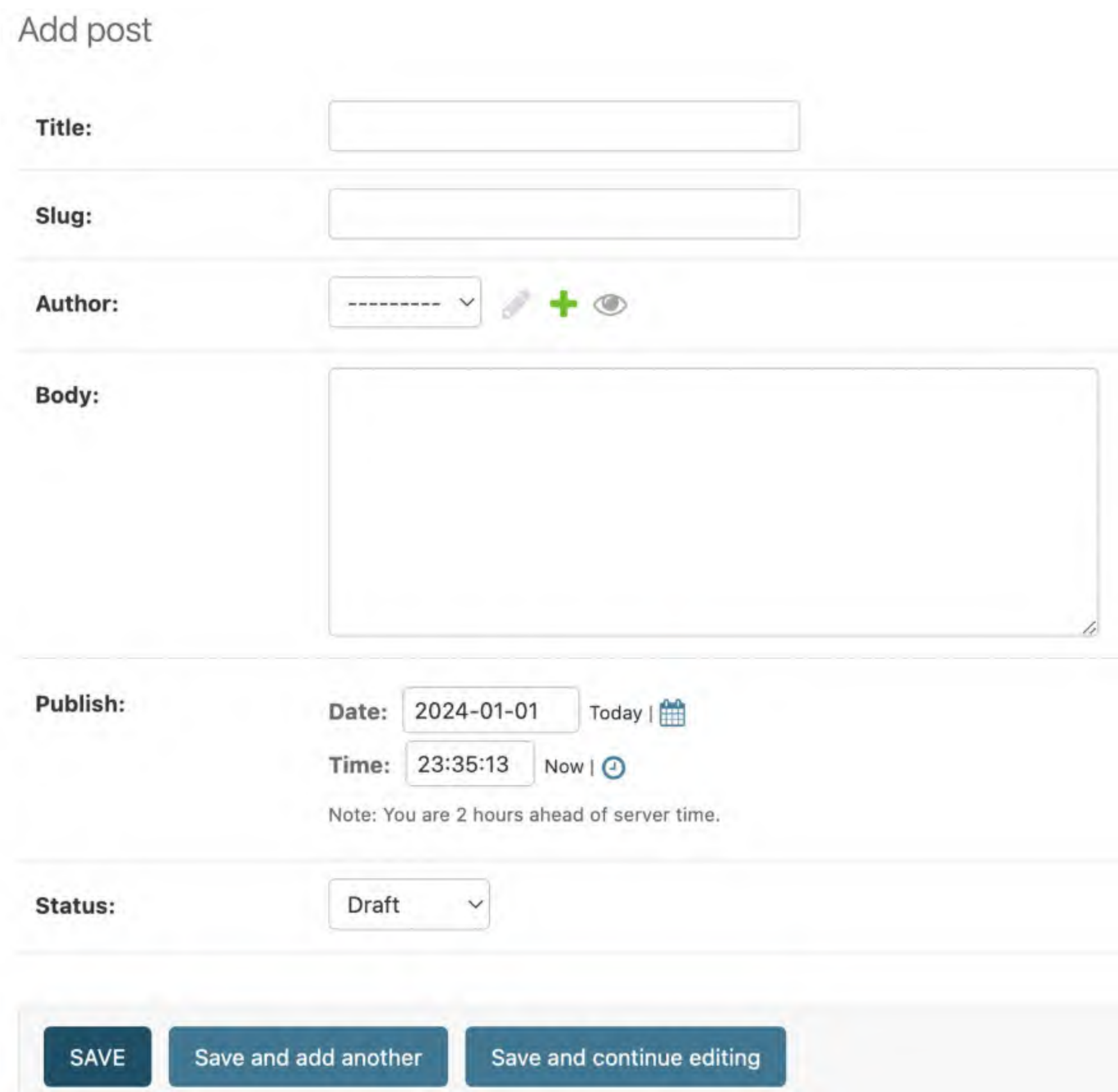


Figure 1.10: The Django administration site edit form for the Post model

Django uses different form widgets for each type of field. Even complex fields, such as `DateTimeField`, are displayed with an easy interface, such as a JavaScript date picker.

Fill in the form and click on the **SAVE** button. You should be redirected to the post list page with a success message and the post you just created, as shown in *Figure 1.11*:

Figure 1.11: The Django administration site list view for the Post model with an added successfully message

Customizing how models are displayed

Now, we will take a look at how to customize the administration site.

Edit the `admin.py` file of your `blog` application and change it, as follows. The new lines are highlighted in bold:

```
from django.contrib import admin
from .models import Post


@admin.register(Post)
class PostAdmin(admin.ModelAdmin):
    list_display = ['title', 'slug', 'author', 'publish', 'status']
```

We are telling the Django administration site that the model is registered in the site using a custom class that inherits from `ModelAdmin`. In this class, we can include information about how to display the model on the administration site and how to interact with it.

The `list_display` attribute allows you to set the fields of your model that you want to display on the administration object list page. The `@admin.register()` decorator performs the same function as the `admin.site.register()` function that you replaced, registering the `ModelAdmin` class that it decorates.

Let's customize the `admin` model with some more options.

Edit the `admin.py` file of your `blog` application and change it, as follows. The new lines are highlighted in bold:

```
from django.contrib import admin
from .models import Post


@admin.register(Post)
class PostAdmin(admin.ModelAdmin):
    list_display = ['title', 'slug', 'author', 'publish', 'status']
    list_filter = ['status', 'created', 'publish', 'author']
    search_fields = ['title', 'body']
    prepopulated_fields = {'slug': ('title',)}
    raw_id_fields = ['author']
    date_hierarchy = 'publish'
    ordering = ['status', 'publish']
```

Return to your browser and reload the post list page. Now, it will look like this:

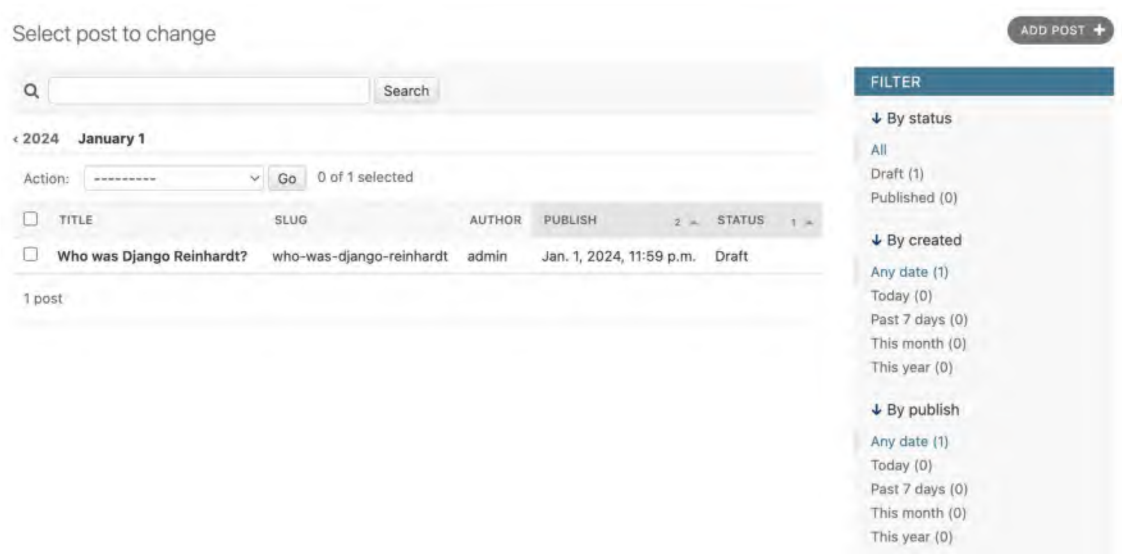


Figure 1.12: The Django administration site custom list view for the Post model

You can see that the fields displayed on the post list page are the ones we specified in the `list_display` attribute. The list page now includes a right sidebar that allows you to filter the results by the fields included in the `list_filter` attribute. Filters for `ForeignKey` fields like `author` are only displayed in the sidebar if more than one object exists in the database.

A search bar has appeared on the page. This is because we have defined a list of searchable fields using the `search_fields` attribute. Just below the search bar, there are navigation links to navigate through a date hierarchy; this has been defined by the `date_hierarchy` attribute. You can also see that the posts are ordered by **STATUS** and **PUBLISH** columns by default. We have specified the default sorting criteria using the `ordering` attribute.

Next, click on the **ADD POST** link. You will also note some changes here. As you type the title of a new post, the `slug` field is filled in automatically. You have told Django to prepopulate the `slug` field with the input of the `title` field using the `prepopulated_fields` attribute:

Figure 1.13: The slug model is now automatically prepopulated as you type in the title

Also, the `author` field is now displayed with a lookup widget, which can be much better than an input selection drop-down when you have thousands of users. This is achieved with the `raw_id_fields` attribute and it looks like this:

Figure 1.14: The widget to select related objects for the Author field of the Post model

Adding facet counts to filters

Django 5.0 introduces facet filters to the administration site, showcasing facet counts. These counts indicate the number of objects corresponding to each specific filter, making it easier to identify matching objects in the admin changelist view. Next, we are going to make sure facet filters are always displayed for the `PostAdmin` admin model.

Edit the `admin.py` file of your `blog` application and add the following line highlighted in bold:

```
from django.contrib import admin
from .models import Post


@admin.register(Post)
class PostAdmin(admin.ModelAdmin):
    list_display = ['title', 'slug', 'author', 'publish', 'status']
    list_filter = ['status', 'created', 'publish', 'author']
    search_fields = ['title', 'body']
    prepopulated_fields = {'slug': ('title',)}
    raw_id_fields = ['author']
    date_hierarchy = 'publish'
    ordering = ['status', 'publish']
    show_facets = admin.ShowFacets.ALWAYS
```

Create some posts using the administration site and access `http://127.0.0.1:8000/admin/blog/post/`. The filters should now include total facet counts, as shown in *Figure 1.15*:

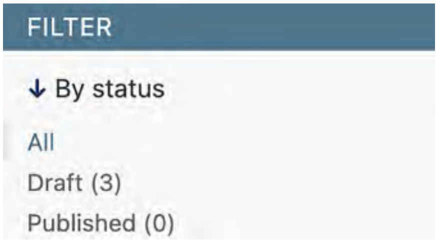


Figure 1.15: Status field filters including facet counts

With a few lines of code, we have customized the way the model is displayed on the administration site. There are plenty of ways to customize and extend the Django administration site; you will learn more about these later in this book.

You can find more information about the Django administration site at `https://docs.djangoproject.com/en/5.0/ref/contrib/admin/`.

Working with QuerySets and managers

Now that we have a fully functional administration site to manage blog posts, it is a good time to learn how to read and write content to the database programmatically.

The Django **object-relational mapper** (**ORM**) is a powerful database abstraction API that lets you create, retrieve, update, and delete objects easily. An ORM allows you to generate SQL queries using the object-oriented paradigm of Python. You can think of it as a way to interact with your database in a Pythonic fashion instead of writing raw SQL queries.

The ORM maps your models to database tables and provides you with a simple Pythonic interface to interact with your database. The ORM generates SQL queries and maps the results to model objects. The Django ORM is compatible with MySQL, PostgreSQL, SQLite, Oracle, and MariaDB.

Remember that you can define the database of your project in the `DATABASES` setting of your project's `settings.py` file. Django can work with multiple databases at a time, and you can program database routers to create custom data routing schemes.

Once you have created your data models, Django gives you a free API to interact with them. You can find the model API reference of the official documentation at `https://docs.djangoproject.com/en/5.0/ref/models/`.

The Django ORM is based on QuerySets. A QuerySet is a collection of database queries to retrieve objects from your database. You can apply filters to QuerySets to narrow down the query results based on given parameters. The QuerySet equates to a `SELECT` SQL statement and the filters are limiting SQL clauses such as `WHERE` or `LIMIT`.

Next, you are going to learn how to build and execute QuerySets.

Creating objects

Run the following command in the shell prompt to open the Python shell:

```
python manage.py shell
```

Then, type the following lines:

```
>>> from django.contrib.auth.models import User
>>> from blog.models import Post
>>> user = User.objects.get(username='admin')
>>> post = Post(title='Another post',
...             slug='another-post',
...             body='Post body.',
...             author=user)
>>> post.save()
```

Let's analyze what this code does.

First, we are retrieving the `user` object with the username `admin`:

```
>>> user = User.objects.get(username='admin')
```

The `get()` method allows us to retrieve a single object from the database. This method executes a `SELECT` SQL statement behind the scenes. Note that this method expects a result that matches the query. If no results are returned by the database, this method will raise a `DoesNotExist` exception, and if the database returns more than one result, it will raise a `MultipleObjectsReturned` exception. Both exceptions are attributes of the model class that the query is being performed on.

Then, we create a `Post` instance with a custom title, slug, and body, and set the user that we previously retrieved as the author of the post:

```
>>> post = Post(title='Another post', slug='another-post', body='Post body.',
author=user)
```

This object is in memory and not persisted to the database; we created a Python object that can be used during runtime but is not saved into the database.

Finally, we are saving the `Post` object in the database using the `save()` method:

```
>>> post.save()
```

This action performs an `INSERT` SQL statement behind the scenes.

We created an object in memory first and then persisted it to the database. However, you can create the object and persist it to the database in a single operation using the `create()` method, as follows:

```
>>> Post.objects.create(title='One more post',
                        slug='one-more-post',
                        body='Post body.',
                        author=user)
```

In certain situations, you might need to fetch an object from the database or create it if it's absent. The `get_or_create()` method facilitates this by either retrieving an object or creating it if not found. This method returns a tuple with the object retrieved and a Boolean indicating whether a new object was created. The following code attempts to retrieve a `User` object with the username `user2`, and if it doesn't exist, it will create one:

```
>>> user, created = User.objects.get_or_create(username='user2')
```

Updating objects

Now, change the title of the previous `Post` object to something different and save the object again:

```
>>> post.title = 'New title'
>>> post.save()
```

This time, the `save()` method performs an `UPDATE` SQL statement.

> The changes you make to a model object are not persisted to the database until you call the `save()` method.

Retrieving objects

You already know how to retrieve a single object from the database using the `get()` method. We accessed this method using `Post.objects.get()`. Each Django model has at least one manager, and the default manager is called `objects`. You get a QuerySet object using your model manager.

To retrieve all objects from a table, we use the `all()` method on the default `objects` manager, like this:

```
>>> all_posts = Post.objects.all()
```

This is how we create a QuerySet that returns all objects in the database. Note that this QuerySet has not been executed yet. Django QuerySets are *lazy*, which means they are only evaluated when they are forced to. This behavior makes QuerySets very efficient. If you don't assign the QuerySet to a variable but, instead, write it directly on the Python shell, the SQL statement of the QuerySet is executed because you are forcing it to generate output:

```
>>> Post.objects.all()
<QuerySet [<Post: Who was Django Reinhardt?>, <Post: New title>]>
```

Filtering objects

To filter a QuerySet, you can use the `filter()` method of the manager. This method allows you to specify the content of a SQL `WHERE` clause by using field lookups.

For example, you can use the following to filter `Post` objects by their `title`:

```
>>> Post.objects.filter(title='Who was Django Reinhardt?')
```

This QuerySet will return all posts with the exact title *Who was Django Reinhardt?*. Let's review the SQL statement generated with this QuerySet. Run the following code in the shell:

```
>>> posts = Post.objects.filter(title='Who was Django Reinhardt?')
>>> print(posts.query)
```

By printing the `query` attribute of the QuerySet, we can get the SQL produced by it:

```
SELECT "blog_post"."id", "blog_post"."title", "blog_post"."slug", "blog_
post"."author_id", "blog_post"."body", "blog_post"."publish", "blog_
post"."created", "blog_post"."updated", "blog_post"."status" FROM "blog_post"
WHERE "blog_post"."title" = Who was Django Reinhardt? ORDER BY "blog_
post"."publish" DESC
```

The generated `WHERE` clause performs an exact match on the `title` column. The `ORDER BY` clause specifies the default order defined in the `ordering` attribute of the `Post` model's `Meta` options since we haven't provided any specific ordering in the QuerySet. You will learn about ordering in a bit. Note that the `query` attribute is not part of the QuerySet public API.

Using field lookups

The previous QuerySet example consists of a filter lookup with an exact match. The QuerySet interface provides you with multiple lookup types. Two underscores are used to define the lookup type, with the format `field__lookup`. For example, the following lookup produces an exact match:

```
>>> Post.objects.filter(id__exact=1)
```

When no specific lookup type is provided, the lookup type is assumed to be `exact`. The following lookup is equivalent to the previous one:

```
>>> Post.objects.filter(id=1)
```

Let's take a look at other common lookup types. You can generate a case-insensitive lookup with `iexact`:

```
>>> Post.objects.filter(title__iexact='who was django reinhardt?')
```

You can also filter objects using a containment test. The `contains` lookup translates to a SQL lookup using the `LIKE` operator:

```
>>> Post.objects.filter(title__contains='Django')
```

The equivalent SQL clause is `WHERE title LIKE '%Django%'`. A case-insensitive version is also available, named `icontains`:

```
>>> Post.objects.filter(title__icontains='django')
```

You can check for a given iterable (often a list, tuple, or another QuerySet object) with the `in` lookup. The following example retrieves posts with an `id` that is `1` or `3`:

```
>>> Post.objects.filter(id__in=[1, 3])
```

The following example shows the greater than (`gt`) lookup:

```
>>> Post.objects.filter(id__gt=3)
```

The equivalent SQL clause is `WHERE ID > 3`.

This example shows the greater than or equal to lookup:

```
>>> Post.objects.filter(id__gte=3)
```

This one shows the less than lookup:

```
>>> Post.objects.filter(id__lt=3)
```

This shows the less than or equal to lookup:

```
>>> Post.objects.filter(id__lte=3)
```

A case-sensitive/insensitive starts-with lookup can be performed with the `startswith` and `istartswith` lookup types, respectively:

```
>>> Post.objects.filter(title__istartswith='who')
```

A case-sensitive/insensitive ends-with lookup can be performed with the `endswith` and `iendswith` lookup types, respectively:

```
>>> Post.objects.filter(title__iendswith='reinhardt?')
```

There are also different lookup types for date lookups. An exact date lookup can be performed as follows:

```
>>> from datetime import date
>>> Post.objects.filter(publish__date=date(2024, 1, 31))
```

This shows how to filter a `DateField` or `DateTimeField` field by year:

```
>>> Post.objects.filter(publish__year=2024)
```

You can also filter by month:

```
>>> Post.objects.filter(publish__month=1)
```

And you can filter by day:

```
>>> Post.objects.filter(publish__day=1)
```

You can chain additional lookups to `date`, `year`, `month`, and `day`. For example, here is a lookup for a value greater than a given date:

```
>>> Post.objects.filter(publish__date__gt=date(2024, 1, 1))
```

To lookup related object fields, you also use the two-underscores notation. For example, to retrieve the posts written by the user with the `admin` username, use the following:

```
>>> Post.objects.filter(author__username='admin')
```

You can also chain additional lookups for the related fields. For example, to retrieve posts written by any user with a username that starts with `ad`, use the following:

```
>>> Post.objects.filter(author__username__starstwith='ad')
```

You can also filter by multiple fields. For example, the following QuerySet retrieves all posts published in 2024 by the author with the username `admin`:

```
>>> Post.objects.filter(publish__year=2024, author__username='admin')
```

Chaining filters

The result of a filtered QuerySet is another QuerySet object. This allows you to chain QuerySets together. You can build an equivalent QuerySet to the previous one by chaining multiple filters:

```
>>> Post.objects.filter(publish__year=2024) \
>>>             .filter(author__username='admin')
```

Excluding objects

You can exclude certain results from your QuerySet by using the `exclude()` method of the manager. For example, you can retrieve all posts published in 2024 whose titles don't start with `Why`:

```
>>> Post.objects.filter(publish__year=2024) \
>>>             .exclude(title__startswith='Why')
```

Ordering objects

The default order is defined in the `ordering` option of the model's `Meta`. You can override the default ordering using the `order_by()` method of the manager. For example, you can retrieve all objects ordered by their `title`, as follows:

```
>>> Post.objects.order_by('title')
```

Ascending order is implied. You can indicate descending order with a negative sign prefix, like this:

```
>>> Post.objects.order_by('-title')
```

You can order by multiple fields. The following example orders objects by `author` first and then `title`:

```
>>> Post.objects.order_by('author', 'title')
```

To order randomly, use the string `'?'`, as follows:

```
>>> Post.objects.order_by('?')
```

Limiting QuerySets

You can limit a QuerySet to a certain number of results by using a subset of Python's array-slicing syntax. For example, the following QuerySet limits the results to 5 objects:

```
>>> Post.objects.all()[:5]
```

This translates to a SQL `LIMIT 5` clause. Note that negative indexing is not supported.

```
>>> Post.objects.all()[3:6]
```

The preceding translates to a SQL `OFFSET 3 LIMIT 6` clause, to return the fourth through sixth objects.

To retrieve a single object, you can use an index instead of a slice. For example, use the following to retrieve the first object of posts in random order:

```
>>> Post.objects.order_by('?')[0]
```

Counting objects

The `count()` method counts the total number of objects matching the QuerySet and returns an integer. This method translates to a `SELECT COUNT(*)` SQL statement. The following example returns the total number of posts with an `id` lower than `3`:

```
>>> Post.objects.filter(id_lt=3).count()
2
```

Checking if an object exists

The `exists()` method allows you to check if a QuerySet contains any results. This method returns `True` if the QuerySet contains any items and `False` otherwise. For example, you can check if there are any posts with a `title` that starts with *Why* using the following QuerySet:

```
>>> Post.objects.filter(title__startswith='Why').exists()
False
```

Deleting objects

If you want to delete an object, you can do it from an object instance using the `delete()` method, as follows:

```
>>> post = Post.objects.get(id=1)
>>> post.delete()
```

Note that deleting objects will also delete any dependent relationships for `ForeignKey` objects defined with `on_delete` set to `CASCADE`.

Complex lookups with Q objects

Field lookups using `filter()` are joined with a SQL `AND` operator. For example, `filter(field1='foo', field2='bar')` will retrieve objects where `field1` is *foo* **and** `field2` is *bar*. If you need to build more complex queries, such as queries with `OR` statements, you can use `Q` objects.

A `Q` object allows you to encapsulate a collection of field lookups. You can compose statements by combining `Q` objects with the `&` (and), `|` (or), and `^` (xor) operators.

For example, the following code retrieves posts with a title that starts with the string *who* **or** *why* (case-insensitive):

```
>>> from django.db.models import Q
>>> starts_who = Q(title__istartswith='who')
>>> starts_why = Q(title__istartswith='why')
>>> Post.objects.filter(starts_who | starts_why)
```

In this case, we use the `|` operator to build an `OR` statement.

You can read more about `Q` objects at `https://docs.djangoproject.com/en/5.0/topics/db/queries/#complex-lookups-with-q-objects`.

When QuerySets are evaluated

Creating a QuerySet doesn't involve any database activity until it is evaluated. QuerySets will usually return another unevaluated QuerySet. You can concatenate as many filters as you like to a QuerySet, and you will not hit the database until the QuerySet is evaluated. When a QuerySet is evaluated, it translates into a SQL query to the database.

QuerySets are only evaluated in the following cases:

- The first time you iterate over them
- When you slice them, for instance, `Post.objects.all()[:3]`
- When you pickle or cache them
- When you call `repr()` or `len()` on them
- When you explicitly call `list()` on them
- When you test them in a statement, such as `bool()`, `or`, `and`, or `if`

More on QuerySets

You will use QuerySets in all the project examples featured in this book. You will learn how to generate aggregates over QuerySets in the *Retrieving posts by similarity* section of *Chapter 3, Extending Your Blog Application*.

You will learn how to optimize QuerySets in the *Optimizing QuerySets that involve related objects* section in *Chapter 7, Tracking User Actions*.

The QuerySet API reference is located at `https://docs.djangoproject.com/en/5.0/ref/models/querysets/`.

You can read more about making queries with the Django ORM at `https://docs.djangoproject.com/en/5.0/topics/db/queries/`.

Creating model managers

The default manager for every model is the `objects` manager. This manager retrieves all the objects in the database. However, we can define custom managers for models.

Let's create a custom manager to retrieve all posts that have a `PUBLISHED` status.

There are two ways to add or customize managers for your models: you can add extra manager methods to an existing manager or create a new manager by modifying the initial QuerySet that the manager returns. The first method provides you with a QuerySet notation like `Post.objects.my_manager()`, and the latter provides you with a QuerySet notation like `Post.my_manager.all()`.

We will choose the second method to implement a manager that will allow us to retrieve posts using the notation `Post.published.all()`.

Edit the `models.py` file of your `blog` application to add the custom manager, as follows. The new lines are highlighted in bold:

```
class PublishedManager(models.Manager):
    def get_queryset(self):
        return (
            super().get_queryset().filter(status=Post.Status.PUBLISHED)
        )


class Post(models.Model):
    # model fields
    # ...
    objects = models.Manager() # The default manager.
    published = PublishedManager() # Our custom manager.

    class Meta:
        ordering = ['-publish']
        indexes = [
            models.Index(fields=['-publish']),
        ]

    def __str__(self):
        return self.title
```

The first manager declared in a model becomes the default manager. You can use the `Meta` attribute `default_manager_name` to specify a different default manager. If no manager is defined in the model, Django automatically creates the `objects` default manager for it. If you declare any managers for your model but you want to keep the `objects` manager as well, you have to add it explicitly to your model. In the preceding code, we have added the default `objects` manager and the `published` custom manager to the `Post` model.

The `get_queryset()` method of a manager returns the QuerySet that will be executed. We have overridden this method to build a custom QuerySet that filters posts by their status and returns a successive QuerySet that only includes posts with the `PUBLISHED` status.

We have now defined a custom manager for the `Post` model. Let's test it!

Start the development server again with the following command in the shell prompt:

```
python manage.py shell
```

Now, you can import the `Post` model and retrieve all published posts whose title starts with `Who`, executing the following QuerySet:

```
>>> from blog.models import Post
>>> Post.published.filter(title__startswith='Who')
```

To obtain results for this QuerySet, make sure to set the `status` field to `PUBLISHED` in the `Post` object whose `title` starts with the string *Who*.

Building list and detail views

Now that you understand how to use the ORM, you are ready to build the views of the `blog` application. A Django view is just a Python function that receives a web request and returns a web response. All the logic to return the desired response goes inside the view.

First, you will create your application views, then you will define a URL pattern for each view, and finally, you will create HTML templates to render the data generated by the views. Each view will render a template, passing variables to it, and will return an HTTP response with the rendered output.

Creating list and detail views

Let's start by creating a view to display the list of posts.

Edit the `views.py` file of the `blog` application and make it look like this; the new lines are highlighted in bold:

```
from django.shortcuts import render
from .models import Post


def post_list(request):
    posts = Post.published.all()
```

```
    return render(
        request,
        'blog/post/list.html',
        {'posts': posts}
    )
```

This is our very first Django view. The `post_list` view takes the `request` object as the only parameter. This parameter is required by all views.

In this view, we retrieve all the posts with the `PUBLISHED` status using the `published` manager that we created previously.

Finally, we use the `render()` shortcut provided by Django to render the list of posts with the given template. This function takes the `request` object, the template path, and the context variables to render the given template. It returns an `HttpResponse` object with the rendered text (normally HTML code).

The `render()` shortcut takes the request context into account, so any variable set by the template context processors is accessible by the given template. Template context processors are just callables that set variables into the context. You will learn how to use context processors in *Chapter 4*, *Building a Social Website*.

Let's create a second view to display a single post. Add the following function to the `views.py` file:

```
from django.http import Http404

def post_detail(request, id):
    try:
        post = Post.published.get(id=id)
    except Post.DoesNotExist:
        raise Http404("No Post found.")
    return render(
        request,
        'blog/post/detail.html',
        {'post': post}
    )
```

This is the `post_detail` view. This view takes the `id` argument of a post. In the view, we try to retrieve the `Post` object with the given `id` by calling the `get()` method on the `published` manager. We raise an `Http404` exception to return an HTTP 404 error if the model `DoesNotExist` exception is raised because no result is found.

Finally, we use the `render()` shortcut to render the retrieved post using a template.

Using the get_object_or_404 shortcut

Django provides a shortcut to call `get()` on a given model manager and raises an `Http404` exception instead of a `DoesNotExist` exception when no object is found.

Edit the `views.py` file to import the `get_object_or_404` shortcut and change the `post_detail` view, as follows. The new code is highlighted in bold:

```
from django.shortcuts import get_object_or_404, render

# ...

def post_detail(request, id):
    post = get_object_or_404(
        Post,
        id=id,
        status=Post.Status.PUBLISHED
    )
    return render(
        request,
        'blog/post/detail.html',
        {'post': post}
    )
```

In the detail view, we now use the `get_object_or_404()` shortcut to retrieve the desired post. This function retrieves the object that matches the given parameters or an HTTP 404 (not found) exception if no object is found.

Adding URL patterns for your views

URL patterns allow you to map URLs to views. A URL pattern is composed of a string pattern, a view, and, optionally, a name that allows you to name the URL project-wide. Django runs through each URL pattern and stops at the first one that matches the requested URL. Then, Django imports the view of the matching URL pattern and executes it, passing an instance of the `HttpRequest` class and the keyword or positional arguments.

Create a `urls.py` file in the directory of the `blog` application and add the following lines to it:

```
from django.urls import path
from . import views


app_name = 'blog'

urlpatterns = [
    # post views
    path('', views.post_list, name='post_list'),
    path('<int:id>/', views.post_detail, name='post_detail'),
]
```

In the preceding code, you define an application namespace with the `app_name` variable. This allows you to organize URLs by application and use the name when referring to them. You define two different patterns using the `path()` function. The first URL pattern doesn't take any arguments and is mapped to the `post_list` view. The second pattern is mapped to the `post_detail` view and takes only one argument `id`, which matches an integer, set by the path converter `int`.

You use angle brackets to capture the values from the URL. Any value specified in the URL pattern as <parameter> is captured as a string. You use path converters, such as <int:year>, to specifically match and return an integer. For example <slug:post> would specifically match a slug (a string that can only contain letters, numbers, underscores, or hyphens). You can see all the path converters provided by Django at `https://docs.djangoproject.com/en/5.0/topics/http/urls/#path-converters`.

If using `path()` and converters isn't sufficient for you, you can use `re_path()` instead to define complex URL patterns with Python regular expressions. You can learn more about defining URL patterns with regular expressions at `https://docs.djangoproject.com/en/5.0/ref/urls/#django.urls.re_path`. If you haven't worked with regular expressions before, you might want to take a look at *Regular Expression HOWTO*, located at `https://docs.python.org/3/howto/regex.html`, first.

> Creating a `urls.py` file for each application is the best way to make your applications reusable by other projects.

Next, you have to include the URL patterns of the `blog` application in the main URL patterns of the project.

Edit the `urls.py` file located in the `mysite` directory of your project and make it look like the following. The new code is highlighted in bold:

```
from django.contrib import admin
from django.urls import include, path


urlpatterns = [
    path('admin/', admin.site.urls),
    path('blog/', include('blog.urls', namespace='blog')),
]
```

The new URL pattern defined with `include` refers to the URL patterns defined in the `blog` application so that they are included under the `blog/` path. You include these patterns under the namespace `blog`. Namespaces have to be unique across your entire project. Later, you will refer to your blog URLs easily by using the namespace followed by a colon and the URL name, for example, `blog:post_list` and `blog:post_detail`. You can learn more about URL namespaces at `https://docs.djangoproject.com/en/5.0/topics/http/urls/#url-namespaces`.

Creating templates for your views

You have created views and URL patterns for the `blog` application. URL patterns map URLs to views, and views decide which data gets returned to the user. Templates define how the data is displayed; they are usually written in HTML in combination with the Django template language. You can find more information about the Django template language at `https://docs.djangoproject.com/en/5.0/ref/templates/language/`.

Let's add templates to your application to display posts in a user-friendly manner.

Create the following directories and files inside your `blog` application directory:

```
templates/
    blog/
        base.html
        post/
            list.html
            detail.html
```

The preceding structure will be the file structure for your templates. The `base.html` file will include the main HTML structure of the website and divide the content into the main content area and a sidebar. The `list.html` and `detail.html` files will inherit from the `base.html` file to render the blog post list and detail views, respectively.

Django has a powerful template language that allows you to specify how data is displayed. It is based on *template tags*, *template variables*, and *template filters*:

- Template tags control the rendering of the template and look like this: `{% tag %}`.
- Template variables get replaced with values when the template is rendered and look like this: `{{ variable }}`.
- Template filters allow you to modify variables for display and look like this: `{{ variable|filter }}`.

You can see all the built-in template tags and filters at `https://docs.djangoproject.com/en/5.0/ref/templates/builtins/`.

Creating a base template

Edit the `base.html` file and add the following code:

```
{% load static %}
<!DOCTYPE html>
<html>
<head>
  <title>{% block title %}{% endblock %}</title>
  <link href="{% static "css/blog.css" %}" rel="stylesheet">
</head>
<body>
```

```
    <div id="content">
      {% block content %}
      {% endblock %}
    </div>
    <div id="sidebar">
      <h2>My blog</h2>
      <p>This is my blog.</p>
    </div>
  </body>
  </html>
```

`{% load static %}` tells Django to load the `static` template tags that are provided by the `django.contrib.staticfiles` application, which is contained in the `INSTALLED_APPS` setting. After loading them, you can use the `{% static %}` template tag throughout this template. With this template tag, you can include the static files, such as the `blog.css` file, which you will find in the code of this example under the `static/` directory of the `blog` application. Copy the `static/` directory from the code that comes along with this chapter into the same location as your project to apply the CSS styles to the templates. You can find the directory's contents at `https://github.com/PacktPublishing/Django-5-by-example/tree/master/Chapter01/mysite/blog/static`.

You can see that there are two `{% block %}` tags. These tell Django that you want to define a block in that area. Templates that inherit from this template can fill in the blocks with content. You have defined a block called `title` and a block called `content`.

Creating the post list template

Let's edit the `post/list.html` file and make it look like the following:

```
{% extends "blog/base.html" %}

{% block title %}My Blog{% endblock %}

{% block content %}
  <h1>My Blog</h1>
  {% for post in posts %}
    <h2>
      <a href="{% url 'blog:post_detail' post.id %}">
        {{ post.title }}
      </a>
    </h2>
    <p class="date">
      Published {{ post.publish }} by {{ post.author }}
    </p>
```

```
      {{ post.body|truncatewords:30|linebreaks }}
    {% endfor %}
  {% endblock %}
```

With the `{% extends %}` template tag, you tell Django to inherit from the `blog/base.html` template. Then, you fill the `title` and `content` blocks of the base template with content. You iterate through the posts and display their title, date, author, and body, including a link in the title to the detail URL of the post. We build the URL using the `{% url %}` template tag provided by Django.

This template tag allows you to build URLs dynamically by their name. We use `blog:post_detail` to refer to the `post_detail` URL in the `blog` namespace. We pass the required `post.id` parameter to build the URL for each post.

> Always use the `{% url %}` template tag to build URLs in your templates instead of writing hardcoded URLs. This will make your URLs more maintainable.

In the body of the post, we apply two template filters: `truncatewords` truncates the value to the number of words specified, and `linebreaks` converts the output into HTML line breaks. You can concatenate as many template filters as you wish; each one will be applied to the output generated by the preceding one.

Accessing our application

Change the status of the initial post to **Published**, as shown in *Figure 1.16*, and create some new posts, also with a **Published** status.

Figure 1.16: The status field for a published post

Open the shell and execute the following command to start the development server:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/blog/` in your browser; you will see everything running. You should see something like this:

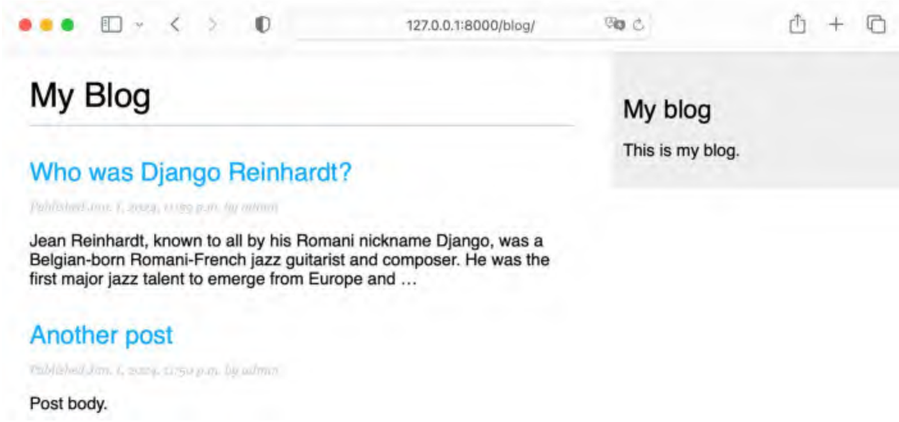


Figure 1.17: The page for the post list view

Creating the post detail template

Next, edit the `post/detail.html` file:

```
{% extends "blog/base.html" %}

{% block title %}{{ post.title }}{% endblock %}

{% block content %}
  <h1>{{ post.title }}</h1>
  <p class="date">
    Published {{ post.publish }} by {{ post.author }}
  </p>
  {{ post.body|linebreaks }}
{% endblock %}
```

Next, you can return to your browser and click on one of the post titles to take a look at the detail view of the post. You should see something like this:

Figure 1.18: The page for the post's detail view

Take a look at the URL – it should include the auto-generated post ID, like `/blog/1/`.

The request/response cycle

Let's review the request/response cycle of Django with the application we built. The following schema shows a simplified example of how Django processes HTTP requests and generates HTTP responses:

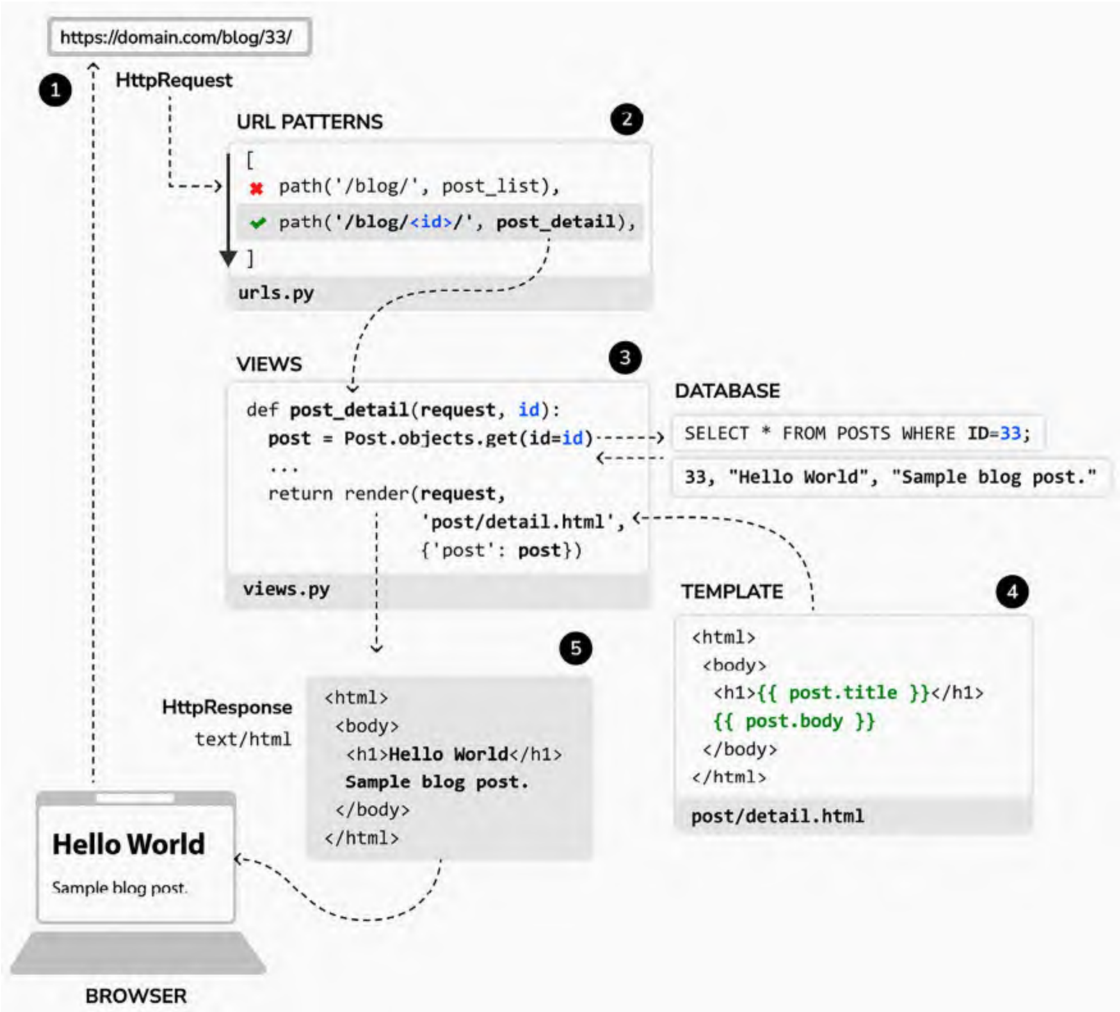


Figure 1.19: The Django request/response cycle

Let's review the Django request/response process:

A web browser requests a page by its URL, for example, `https://domain.com/blog/33/`. The web server receives the HTTP request and passes it over to Django.

Django runs through each URL pattern defined in the URL patterns configuration. The framework checks each pattern against the given URL path, in order of appearance, and stops at the first one that matches the requested URL. In this case, the pattern `/blog/<id>/` matches the path `/blog/33/`.

Django imports the view of the matching URL pattern and executes it, passing an instance of the `HttpRequest` class and the keyword or positional arguments. The view uses the models to retrieve information from the database. Using the Django ORM, QuerySets are translated into SQL and executed in the database.

The view uses the `render()` function to render an HTML template passing the `Post` object as a context variable.

The rendered content is returned as a `HttpResponse` object by the view with the `text/html` content type by default.

You can always use this schema as the basic reference for how Django processes requests. This schema doesn't include Django middleware, for the sake of simplicity. You will use middleware in different examples of this book, and you will learn how to create custom middleware in *Chapter 17*, *Going Live*.

Management commands used in this chapter

In this chapter, we have introduced a variety of Django management commands. You need to get familiar with them, as they will be used often throughout the book. Let's revisit the commands we have covered in this chapter.

To create the file structure for a new Django project named `mysite`, we used the following command:

```
django-admin startproject mysite
```

To create the file structure for a new Django application named `blog`:

```
python manage.py startapp blog
```

To apply all database migrations:

```
python manage.py migrate
```

To create migrations for the models of the `blog` application:

```
python manage.py makemigrations blog
```

To view the SQL statements that will be executed with the first migration of the `blog` application:

```
python manage.py sqlmigrate blog 0001
```

To run the Django development server:

```
python manage.py runserver
```

To run the development server specifying host/port and settings file:

```
python manage.py runserver 127.0.0.1:8001 --settings=mysite.settings
```

To run the Django shell:

```
python manage.py shell
```

To create a superuser using the Django authentication framework:

```
python manage.py createsuperuser
```

For the full list of available management commands, check out `https://docs.djangoproject.com/en/5.0/ref/django-admin/`.

Summary

In this chapter, you learned the basics of the Django web framework by creating a simple blog application. You designed the data models and applied migrations to the database. You also created the views, templates, and URLs for your blog.

In the next chapter, you will enhance your blog by creating canonical URLs for your posts and building SEO-friendly URLs. You will also learn how to implement object pagination and how to build class-based views. You will also create forms to let your users recommend posts by email and comment on posts.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter01`
- Download Python: `https://www.python.org/downloads/`
- Windows Python launcher: `https://docs.python.org/3/using/windows.html#launcher`
- Python `venv` library for virtual environments: `https://docs.python.org/3/library/venv.html`
- Python `pip` installation instructions: at `https://pip.pypa.io/en/stable/installation/`
- Django installation options: `https://docs.djangoproject.com/en/5.0/topics/install/`
- Django 5.0 release notes: `https://docs.djangoproject.com/en/5.0/releases/5.0/`
- The `django-upgrade` tool: `https://github.com/adamchainz/django-upgrade`
- The `pyupgrade` tool: `https://github.com/asottile/pyupgrade`
- Django's design philosophies: `https://docs.djangoproject.com/en/5.0/misc/design-philosophies/`
- Django model field reference: `https://docs.djangoproject.com/en/5.0/ref/models/fields/`
- Model index reference: `https://docs.djangoproject.com/en/5.0/ref/models/indexes/`
- Python support for enumerations: `https://docs.python.org/3/library/enum.html`
- Django model enumeration types: `https://docs.djangoproject.com/en/5.0/ref/models/fields/#enumeration-types`
- Django settings reference: `https://docs.djangoproject.com/en/5.0/ref/settings/`
- Database default values for model fields: `https://docs.djangoproject.com/en/5.0/ref/models/fields/#django.db.models.Field.db_default`
- Database functions: `https://docs.djangoproject.com/en/5.0/ref/models/database-functions/`

- Django administration site: `https://docs.djangoproject.com/en/5.0/ref/contrib/admin/`
- Model API reference: `https://docs.djangoproject.com/en/5.0/ref/models/`
- Making queries with the Django ORM: `https://docs.djangoproject.com/en/5.0/topics/db/queries/`
- QuerySet API reference: `https://docs.djangoproject.com/en/5.0/ref/models/querysets/`
- Complex lookups with Q objects: `https://docs.djangoproject.com/en/5.0/topics/db/queries/#complex-lookups-with-q-objects`
- Django URL dispatcher: `https://docs.djangoproject.com/en/5.0/topics/http/urls/`
- Django template language: `https://docs.djangoproject.com/en/5.0/ref/templates/language/`
- Built-in template tags and filters: `https://docs.djangoproject.com/en/5.0/ref/templates/builtins/`
- Django management commands: `https://docs.djangoproject.com/en/5.0/ref/django-admin/`
- Static files for the code in this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/master/Chapter01/mysite/blog/static`

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`https://packt.link/Django5ByExample`

2

Enhancing Your Blog and Adding Social Features

In the preceding chapter, we learned the main components of Django by developing a simple blog application using views, templates, and URLs. In this chapter, we will extend the functionalities of the blog application with features that can be found in many blogging platforms nowadays.

In this chapter, you will learn the following topics:

- Using canonical URLs for models
- Creating SEO-friendly URLs for posts
- Adding pagination to the post list view
- Building class-based views
- Sending emails with Django
- Using Django forms to share posts via email
- Adding comments to posts using forms from models

Functional overview

Figure 2.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

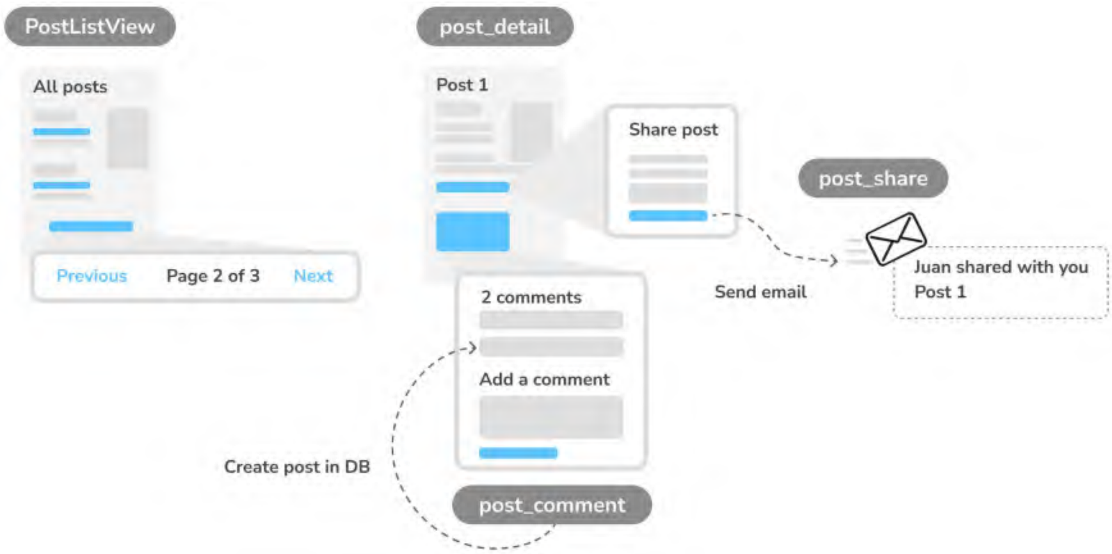

Figure 2.1: Diagram of functionalities built in Chapter 2

In this chapter, we will add pagination to the post list page to navigate through all posts. We will also learn how to build class-based views with Django and convert the `post_list` view to a class-based view named `PostListView`.

We will create the `post_share` view to share posts via email. We will use Django forms to share posts and send email recommendations via **Simple Mail Transfer Protocol** (**SMTP**). To add comments to posts, we will create a `Comment` model to store comments, and we will build the `post_comment` view using forms for models.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter02`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all the requirements at once with the `python -m pip install -r requirements.txt` command.

Using canonical URLs for models

A website might have different pages that display the same content. In our application, the initial part of the content for each post is displayed both on the post list page and the post detail page. A canonical URL is the preferred URL for a resource. You can think of it as the URL of the most representative page for specific content. There might be different pages on your site that display posts, but there is a single URL that you use as the main URL for a post.

Canonical URLs allow you to specify the URL for the master copy of a page. Django allows you to implement the `get_absolute_url()` method in your models to return the canonical URL for the object.

We will use the `post_detail` URL defined in the URL patterns of the application to build the canonical URL for `Post` objects. Django provides different URL resolver functions that allow you to build URLs dynamically using their name and any required parameters. We will use the `reverse()` utility function of the `django.urls` module.

Edit the `models.py` file of the `blog` application to import the `reverse()` function and add the `get_absolute_url()` method to the `Post` model as follows. The new code is highlighted in bold:

```
from django.conf import settings
from django.db import models
from django.urls import reverse
from django.utils import timezone


class PublishedManager(models.Manager):
    def get_queryset(self):
        return (
            super().get_queryset().filter(status=Post.Status.PUBLISHED)
        )

class Post(models.Model):
    # ...
    class Meta:
        ordering = ['-publish']
        indexes = [
            models.Index(fields=['-publish']),
        ]

    def __str__(self):
        return self.title

    def get_absolute_url(self):
        return reverse(
            'blog:post_detail',
            args=[self.id]
    )
```

The `reverse()` function will build the URL dynamically using the URL name defined in the URL patterns. We have used the `blog` namespace followed by a colon and the `post_detail` URL name. Remember that the `blog` namespace is defined in the main `urls.py` file of the project when including the URL patterns from `blog.urls`. The `post_detail` URL is defined in the `urls.py` file of the `blog` application.

The resulting string, `blog:post_detail`, can be used globally in your project to refer to the post detail URL. This URL has a required parameter, which is the `id` of the blog post to retrieve. We have included the `id` of the `Post` object as a positional argument by using `args=[self.id]`.

You can learn more about the URL's utility functions at `https://docs.djangoproject.com/en/5.0/ref/urlresolvers/`.

Let's replace the post detail URLs in the templates with the new `get_absolute_url()` method.

Edit the `blog/post/list.html` file and replace the following line:

```
<a href="{% url 'blog:post_detail' post.id %}">
```

Replace the preceding line with the following line:

```
<a href="{{ post.get_absolute_url }}">
```

The `blog/post/list.html` file should now look as follows:

```
{% extends "blog/base.html" %}

{% block title %}My Blog{% endblock %}

{% block content %}
  <h1>My Blog</h1>
  {% for post in posts %}
    <h2>
      <a href="{{ post.get_absolute_url }}">
        {{ post.title }}
      </a>
    </h2>
    <p class="date">
      Published {{ post.publish }} by {{ post.author }}
    </p>
    {{ post.body|truncatewords:30|linebreaks }}
  {% endfor %}
{% endblock %}
```

Open the shell prompt and execute the following command to start the development server:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/blog/` in your browser. Links to individual blog posts should still work. Django now builds the post URLs using the `get_absolute_url()` method of the `Post` model.

Creating SEO-friendly URLs for posts

The canonical URL for a blog post detail view currently looks like `/blog/1/`. We will change the URL pattern to create SEO-friendly URLs for posts. We will be using both the `publish` date and `slug` values to build the URLs for single posts. By combining dates, we will make a post detail URL to look like `/blog/2024/1/1/who-was-django-reinhardt/`. We will provide search engines with friendly URLs to index, containing both the title and date of the post.

To retrieve single posts with the combination of publication date and slug, we need to ensure that no post can be stored in the database with the same `slug` and `publish` date as an existing post. We will prevent the `Post` model from storing duplicated posts by defining slugs to be unique for the publication date of the post.

Edit the `models.py` file and add the following `unique_for_date` parameter to the `slug` field of the `Post` model:

```
class Post(models.Model):
    # ...
    slug = models.SlugField(
        max_length=250,
        unique_for_date='publish'
    )
    # ...
```

By using `unique_for_date`, the `slug` field is now required to be unique for the date stored in the `publish` field. Note that the `publish` field is an instance of `DateTimeField`, but the check for unique values will be done only against the date (not the time). Django will prevent you from saving a new post with the same slug as an existing post for a given publication date. We have now ensured that slugs are unique for the publication date, so we can now retrieve single posts by the `publish` and `slug` fields.

We have changed our models, so, let's create migrations. Note that `unique_for_date` is not enforced at the database level, so no database migration is required. However, Django uses migrations to keep track of all model changes. We will create a migration just to keep migrations aligned with the current state of the model.

Run the following command in the shell prompt:

```
python manage.py makemigrations blog
```

You should get the following output:

```
Migrations for 'blog':
    blog/migrations/0002_alter_post_slug.py
    - Alter field slug on post
```

Django just created the `0002_alter_post_slug.py` file inside the `migrations` directory of the `blog` application.

Execute the following command in the shell prompt to apply existing migrations:

```
python manage.py migrate
```

You will get an output that ends with the following line:

```
Applying blog.0002_alter_post_slug... OK
```

Django will consider that all migrations have been applied and the models are in sync. No action will be done in the database because `unique_for_date` is not enforced at the database level.

Modifying the URL patterns

Let's modify the URL patterns to use the publication date and slug for the post detail URL.

Edit the `urls.py` file of the `blog` application and replace the following line:

```
path('<int:id>/', views.post_detail, name='post_detail'),
```

Replace the preceding line with the following lines:

```
path(
    '<int:year>/<int:month>/<int:day>/<slug:post>/',
    views.post_detail,
    name='post_detail'
),
```

The `urls.py` file should now look like this:

```
from django.urls import path
from . import views


app_name = 'blog'

urlpatterns = [
    # Post views
    path('', views.post_list, name='post_list'),
    path(
        '<int:year>/<int:month>/<int:day>/<slug:post>/',
        views.post_detail,
        name='post_detail'
    ),
]
```

The URL pattern for the `post_detail` view takes the following arguments:

- `year`: This requires an integer
- `month`: This requires an integer

- day: This requires an integer
- post: This requires a slug (a string that contains only letters, numbers, underscores, or hyphens)

The int path converter is used for the year, month, and day parameters, whereas the slug path converter is used for the post parameter. You learned about path converters in the previous chapter. You can see all path converters provided by Django at https://docs.djangoproject.com/en/5.0/topics/http/urls/#path-converters.

Our posts have now an SEO-friendly URL that is built with the date and slug of each post. Let's modify the post_detail view accordingly.

Modifying the views

We will change the parameters of the post_detail view to match the new URL parameters and use them to retrieve the corresponding Post object.

Edit the views.py file and edit the post_detail view like this:

```
def post_detail(request, year, month, day, post):
    post = get_object_or_404(
        Post,
        status=Post.Status.PUBLISHED,
        slug=post,
        publish__year=year,
        publish__month=month,
        publish__day=day)
    return render(
        request,
        'blog/post/detail.html',
        {'post': post}
    )
```

We have modified the post_detail view to take the year, month, day, and post arguments and retrieve a published post with the given slug and publication date. By adding unique_for_date='publish' to the slug field of the Post model, we ensured that there would be only one post with a slug for a given date. Thus, you can retrieve single posts using the date and slug.

Modifying the canonical URL for posts

We also have to modify the parameters of the canonical URL for blog posts to match the new URL parameters.

Edit the models.py file of the blog application and edit the get_absolute_url() method as follows:

```
class Post(models.Model):
    # ...
    def get_absolute_url(self):
```

```
        return reverse(
            'blog:post_detail',
            args=[
                self.publish.year,
                self.publish.month,
                self.publish.day,
                self.slug
            ]
        )
```

Start the development server by typing the following command in the shell prompt:

```
python manage.py runserver
```

Next, you can return to your browser and click on one of the post titles to take a look at the detail view of the post. You should see something like this:

Figure 2.2: The page for the post's detail view

You have designed SEO-friendly URLs for the blog posts. The URL for a post now looks like `/blog/2024/1/1/who-was-django-reinhardt/`.

Now that you have implemented SEO-friendly URLs, let's focus on implementing navigation through posts using pagination.

Adding pagination

When you start adding content to your blog, you can easily store tens or hundreds of posts in your database. Instead of displaying all the posts on a single page, you may want to split the list of posts across several pages and include navigation links to the different pages. This functionality is called pagination, and you can find it in almost every web application that displays long lists of items.

For example, Google uses pagination to divide search results across multiple pages. *Figure 2.3* shows Google's pagination links for search result pages:

Figure 2.3: Google pagination links for search result pages

Django has a built-in pagination class that allows you to manage paginated data easily. You can define the number of objects you want to be returned per page and you can retrieve the posts that correspond to the page requested by the user.

Adding pagination to the post list view

We will add pagination to the list of posts so that users can easily navigate through all posts published on the blog.

Edit the `views.py` file of the `blog` application to import the Django `Paginator` class and modify the `post_list` view as follows:

```
from django.core.paginator import Paginator
from django.shortcuts import get_object_or_404, render
from .models import Post


def post_list(request):
    post_list = Post.published.all()
    # Pagination with 3 posts per page
    paginator = Paginator(post_list, 3)
    page_number = request.GET.get('page', 1)
    posts = paginator.page(page_number)

    return render(
        request,
        'blog/post/list.html',
        {'posts': posts}
    )
```

Let's review the new code we have added to the view:

1. We instantiate the `Paginator` class with the number of objects to return per page. We will display three posts per page.
2. We retrieve the `page` `GET` HTTP parameter and store it in the `page_number` variable. This parameter contains the requested page number. If the `page` parameter is not in the `GET` parameters of the request, we use the default value `1` to load the first page of results.
3. We obtain the objects for the desired page by calling the `page()` method of `Paginator`. This method returns a `Page` object that we store in the `posts` variable.
4. We pass the `posts` object to the template.

Creating a pagination template

We need to create a page navigation for users to browse through the different pages. In this section, we will create a template to display the pagination links, and we'll make it generic so that we can reuse the template for any object pagination on our website.

In the `templates/` directory, create a new file and name it `pagination.html`. Add the following HTML code to the file:

```
<div class="pagination">
  <span class="step-links">
    {% if page.has_previous %}
      <a href="?page={{ page.previous_page_number }}">Previous</a>
    {% endif %}
    <span class="current">
      Page {{ page.number }} of {{ page.paginator.num_pages }}.
    </span>
    {% if page.has_next %}
      <a href="?page={{ page.next_page_number }}">Next</a>
    {% endif %}
  </span>
</div>
```

This is the generic pagination template. The template expects to have a `Page` object in the context to render the previous and next links and to display the current page and total pages of results.

Let's return to the `blog/post/list.html` template and include the `pagination.html` template at the bottom of the `{% content %}` block, as follows:

```
{% extends "blog/base.html" %}

{% block title %}My Blog{% endblock %}

{% block content %}
  <h1>My Blog</h1>
  {% for post in posts %}
    <h2>
      <a href="{{ post.get_absolute_url }}">
        {{ post.title }}
      </a>
    </h2>
    <p class="date">
      Published {{ post.publish }} by {{ post.author }}
    </p>
    {{ post.body|truncatewords:30|linebreaks }}
  {% endfor %}
  {% include "pagination.html" with page=posts %}
{% endblock %}
```

The `{% include %}` template tag loads the given template and renders it using the current template context. We use `with` to pass additional context variables to the template. The pagination template uses the `page` variable to render, while the `Page` object that we pass from our view to the template is called `posts`. We use `with page=posts` to pass the variable expected by the pagination template. You can follow this method to use the pagination template for any type of object.

Start the development server by typing the following command in the shell prompt:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/blog/post/` in your browser and use the administration site to create a total of four different posts. Make sure to set the status to **Published** for all of them.

Now, open `http://127.0.0.1:8000/blog/` in your browser. You should see the first three posts in reverse chronological order, and then the navigation links at the bottom of the post list like this:

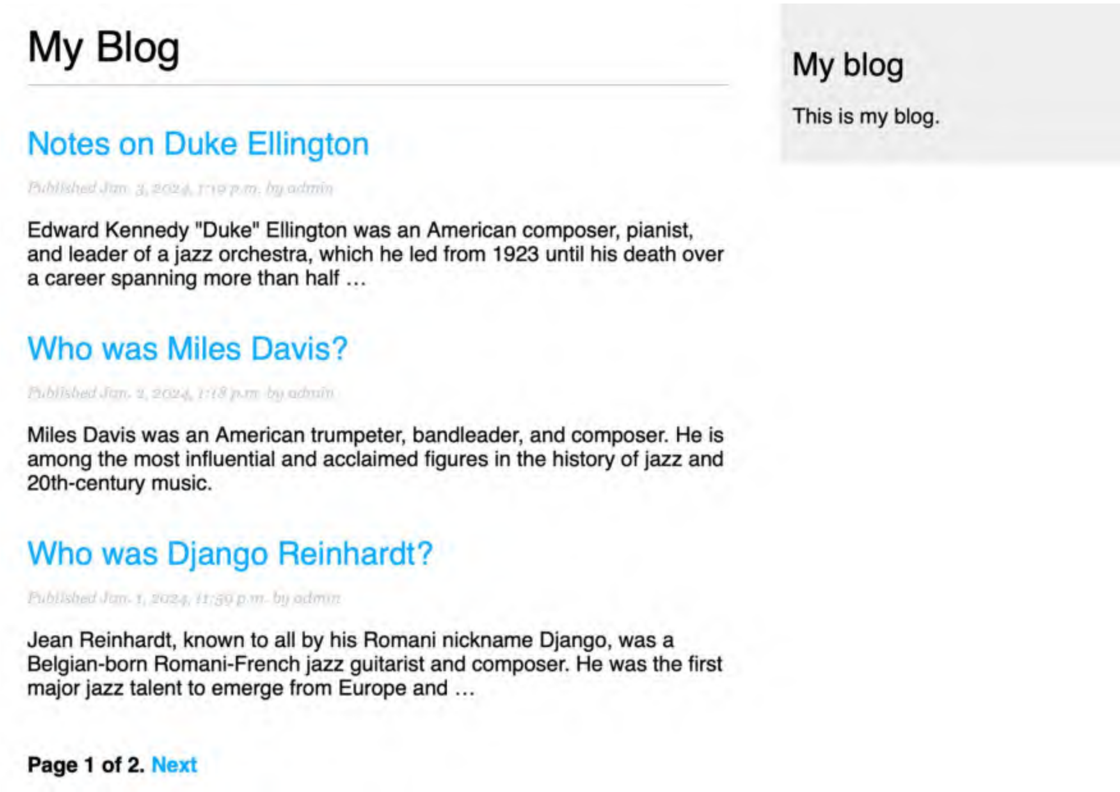

Figure 2.4: The post list page including pagination

If you click on **Next**, you will see the last post. The URL for the second page contains the `?page=2` GET parameter. This parameter is used by the view to load the requested page of results using the paginator.

Figure 2.5: The second page of results

Great! The pagination links are working as expected.

Handling pagination errors

Now that the pagination is working, we can add exception handling for pagination errors in the view. The `page` parameter used by the view to retrieve the given page could potentially be used with wrong values, such as non-existing page numbers or a string value that cannot be used as a page number. We will implement appropriate error handling for those cases.

Open `http://127.0.0.1:8000/blog/?page=3` in your browser. You should see the following error page:

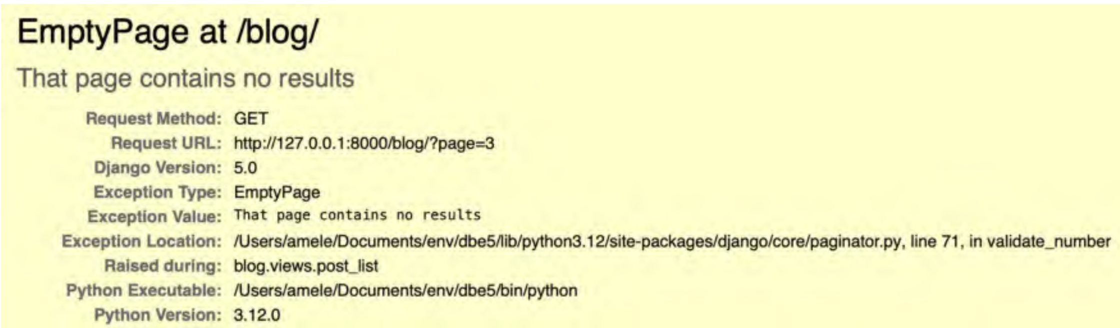

Figure 2.6: The EmptyPage error page

The `Paginator` object throws an `EmptyPage` exception when retrieving page `3` because it's out of range. There are no results to display. Let's handle this error in our view.

Edit the `views.py` file of the `blog` application to add the necessary imports and modify the `post_list` view as follows:

```python
from django.core.paginator import EmptyPage, Paginator
from django.shortcuts import get_object_or_404, render
from .models import Post


def post_list(request):
    post_list = Post.published.all()
    # Pagination with 3 posts per page
    paginator = Paginator(post_list, 3)
    page_number = request.GET.get('page', 1)
    try:
        posts = paginator.page(page_number)
    except EmptyPage:
        # If page_number is out of range get last page of results
        posts = paginator.page(paginator.num_pages)
    return render(
        request,
        'blog/post/list.html',
        {'posts': posts}
    )
```

We have added a try and except block to manage the `EmptyPage` exception when retrieving a page. If the page requested is out of range, we return the last page of results. We get the total number of pages with `paginator.num_pages`. The total number of pages is the same as the last page number.

Open `http://127.0.0.1:8000/blog/?page=3` in your browser again. Now, the exception is managed by the view, and the last page of results is returned as follows:

Figure 2.7: The last page of results

Our view should also handle the case when something different than an integer is passed in the page parameter.

Open `http://127.0.0.1:8000/blog/?page=asdf` in your browser. You should see the following error page:

Figure 2.8: The PageNotAnInteger error page

In this case, the `Paginator` object throws a `PageNotAnInteger` exception when retrieving the page `asdf` because page numbers can only be integers. Let's handle this error in our view.

Edit the `views.py` file of the `blog` application to add the necessary imports and modify the `post_list` view as follows:

```
from django.shortcuts import get_object_or_404, render
from .models import Post
from django.core.paginator import EmptyPage, PageNotAnInteger, Paginator


def post_list(request):
    post_list = Post.published.all()
    # Pagination with 3 posts per page
    paginator = Paginator(post_list, 3)
    page_number = request.GET.get('page')
    try:
        posts = paginator.page(page_number)
    except PageNotAnInteger:
        # If page_number is not an integer get the first page
        posts = paginator.page(1)
    except EmptyPage:
        # If page_number is out of range get last page of results
        posts = paginator.page(paginator.num_pages)
    return render(
        request,
        'blog/post/list.html',
        {'posts': posts}
    )
```

We have added a new `except` block to manage the `PageNotAnInteger` exception when retrieving a page. If the page requested is not an integer, we return the first page of results.

Open `http://127.0.0.1:8000/blog/?page=asdf` in your browser again. Now, the exception is man-

Class-based views are an alternative way to implement views as Python objects instead of functions. Since a view is a function that takes a web request and returns a web response, you can also define your views as class methods. Django provides base view classes that you can use to implement your own views. All of them inherit from the `View` class, which handles HTTP method dispatching and other common functionalities.

Why use class-based views

Class-based views offer some advantages over function-based views that are useful for specific use cases. Class-based views allow you to:

- Organize code related to HTTP methods, such as `GET`, `POST`, or `PUT`, in separate methods, instead of using conditional branching
- Use multiple inheritance to create reusable view classes (also known as *mixins*)

Using a class-based view to list posts

To understand how to write class-based views, we will create a new class-based view that is equivalent to the `post_list` view. We will create a class that will inherit from the generic `ListView` view offered by Django. `ListView` allows you to list any type of object.

Edit the `views.py` file of the `blog` application and add the following code to it:

```
from django.views.generic import ListView


class PostListView(ListView):
    """
    Alternative post list view
    """
    queryset = Post.published.all()
    context_object_name = 'posts'
    paginate_by = 3
    template_name = 'blog/post/list.html'
```

The `PostListView` view is analogous to the `post_list` view we built previously. We have implemented a class-based view that inherits from the `ListView` class. We have defined a view with the following attributes:

- We use `queryset` to use a custom QuerySet instead of retrieving all objects. Instead of defining a `queryset` attribute, we could have specified `model = Post` and Django would have built the generic `Post.objects.all()` QuerySet for us.
- We use the context variable `posts` for the query results. The default variable is `object_list` if you don't specify any `context_object_name`.
- We define the pagination of results with `paginate_by`, returning three objects per page.

- We use a custom template to render the page with `template_name`. If you don't set a default template, `ListView` will use `blog/post_list.html` by default.

Now, edit the `urls.py` file of the `blog` application, comment the preceding `post_list` URL pattern, and add a new URL pattern using the `PostListView` class, as follows:

```
urlpatterns = [
    # Post views
    # path('', views.post_list, name='post_list'),
    path('', views.PostListView.as_view(), name='post_list'),
    path(
        '<int:year>/<int:month>/<int:day>/<slug:post>/',
        views.post_detail,
        name='post_detail'
    ),
]
```

In order to keep pagination working, we have to use the right page object that is passed to the template. Django's `ListView` generic view passes the page requested in a variable called `page_obj`. We have to edit the `post/list.html` template accordingly to include the paginator using the right variable, as follows:

```
{% extends "blog/base.html" %}

{% block title %}My Blog{% endblock %}

{% block content %}
  <h1>My Blog</h1>
  {% for post in posts %}
    <h2>
      <a href="{{ post.get_absolute_url }}">
        {{ post.title }}
      </a>
    </h2>
    <p class="date">
      Published {{ post.publish }} by {{ post.author }}
    </p>
    {{ post.body|truncatewords:30|linebreaks }}
  {% endfor %}
  {% include "pagination.html" with page=page_obj %}
{% endblock %}
```

Open `http://127.0.0.1:8000/blog/` in your browser and verify that the pagination links work as expected. The behavior of the pagination links should be the same as with the previous `post_list` view.

The exception handling in this case is a bit different. If you try to load a page out of range or pass a non-integer value in the page parameter, the view will return an HTTP response with the status code `404` (page not found) like this:

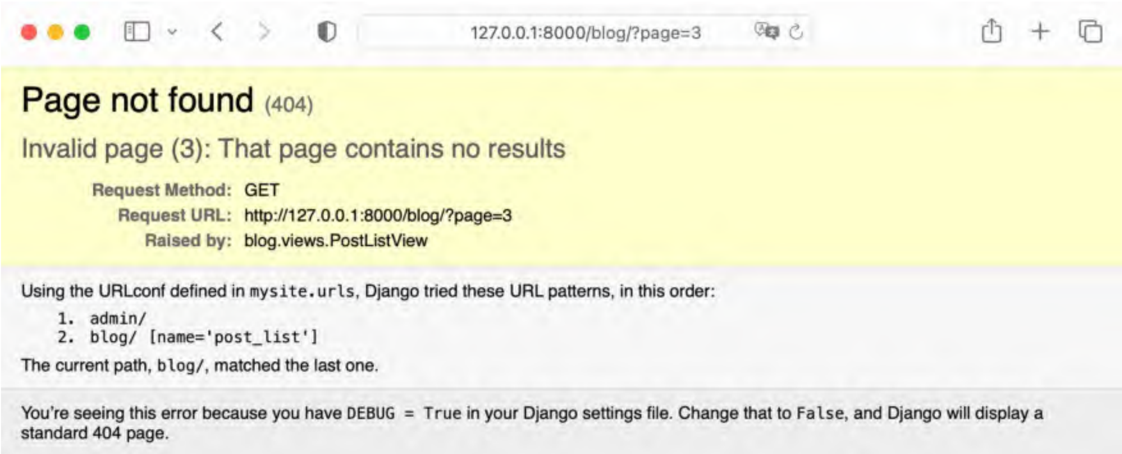

Figure 2.10: HTTP 404 Page not found response

The exception handling that returns the HTTP `404` status code is provided by the `ListView` view.

This is a simple example of how to write class-based views. You will learn more about class-based views in *Chapter 13*, *Creating a Content Management System*, and successive chapters.

You can read an introduction to class-based views at `https://docs.djangoproject.com/en/5.0/topics/class-based-views/intro/`.

After learning how to use class-based views and using built-in object pagination, we will implement the functionality for sharing posts by email to engage your blog readers.

Recommending posts by email

We will allow users to share blog posts with others by sending post recommendations via email. You will learn how to create forms in Django, handle data submission, and send emails with Django, enhancing your blog with a personal touch.

Take a minute to think about how you could use *views*, *URLs*, and *templates* to create this functionality using what you learned in the preceding chapter.

To allow users to share posts via email, we will need to:

1. Create a form for users to fill in their name, their email address, the recipient's email address, and optional comments
2. Create a view in the `views.py` file that handles the posted data and sends the email
3. Add a URL pattern for the new view in the `urls.py` file of the blog application
4. Create a template to display the form

Creating forms with Django

Let's start by building the form to share posts. Django has a built-in forms framework that allows you to create forms easily. The forms framework makes it simple to define the fields of the form, specify how they have to be displayed, and indicate how they have to validate input data. The Django forms framework offers a flexible way to render forms in HTML and handle data.

Django comes with two base classes to build forms:

- `Form`: This allows you to build standard forms by defining fields and validations.
- `ModelForm`: This allows you to build forms tied to model instances. It provides all the functionalities of the base `Form` class, but form fields can be explicitly declared, or automatically generated, from model fields. The form can be used to create or edit model instances.

First, create a `forms.py` file inside the directory of your `blog` application and add the following code to it:

```
from django import forms


class EmailPostForm(forms.Form):
    name = forms.CharField(max_length=25)
    email = forms.EmailField()
    to = forms.EmailField()
    comments = forms.CharField(
        required=False,
        widget=forms.Textarea
    )
```

We have defined our first Django form. The `EmailPostForm` form inherits from the base `Form` class. We use different field types to validate data accordingly.

Forms can reside anywhere in your Django project. The convention is to place them inside a `forms.py` file for each application.

The form contains the following fields:

- `name`: An instance of `CharField` with a maximum length of `25` characters. We will use it for the name of the person sending the post.
- `email`: An instance of `EmailField`. We will use the email of the person sending the post recommendation.
- `to`: An instance of `EmailField`. We will use the email address of the recipient, who will receive an email recommending the post.
- `comments`: An instance of `CharField`. We will use it for comments to include in the post recommendation email. We have made this field optional by setting `required` to `False`, and we have specified a custom widget to render the field.

Each field type has a default widget that determines how the field is rendered in HTML. The `name` field is an instance of `CharField`. This type of field is rendered as an `<input type="text">` HTML element. The default widget can be overridden with the `widget` attribute. In the `comments` field, we use the `Textarea` widget to display it as a `<textarea>` HTML element instead of the default `<input>` element.

Field validation also depends on the field type. For example, the `email` and `to` fields are `EmailField` fields. Both fields require a valid email address; the field validation will otherwise raise a `forms.ValidationError` exception and the form will not validate. Other parameters are also taken into account for the form field validation, such as the `name` field having a maximum length of `25` or the `comments` field being optional.

These are only some of the field types that Django provides for forms. You can find a list of all field types available at `https://docs.djangoproject.com/en/5.0/ref/forms/fields/`.

Handling forms in views

We have defined the form to recommend posts via email. Now, we need a view to create an instance of the form and handle the form submission.

Edit the `views.py` file of the `blog` application and add the following code to it:

```
from .forms import EmailPostForm


def post_share(request, post_id):
    # Retrieve post by id
    post = get_object_or_404(
        Post,
        id=post_id,
        status=Post.Status.PUBLISHED
    )

    if request.method == 'POST':
        # Form was submitted
        form = EmailPostForm(request.POST)
        if form.is_valid():
            # Form fields passed validation
            cd = form.cleaned_data
            # ... send email
    else:
        form = EmailPostForm()
    return render(
        request,
        'blog/post/share.html',
        {
```

```
            'post': post,
            'form': form
        }
    )
```

We have defined the `post_share` view that takes the `request` object and the `post_id` variable as parameters. We use the `get_object_or_404()` shortcut to retrieve a published post by its `id`.

We use the same view both for displaying the initial form and processing the submitted data. The HTTP `request` method allows us to differentiate whether the form is being submitted. A `GET` request will indicate that an empty form has to be displayed to the user and a `POST` request will indicate the form is being submitted. We use `request.method == 'POST'` to differentiate between the two scenarios.

This is the process to display the form and handle the form submission:

1. When the page is loaded for the first time, the view receives a `GET` request. In this case, a new `EmailPostForm` instance is created and stored in the `form` variable. This form instance will be used to display the empty form in the template:

   ```
   form = EmailPostForm()
   ```

2. When the user fills in the form and submits it via `POST`, a form instance is created using the submitted data contained in `request.POST`:

   ```
   if request.method == 'POST':
       # Form was submitted
       form = EmailPostForm(request.POST)
   ```

3. After this, the data submitted is validated using the form's `is_valid()` method. This method validates the data introduced in the form and returns `True` if all fields contain valid data. If any field contains invalid data, then `is_valid()` returns `False`. The list of validation errors can be obtained with `form.errors`.
4. If the form is not valid, the form is rendered in the template again, including the data submitted. Validation errors will be displayed in the template.
5. If the form is valid, the validated data is retrieved with `form.cleaned_data`. This attribute is a dictionary of form fields and their values. Forms not only validate the data but also *clean* the data by normalizing it to a consistent format.

> If your form data does not validate, `cleaned_data` will contain only the valid fields.

We have implemented the view to display the form and handle the form submission. We will now learn how to send emails using Django and then we will add that functionality to the `post_share` view.

Sending emails with Django

Sending emails with Django is very straightforward. You need to have a local SMTP server, or you need to access an external SMTP server, like your email service provider.

The following settings allow you to define the SMTP configuration to send emails with Django:

- `EMAIL_HOST`: The SMTP server host; the default is `localhost`
- `EMAIL_PORT`: The SMTP port; the default is `25`
- `EMAIL_HOST_USER`: The username for the SMTP server
- `EMAIL_HOST_PASSWORD`: The password for the SMTP server
- `EMAIL_USE_TLS`: Whether to use a **Transport Layer Security** (**TLS**) secure connection
- `EMAIL_USE_SSL`: Whether to use an implicit TLS secure connection

Additionally, you can use the `DEFAULT_FROM_EMAIL` setting to specify the default sender when sending emails with Django. For this example, we will use Google's SMTP server with a standard Gmail account.

Working with environment variables

We will add SMTP configuration settings to the project, and we will load the SMTP credentials from environment variables. By using environment variables, we will avoid embedding credentials in the source code. There are multiple reasons to keep configuration separate from the code:

- **Security**: Credentials or secret keys in the code can lead to unintentional exposure, especially if you push the code to public repositories.
- **Flexibility**: Keeping the configuration separate will allow you to use the same code base across different environments without any changes. You will learn how to build multiple environments in *Chapter 17*, *Going Live*.
- **Maintainability**: Changing a configuration won't require a code change, ensuring that your project remains consistent across versions.

To facilitate the separation of configuration from code, we are going to use `python-decouple`. This library simplifies the use of environment variables in your projects. You can find information about `python-decouple` at `https://github.com/HBNetwork/python-decouple`.

First, install `python-decouple` via `pip` by running the following command:

```
python -m pip install python-decouple==3.8
```

Then, create a new file inside your project's root directory and name it `.env`. The `.env` file will contain key-value pairs of environment variables. Add the following lines to the new file:

```
EMAIL_HOST_USER=your_account@gmail.com
EMAIL_HOST_PASSWORD=
DEFAULT_FROM_EMAIL=My Blog <your_account@gmail.com>
```

If you have a Gmail account, replace `your_account@gmail.com` with your Gmail account. The `EMAIL_HOST_PASSWORD` variable has no value yet, we will add it later. The `DEFAULT_FROM_EMAIL` variable will be used to specify the default sender for our emails. If you don't have a Gmail account, you can use the SMTP credentials for your email service provider.

If you are using a `git` repository for your code, make sure to include `.env` in the `.gitignore` file of your repository. By doing so, you ensure that credentials are excluded from the repository.

Edit the `settings.py` file of your project and add the following code to it:

```
from decouple import config
# ...
# Email server configuration
EMAIL_HOST = 'smtp.gmail.com'
EMAIL_HOST_USER = config('EMAIL_HOST_USER')
EMAIL_HOST_PASSWORD = config('EMAIL_HOST_PASSWORD')
EMAIL_PORT = 587
EMAIL_USE_TLS = True
DEFAULT_FROM_EMAIL = config('DEFAULT_FROM_EMAIL')
```

The `EMAIL_HOST_USER`, `EMAIL_HOST_PASSWORD` and `DEFAULT_FROM_EMAIL` settings are now loaded from environment variables defined in the `.env` file.

The provided `EMAIL_HOST`, `EMAIL_PORT` and `EMAIL_USE_TLS` settings are for Gmail's SMTP server. If you don't have a Gmail account, you can use the SMTP server configuration of your email service provider.

Instead of Gmail, you can also use a professional, scalable email service that allows you to send emails via SMTP using your own domain, such as SendGrid (`https://sendgrid.com/`) or Amazon **Simple Email Service** (**SES**) (`https://aws.amazon.com/ses/`). Both services will require you to verify your domain and sender email accounts and will provide you with SMTP credentials to send emails. The `django-anymail` application simplifies the task of adding email service providers to your project like SendGrid or Amazon SES. You can find installation instructions for `django-anymail` at `https://anymail.dev/en/stable/installation/`, and the list of supported email service providers at `https://anymail.dev/en/stable/esps/`.

If you can't use an SMTP server, you can tell Django to write emails to the console by adding the following setting to the `settings.py` file:

```
EMAIL_BACKEND = 'django.core.mail.backends.console.EmailBackend'
```

By using this setting, Django will output all emails to the shell instead of sending them. This is very useful for testing your application without an SMTP server.

In order to send emails with Gmail's SMTP server, make sure that two-step verification is active in your Gmail account.

Open `https://myaccount.google.com/security` in your browser and enable **2-Step Verification** for your account, as shown in *Figure 2.11*:

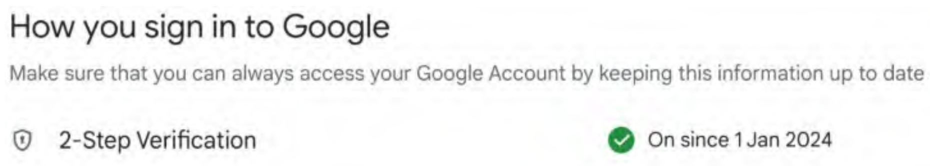

Figure 2.11: The sign in to Google page for Google accounts

Then, you need to create an app password and use it for your SMTP credentials. An app password is a 16-digit passcode that gives a *less secure* app or device permission to access your Google account.

To create an app password, open `https://myaccount.google.com/apppasswords` in your browser. You will see the following screen:

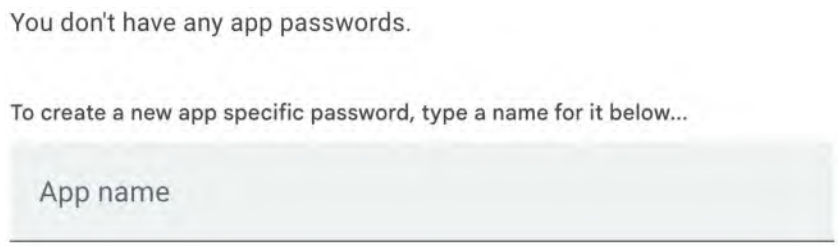

Figure 2.12: Form to generate a new Google app password

If you cannot access **App passwords**, it might be that 2-Step Verification is not set for your account, your account is an organization account instead of a standard Gmail account, or you turned on Google's advanced protection. Make sure to use a standard Gmail account and activate 2-Step Verification for your Google account. You can find more information at `https://support.google.com/accounts/answer/185833`.

Enter the name `Blog` and click the **Create** button, as follows:

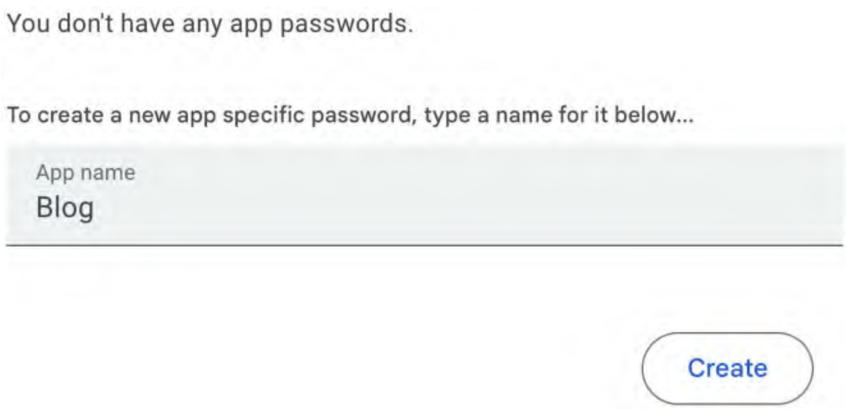

Figure 2.13: Form to generate a new Google app password

A new password will be generated and displayed like this:

Figure 2.14: Generated Google app password

Copy the generated app password.

Next, edit the `.env` file of your project and add the app password to the `EMAIL_HOST_PASSWORD` variable, as follows:

```
EMAIL_HOST_USER=your_account@gmail.com
EMAIL_HOST_PASSWORD=xxxxxxxxxxxxxxxx
DEFAULT_FROM_EMAIL=My Blog <your_account@gmail.com>
```

Open the Python shell by running the following command in the system shell prompt:

```
python manage.py shell
```

Execute the following code in the Python shell:

```
>>> from django.core.mail import send_mail
>>> send_mail('Django mail',
...           'This e-mail was sent with Django.',
...           'your_account@gmail.com',
...           ['your_account@gmail.com'],
...           fail_silently=False)
```

The `send_mail()` function takes the subject, message, sender, and list of recipients as required arguments. By setting the optional argument `fail_silently=False`, we are telling it to raise an exception if the email cannot be sent. If the output you see is `1`, then your email was successfully sent.

If you get a `CERTIFICATE_VERIFY_FAILED` error, install the `certify` module with the command `pip install --upgrade certifi`. If you are using macOS, run the following command on the shell to install `certify` and let Python access macOS root certificates:

```
/Applications/Python\ 3.12/Install\ Certificates.command
```

Check your inbox. You should have received the email as displayed in *Figure 2.15*:

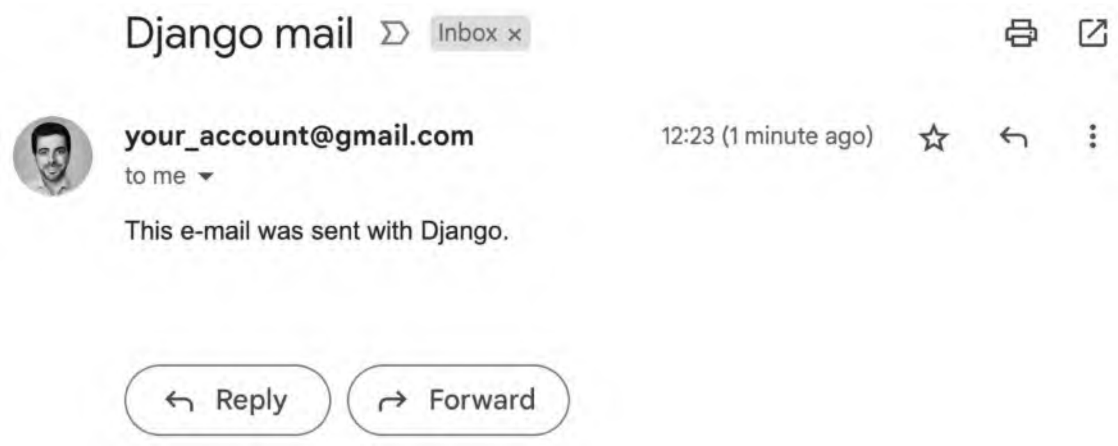

Figure 2.15: Test email sent displayed in Gmail

You just sent your first email with Django! You can find more information about sending emails with Django at `https://docs.djangoproject.com/en/5.0/topics/email/`.

Let's add this functionality to the `post_share` view.

Sending emails in views

Edit the `post_share` view in the `views.py` file of the `blog` application, as follows:

```
# ...
from django.core.mail import send_mail

# ...

def post_share(request, post_id):
    # Retrieve post by id
    post = get_object_or_404(
        Post,
        id=post_id,
        status=Post.Status.PUBLISHED
    )
    sent = False

    if request.method == 'POST':
        # Form was submitted
        form = EmailPostForm(request.POST)
        if form.is_valid():
            # Form fields passed validation
```

```
            cd = form.cleaned_data
            post_url = request.build_absolute_uri(
                post.get_absolute_url()
            )
            subject = (
                f"{cd['name']} ({cd['email']}) "
                f"recommends you read {post.title}"
            )
            message = (
                f"Read {post.title} at {post_url}\n\n"
                f"{cd['name']}\'s comments: {cd['comments']}"
            )
            send_mail(
                subject=subject,
                message=message,
                from_email=None,
                recipient_list=[cd['to']]
            )
            sent = True
    else:
        form = EmailPostForm()
    return render(
        request,
        'blog/post/share.html',
        {
            'post': post,
            'form': form,
            'sent': sent
        }
    )
```

In the preceding code, we have declared a `sent` variable with the initial `False` value. We set this variable to `True` after the email is sent. We will use the `sent` variable later in the template to display a success message when the form is successfully submitted.

Since we have to include a link to the post in the email, we retrieve the absolute path of the post using its `get_absolute_url()` method. We use this path as an input for `request.build_absolute_uri()` to build a complete URL, including the HTTP schema and hostname.

We create the subject and the message body of the email using the cleaned data of the validated form. Finally, we send the email to the email address contained in the `to` field of the form. In the `from_email` parameter, we pass the `None` value, so the value of the `DEFAULT_FROM_EMAIL` setting will be used for the sender.

Now that the view is complete, we have to add a new URL pattern for it.

Open the `urls.py` file of your `blog` application and add the `post_share` URL pattern, as follows:

```
from django.urls import path
from . import views


app_name = 'blog'

urlpatterns = [
    # Post views
    # path('', views.post_list, name='post_list'),
    path('', views.PostListView.as_view(), name='post_list'),
    path(
        '<int:year>/<int:month>/<int:day>/<slug:post>/',
        views.post_detail,
        name='post_detail'),
    path('<int:post_id>/share/', views.post_share, name='post_share'),

]
```

Rendering forms in templates

After creating the form, programming the view, and adding the URL pattern, the only thing missing is the template for the view.

Create a new file in the `blog/templates/blog/post/` directory and name it `share.html`.

Add the following code to the new `share.html` template:

```
{% extends "blog/base.html" %}

{% block title %}Share a post{% endblock %}

{% block content %}
  {% if sent %}
    <h1>E-mail successfully sent</h1>
    <p>
      "{{ post.title }}" was successfully sent to {{ form.cleaned_data.to }}.
    </p>
  {% else %}
    <h1>Share "{{ post.title }}" by e-mail</h1>
    <form method="post">
      {{ form.as_p }}
      {% csrf_token %}
```

```
      <input type="submit" value="Send e-mail">
    </form>
  {% endif %}
{% endblock %}
```

This is the template that is used to both display the form to share a post via email and to display a success message when the email has been sent. We differentiate between both cases with `{% if sent %}`.

To display the form, we have defined an HTML form element, indicating that it has to be submitted by the `POST` method:

```
<form method="post">
```

We have included the form instance with `{{ form.as_p }}`. We tell Django to render the form fields using HTML paragraph `<p>` elements by using the `as_p` method. We could also render the form as an unordered list with `as_ul` or as an HTML table with `as_table`.

We have added a `{% csrf_token %}` template tag. This tag introduces a hidden field with an autogenerated token to avoid **cross-site request forgery** (**CSRF**) attacks. These attacks consist of a malicious website or program performing an unwanted action for a user on the site. You can find more information about CSRF at `https://owasp.org/www-community/attacks/csrf`.

The `{% csrf_token %}` template tag generates a hidden field that is rendered like this:

```
<input type='hidden' name='csrfmiddlewaretoken'
value='26JjKo2lcEtYkGoV9z4XmJIEHLXN5LDR' />
```

By default, Django checks for the CSRF token in all `POST` requests. Remember to include the `csrf_token` tag in all forms that are submitted via `POST`.

Edit the `blog/post/detail.html` template and make it look like this:

```
{% extends "blog/base.html" %}

{% block title %}{{ post.title }}{% endblock %}

{% block content %}
  <h1>{{ post.title }}</h1>
  <p class="date">
    Published {{ post.publish }} by {{ post.author }}
  </p>
  {{ post.body|linebreaks }}
  <p>
    <a href="{% url "blog:post_share" post.id %}">
```

```
      Share this post
    </a>
  </p>
{% endblock %}
```

We have added a link to the `post_share` URL. The URL is built dynamically with the `{% url %}` template tag provided by Django. We use the namespace called `blog` and the URL named `post_share`. We pass the `id` post as a parameter to build the URL.

Open the shell prompt and execute the following command to start the development server:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/blog/` in your browser and click on any post title to view the post detail page.

Under the post body, you should see the link that you just added, as shown in *Figure 2.16*:

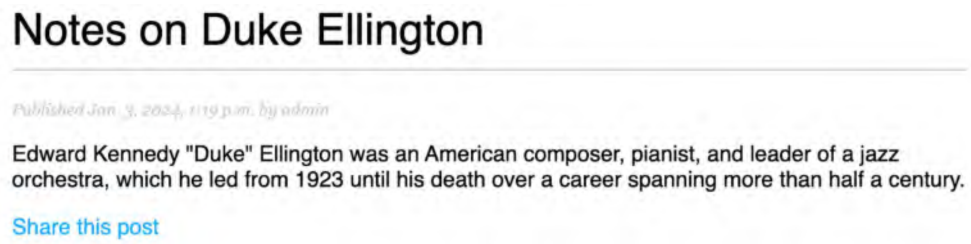

Figure 2.16: The post detail page, including a link to share the post

Click on **Share this post**, and you should see the page, including the form to share this post by email, as follows:

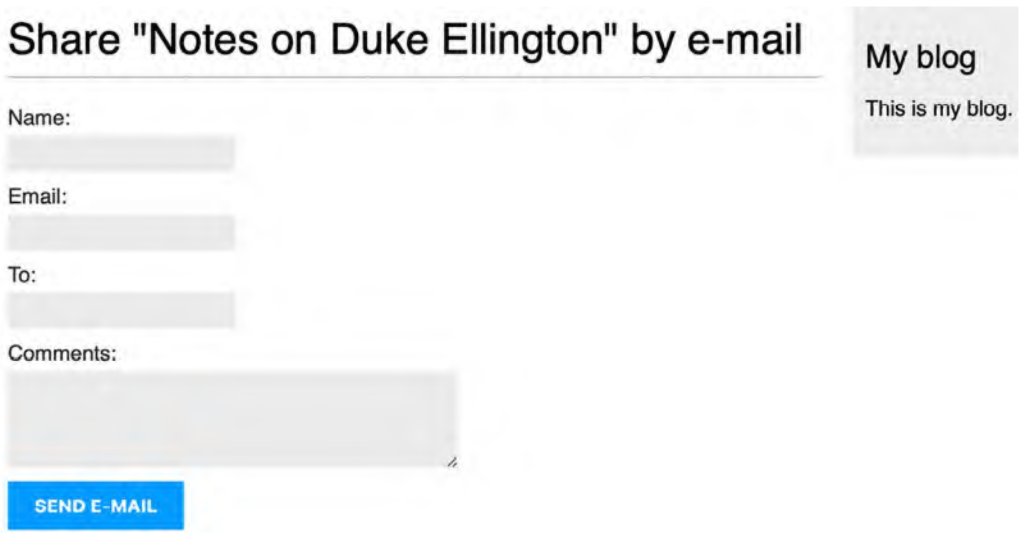

Figure 2.17: The page to share a post via email

CSS styles for the form are included in the example code in the `static/css/blog.css` file. When you click on the **SEND E-MAIL** button, the form is submitted and validated. If all fields contain valid data, you get a success message, as follows:

Figure 2.18: A success message for a post shared via email

Send a post to your own email address and check your inbox. The email you receive should look like this:

Figure 2.19: Test email sent displayed in Gmail

If you submit the form with invalid data, the form will be rendered again, including all validation errors:

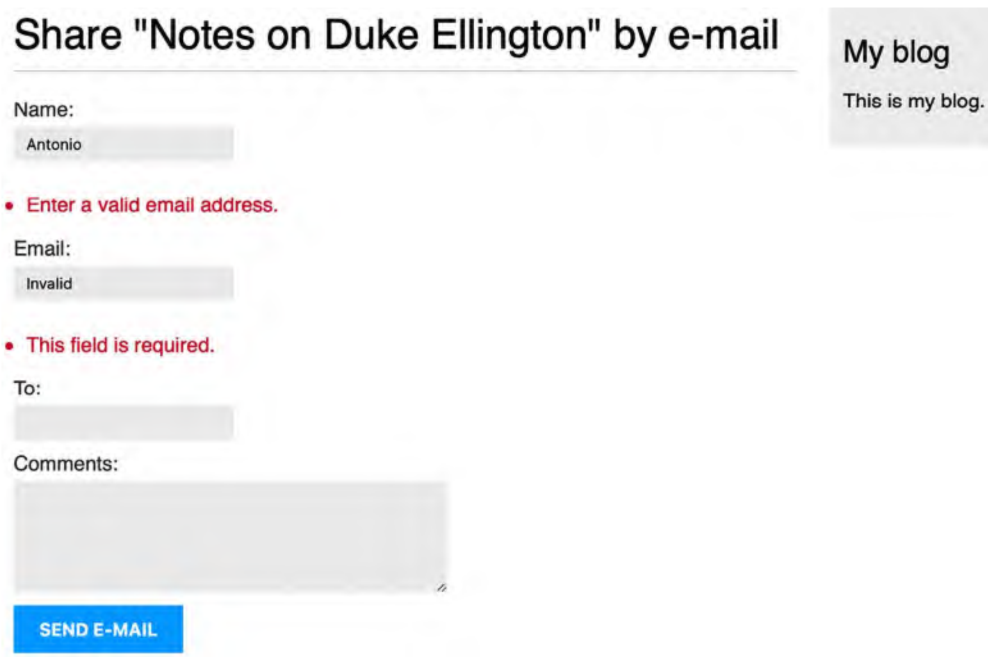

Figure 2.20: The share post form displaying invalid data errors

Most modern browsers will prevent you from submitting a form with empty or erroneous fields. This is because the browser validates the fields based on their attributes before submitting the form. In this case, the form won't be submitted, and the browser will display an error message for the fields that are wrong. To test the Django form validation using a modern browser, you can skip the browser form validation by adding the `novalidate` attribute to the HTML `<form>` element, like `<form method="post" novalidate>`. You can add this attribute to prevent the browser from validating fields and test your own form validation. After you are done testing, remove the `novalidate` attribute to keep the browser form validation.

The functionality for sharing posts by email is now complete. You can find more information about working with forms at `https://docs.djangoproject.com/en/5.0/topics/forms/`.

Creating a comment system

We will continue extending our blog application with a comment system that will allow users to comment on posts. To build the comment system, we will need the following:

- A comment model to store user comments on posts
- A Django form that allows users to submit comments and manages the data validation
- A view that processes the form and saves a new comment to the database
- A list of comments and the HTML form to add a new comment that can be included in the post detail template

Creating a model for comments

Let's start by building a model to store user comments on posts.

Open the `models.py` file of your `blog` application and add the following code:

```
class Comment(models.Model):
    post = models.ForeignKey(
        Post,
        on_delete=models.CASCADE,
        related_name='comments'
    )
    name = models.CharField(max_length=80)
    email = models.EmailField()
    body = models.TextField()
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)
    active = models.BooleanField(default=True)

    class Meta:
        ordering = ['created']
        indexes = [
```

```
                models.Index(fields=['created']),
            ]

    def __str__(self):
        return f'Comment by {self.name} on {self.post}'
```

This is the `Comment` model. We have added a `ForeignKey` field to associate each comment with a single post. This many-to-one relationship is defined in the `Comment` model because each comment will be made on one post, and each post may have multiple comments.

The `related_name` attribute allows you to name the attribute that you use for the relationship from the related object back to this one. We can retrieve the post of a comment object using `comment.post` and retrieve all comments associated with a post object using `post.comments.all()`. If you don't define the `related_name` attribute, Django will use the name of the model in lowercase, followed by `_set` (that is, `comment_set`) to name the relationship of the related object to the object of the model, where this relationship has been defined.

You can learn more about many-to-one relationships at `https://docs.djangoproject.com/en/5.0/topics/db/examples/many_to_one/`.

We have defined the `active` Boolean field to control the status of the comments. This field will allow us to manually deactivate inappropriate comments using the administration site. We use `default=True` to indicate that all comments are active by default.

We have defined the `created` field to store the date and time when the comment was created. By using `auto_now_add`, the date will be saved automatically when creating an object. In the `Meta` class of the model, we have added `ordering = ['created']` to sort comments in chronological order by default, and we have added an index for the `created` field in ascending order. This will improve the performance of database lookups or ordering results using the `created` field.

The `Comment` model that we have built is not synchronized with the database. We need to generate a new database migration to create the corresponding database table.

Run the following command from the shell prompt:

```
python manage.py makemigrations blog
```

You should see the following output:

```
Migrations for 'blog':
  blog/migrations/0003_comment.py
    - Create model Comment
```

Django has generated a `0003_comment.py` file inside the `migrations/` directory of the `blog` application. We need to create the related database schema and apply the changes to the database.

Run the following command to apply existing migrations:

```
python manage.py migrate
```

You will get an output that includes the following line:

```
Applying blog.0003_comment... OK
```

The migration has been applied and the `blog_comment` table has been created in the database.

Adding comments to the administration site

Next, we will add the new model to the administration site to manage comments through a simple interface.

Open the `admin.py` file of the blog application, import the `Comment` model, and add the following `ModelAdmin` class:

```
from .models import Comment, Post


@admin.register(Comment)
class CommentAdmin(admin.ModelAdmin):
    list_display = ['name', 'email', 'post', 'created', 'active']
    list_filter = ['active', 'created', 'updated']
    search_fields = ['name', 'email', 'body']
```

Open the shell prompt and execute the following command to start the development server:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/` in your browser. You should see the new model included in the **BLOG** section, as shown in *Figure 2.21*:

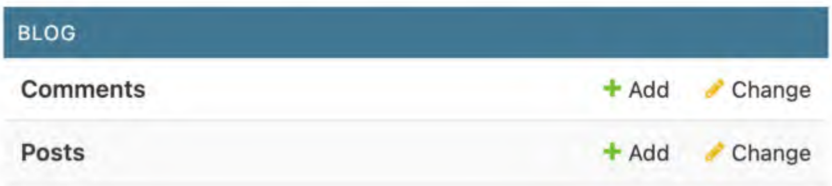

Figure 2.21: Blog application models on the Django administration index page

The model is now registered on the administration site.

In the **Comments** row, click on **Add**. You will see the form to add a new comment:

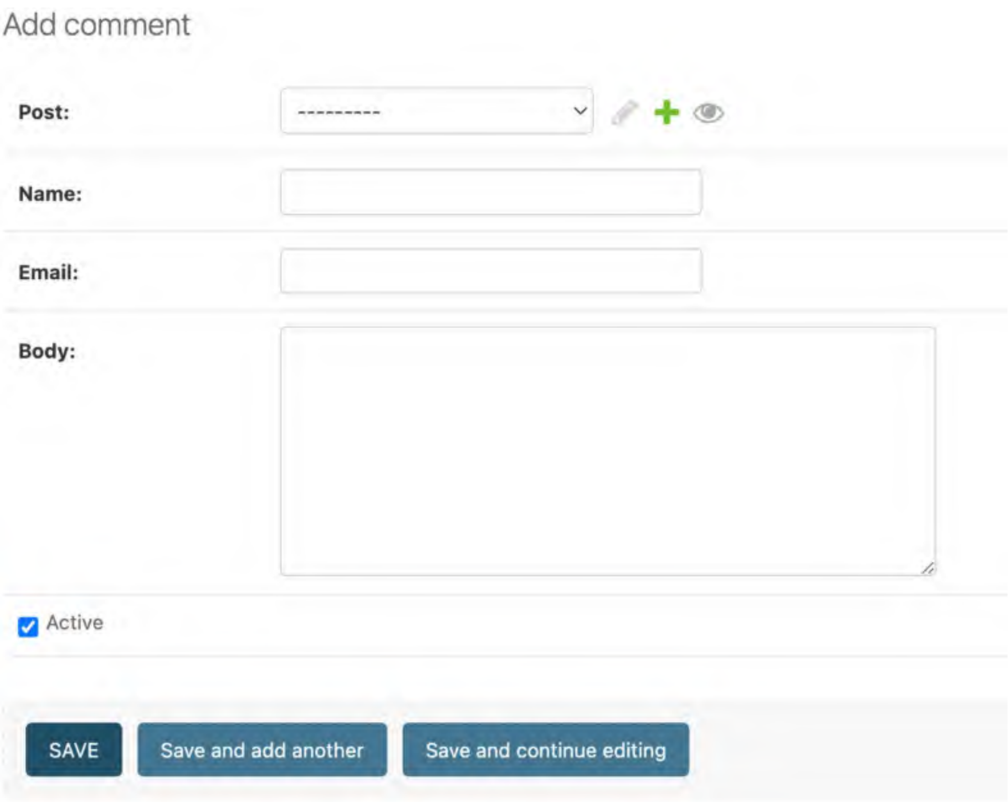

Figure 2.22: Form to add a new comment in the Django administration site

Now we can manage `Comment` instances using the administration site.

Creating forms from models

We need to build a form to let users comment on blog posts. Remember that Django has two base classes that can be used to create forms: `Form` and `ModelForm`. We used the `Form` class to allow users to share posts by email. Now, we will use `ModelForm` to take advantage of the existing `Comment` model and build a form dynamically for it.

Edit the `forms.py` file of your `blog` application and add the following lines:

```
from .models import Comment


class CommentForm(forms.ModelForm):
    class Meta:
        model = Comment
        fields = ['name', 'email', 'body']
```

To create a form from a model, we just indicate which model to build the form for in the `Meta` class of the form. Django will introspect the model and build the corresponding form dynamically.

Each model field type has a corresponding default form field type. The attributes of model fields are taken into account for form validation. By default, Django creates a form field for each field contained in the model. However, we can explicitly tell Django which fields to include in the form using the `fields` attribute or define which fields to exclude using the `exclude` attribute. In the `CommentForm` form, we have explicitly included the `name`, `email`, and `body` fields. These are the only fields that will be included in the form.

You can find more information about creating forms from models at `https://docs.djangoproject.com/en/5.0/topics/forms/modelforms/`.

Handling ModelForms in views

For sharing posts by email, we used the same view to display the form and manage its submission. We used the HTTP method to differentiate between both cases: `GET` to display the form and `POST` to submit it. In this case, we will add the comment form to the post detail page, and we will build a separate view to handle the form submission. The new view that processes the form will allow the user to return to the post detail view once the comment has been stored in the database.

Edit the `views.py` file of the `blog` application and add the following code:

```
from django.core.mail import send_mail
from django.core.paginator import EmptyPage, PageNotAnInteger, Paginator
from django.shortcuts import get_object_or_404, render
from django.views.decorators.http import require_POST
from django.views.generic import ListView
from .forms import CommentForm, EmailPostForm
from .models import Post

# ...

@require_POST
def post_comment(request, post_id):
    post = get_object_or_404(
        Post,
        id=post_id,
        status=Post.Status.PUBLISHED
    )
    comment = None
    # A comment was posted
    form = CommentForm(data=request.POST)
    if form.is_valid():
        # Create a Comment object without saving it to the database
```

```
        comment = form.save(commit=False)
        # Assign the post to the comment
        comment.post = post
        # Save the comment to the database
        comment.save()
    return render(
        request,
        'blog/post/comment.html',
        {
            'post': post,
            'form': form,
            'comment': comment
        }
    )
```

We have defined the `post_comment` view that takes the `request` object and the `post_id` variable as parameters. We will be using this view to manage the post submission. We expect the form to be submitted using the HTTP `POST` method. We use the `require_POST` decorator provided by Django to only allow `POST` requests for this view. Django allows you to restrict the HTTP methods allowed for views. Django will throw an HTTP `405` (method not allowed) error if you try to access the view with any other HTTP method.

In this view, we have implemented the following actions:

1. We retrieve a published post by its `id` using the `get_object_or_404()` shortcut.
2. We define a `comment` variable with the initial value `None`. This variable will be used to store the comment object when it is created.
3. We instantiate the form using the submitted `POST` data and validate it using the `is_valid()` method. If the form is invalid, the template is rendered with the validation errors.
4. If the form is valid, we create a new `Comment` object by calling the form's `save()` method and assign it to the `comment` variable, as follows:

   ```
   comment = form.save(commit=False)
   ```

5. The `save()` method creates an instance of the model that the form is linked to and saves it to the database. If you call it using `commit=False`, the model instance is created but not saved to the database. This allows us to modify the object before finally saving it.

> The `save()` method is available for `ModelForm` but not for `Form` instances since they are not linked to any model.

6. We assign the post to the comment we created:

```
comment.post = post
```

7. We save the new comment to the database by calling its `save()` method:

```
comment.save()
```

8. We render the `blog/post/comment.html` template, passing the `post`, `form`, and `comment` objects in the template context. This template doesn't exist yet; we will create it later.

Let's create a URL pattern for this view.

Edit the `urls.py` file of the `blog` application and add the following URL pattern to it:

```
from django.urls import path
from . import views


app_name = 'blog'

urlpatterns = [
    # Post views
    # path('', views.post_list, name='post_list'),
    path('', views.PostListView.as_view(), name='post_list'),
    path(
        '<int:year>/<int:month>/<int:day>/<slug:post>/',
        views.post_detail,
        name='post_detail'
    ),
    path('<int:post_id>/share/', views.post_share, name='post_share'),
    path(
        '<int:post_id>/comment/', views.post_comment, name='post_comment'
    ),
]
```

We have implemented the view to manage the submission of comments and their corresponding URL. Let's create the necessary templates.

Creating templates for the comment form

We will create a template for the comment form that we will use in two places:

- In the post detail template associated with the `post_detail` view to let users publish comments.
- In the post comment template associated with the `post_comment` view to display the form again if there are any form errors.

We will create the form template and use the `{% include %}` template tag to include it in the two other templates.

In the `templates/blog/post/` directory, create a new `includes/` directory. Add a new file inside this directory and name it `comment_form.html`.

The file structure should look as follows:

```
templates/
  blog/
    post/
      includes/
        comment_form.html
      detail.html
      list.html
      share.html
```

Edit the new `blog/post/includes/comment_form.html` template and add the following code:

```
<h2>Add a new comment</h2>
<form action="{% url "blog:post_comment" post.id %}" method="post">
  {{ form.as_p }}
  {% csrf_token %}
  <p><input type="submit" value="Add comment"></p>
</form>
```

In this template, we build the `action` URL of the HTML `<form>` element dynamically using the `{% url %}` template tag. We build the URL of the `post_comment` view that will process the form. We display the form rendered in paragraphs and we include `{% csrf_token %}` for CSRF protection because this form will be submitted with the `POST` method.

Create a new file in the `templates/blog/post/` directory of the `blog` application and name it `comment.html`.

The file structure should now look as follows:

```
templates/
  blog/
    post/
      includes/
        comment_form.html
      comment.html
      detail.html
      list.html
      share.html
```

Edit the new `blog/post/comment.html` template and add the following code:

```
{% extends "blog/base.html" %}

{% block title %}Add a comment{% endblock %}

{% block content %}
  {% if comment %}
    <h2>Your comment has been added.</h2>
    <p><a href="{{ post.get_absolute_url }}">Back to the post</a></p>
  {% else %}
    {% include "blog/post/includes/comment_form.html" %}
  {% endif %}
{% endblock %}
```

This is the template for the post comment view. In this view, we expect the form to be submitted via the `POST` method. The template covers two different scenarios:

- If the form data submitted is valid, the `comment` variable will contain the `comment` object that was created and a success message will be displayed.
- If the form data submitted is not valid, the `comment` variable will be `None`. In this case, we will display the comment form. We use the `{% include %}` template tag to include the `comment_form.html` template that we have previously created.

Adding comments to the post detail view

To complete the comment functionality, we will add the list of comments and the comment form to the `post_detail` view.

Edit the `views.py` file of the `blog` application and edit the `post_detail` view as follows:

```
def post_detail(request, year, month, day, post):
    post = get_object_or_404(
        Post,
        status=Post.Status.PUBLISHED,
        slug=post,
        publish__year=year,
        publish__month=month,
        publish__day=day
    )

    # List of active comments for this post
    comments = post.comments.filter(active=True)
    # Form for users to comment
    form = CommentForm()
```

```
    return render(
        request,
        'blog/post/detail.html',
        {
            'post': post,
            'comments': comments,
            'form': form
        }
    )
```

Let's review the code we have added to the `post_detail` view:

- We have added a QuerySet to retrieve all active comments for the post, as follows:

```
comments = post.comments.filter(active=True)
```

- This QuerySet is built using the `post` object. Instead of building a QuerySet for the `Comment` model directly, we leverage the `post` object to retrieve the related `Comment` objects. We use the `comments` manager for the related `Comment` objects that we previously defined in the `Comment` model, using the `related_name` attribute of the `ForeignKey` field to the `Post` model.
- We have also created an instance of the comment form with `form = CommentForm()`.

Adding comments to the post detail template

We need to edit the `blog/post/detail.html` template to implement the following:

- Display the total number of comments for a post
- Display the list of comments
- Display the form for users to add a new comment

We will start by adding the total number of comments for a post.

Edit the `blog/post/detail.html` template and change it as follows:

```
{% extends "blog/base.html" %}

{% block title %}{{ post.title }}{% endblock %}

{% block content %}
  <h1>{{ post.title }}</h1>
  <p class="date">
    Published {{ post.publish }} by {{ post.author }}
  </p>
  {{ post.body|linebreaks }}
  <p>
```

```
    <a href="{% url "blog:post_share" post.id %}">
      Share this post
    </a>
  </p>
  {% with comments.count as total_comments %}
    <h2>
      {{ total_comments }} comment{{ total_comments|pluralize }}
    </h2>
  {% endwith %}
{% endblock %}
```

We use the Django **object relational mapper** (**ORM**) in the template, executing the `comments.count()` QuerySet. Note that the Django template language doesn't use parentheses for calling methods. The `{% with %}` tag allows you to assign a value to a new variable that will be available in the template until the `{% endwith %}` tag.

> The `{% with %}` template tag is useful for avoiding hitting the database or accessing expensive methods multiple times.

We use the `pluralize` template filter to display a plural suffix for the word "comment," depending on the `total_comments` value. Template filters take the value of the variable they are applied to as their input and return a computed value. We will learn more about template filters in *Chapter 3*, *Extending Your Blog Application*.

The `pluralize` template filter returns a string with the letter "s" if the value is different from `1`. The preceding text will be rendered as *0 comments*, *1 comment*, or *N comments*, depending on the number of active comments for the post.

Now, let's add the list of active comments to the post detail template.

Edit the `blog/post/detail.html` template and implement the following changes:

```
{% extends "blog/base.html" %}

{% block title %}{{ post.title }}{% endblock %}

{% block content %}
  <h1>{{ post.title }}</h1>
  <p class="date">
    Published {{ post.publish }} by {{ post.author }}
  </p>
  {{ post.body|linebreaks }}
  <p>
```

```
    <a href="{% url "blog:post_share" post.id %}">
      Share this post
    </a>
  </p>
  {% with comments.count as total_comments %}
    <h2>
      {{ total_comments }} comment{{ total_comments|pluralize }}
    </h2>
  {% endwith %}
  {% for comment in comments %}
    <div class="comment">
      <p class="info">
        Comment {{ forloop.counter }} by {{ comment.name }}
        {{ comment.created }}
      </p>
      {{ comment.body|linebreaks }}
    </div>
  {% empty %}
    <p>There are no comments.</p>
  {% endfor %}
{% endblock %}
```

We have added a `{% for %}` template tag to loop through the post comments. If the `comments` list is empty, we display a message that informs users that there are no comments for this post. We enumerate comments with the `{{ forloop.counter }}` variable, which contains the loop counter in each iteration. For each post, we display the name of the user who posted it, the date, and the body of the comment.

Finally, let's add the comment form to the template.

Edit the `blog/post/detail.html` template and include the comment form template as follows:

```
{% extends "blog/base.html" %}

{% block title %}{{ post.title }}{% endblock %}

{% block content %}
  <h1>{{ post.title }}</h1>
  <p class="date">
    Published {{ post.publish }} by {{ post.author }}
  </p>
  {{ post.body|linebreaks }}
  <p>
    <a href="{% url "blog:post_share" post.id %}">
```

```
      Share this post
    </a>
  </p>
  {% with comments.count as total_comments %}
    <h2>
      {{ total_comments }} comment{{ total_comments|pluralize }}
    </h2>
  {% endwith %}
  {% for comment in comments %}
    <div class="comment">
      <p class="info">
        Comment {{ forloop.counter }} by {{ comment.name }}
        {{ comment.created }}
      </p>
      {{ comment.body|linebreaks }}
    </div>
  {% empty %}
    <p>There are no comments.</p>
  {% endfor %}
  {% include "blog/post/includes/comment_form.html" %}
{% endblock %}
```

Open `http://127.0.0.1:8000/blog/` in your browser and click on a post title to take a look at the post detail page. You will see something like *Figure 2.23*:

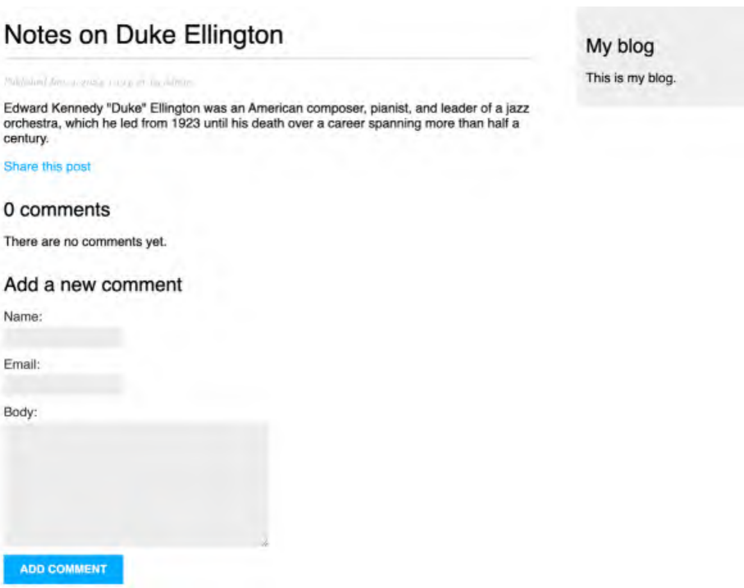

Figure 2.23: The post detail page, including the form to add a comment

Fill in the comment form with valid data and click on **Add comment**. You should see the following page:

Figure 2.24: The comment added success page

Click on the **Back to the post** link. You should be redirected back to the post detail page, and you should be able to see the comment that you just added, as follows:

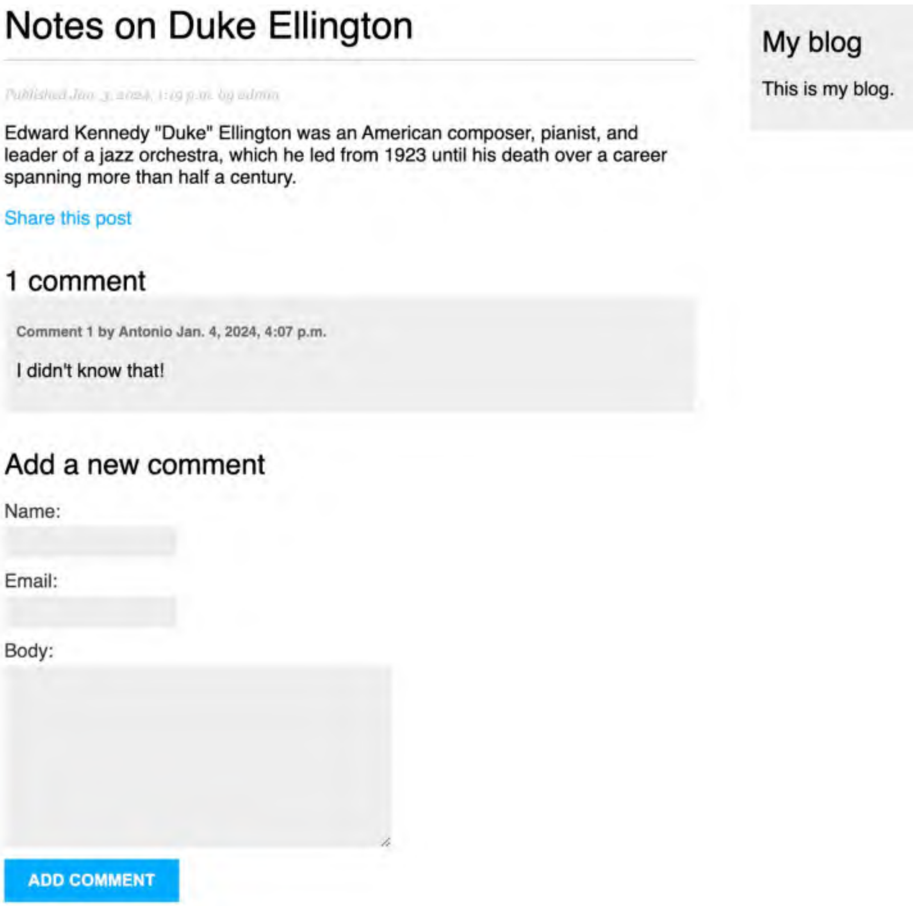

Figure 2.25: The post detail page, including a comment

Add one more comment to the post. The comments should appear below the post contents in chronological order, as follows:

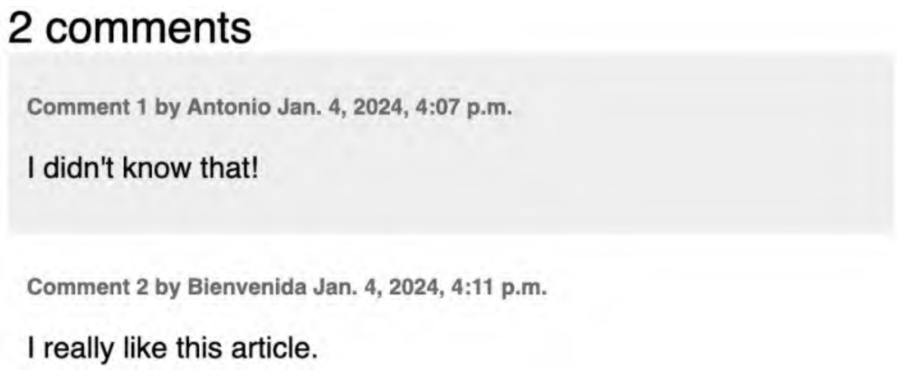

Figure 2.26: The comment list on the post detail page

Open `http://127.0.0.1:8000/admin/blog/comment/` in your browser. You will see the administration page with the list of comments you created, like this:

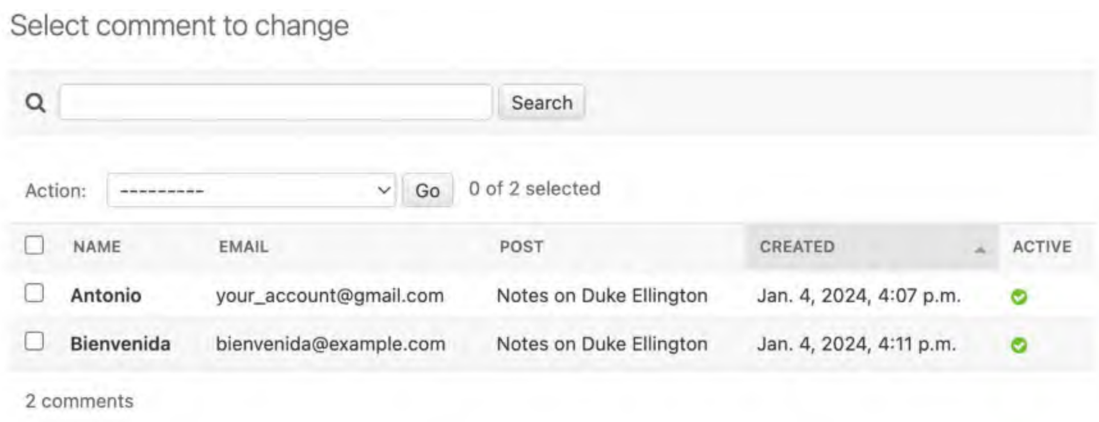

Figure 2.27: List of comments on the administration site

Click on the name of one of the posts to edit it. Uncheck the **Active** checkbox as follows and click on the **Save** button:

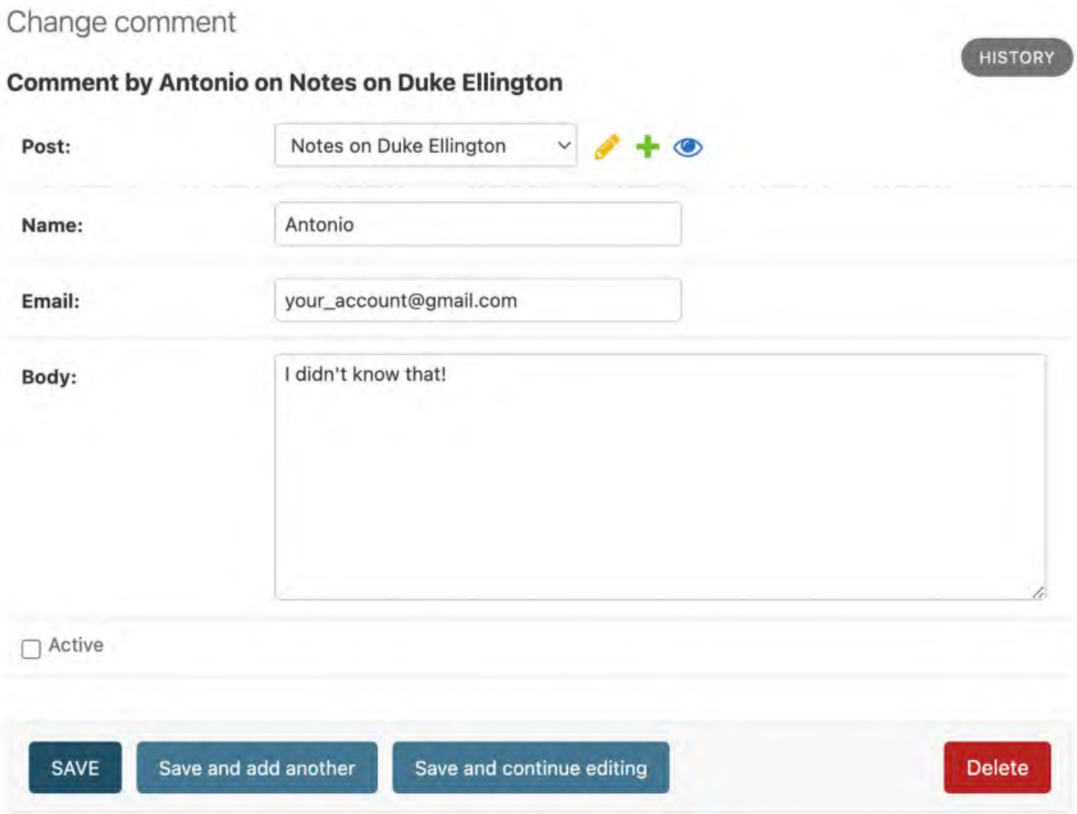

Figure 2.28: Editing a comment on the administration site

You will be redirected to the list of comments. The **Active** column will display an inactive icon for the comment, as shown in *Figure 2.29*:

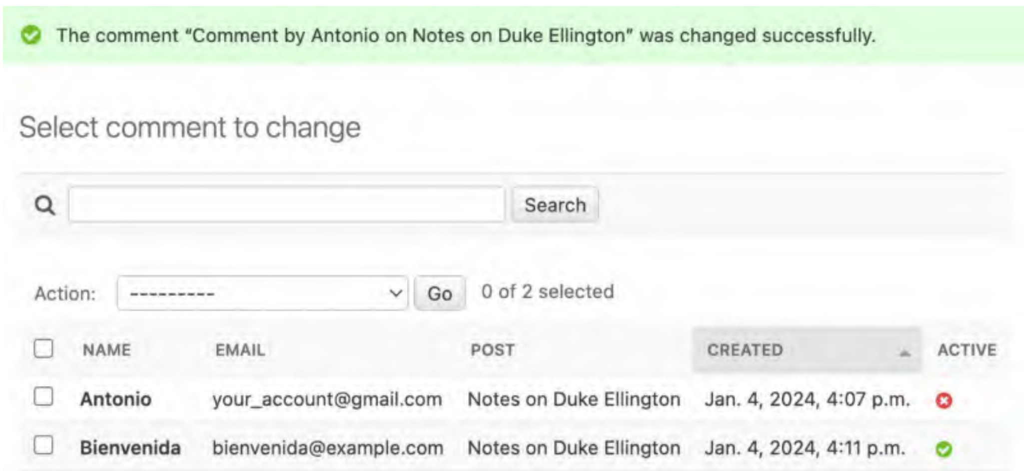

Figure 2.29: Active/inactive comments on the administration site

If you return to the post detail view, you will note that the inactive comment is no longer displayed, neither is it counted for the total number of active comments for the post:

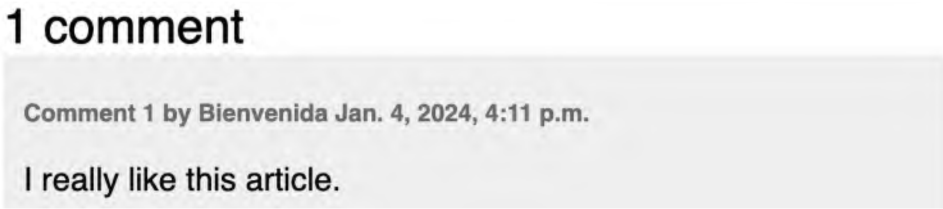

Figure 2.30: A single active comment displayed on the post detail page

Thanks to the `active` field, you can deactivate inappropriate comments and avoid showing them on your posts.

Using simplified templates for form rendering

You have used `{{ form.as_p }}` to render the forms using HTML paragraphs. This is a very straightforward method for rendering forms, but there may be occasions when you need to employ custom HTML markup for rendering forms.

To use custom HTML for rendering form fields, you can access each form field directly, or iterate through the form fields, as in the following example:

```
{% for field in form %}
  <div class="my-div">
    {{ field.errors }}
    {{ field.label_tag }} {{ field }}
    <div class="help-text">{{ field.help_text|safe }}</div>
  </div>
{% endfor %}
```

In this code, we use `{{ field.errors }}` to render any field errors of the form, `{{ field.label_tag }}` to render the form HTML label, `{{ field }}` to render the actual field, and `{{ field.help_text|safe }}` to render the field's help text HTML.

This method is helpful to customize how forms are rendered, but you might need to add certain HTML elements for specific fields or include some fields in containers. Django 5.0 introduces field groups and field group templates. Field groups simplify the rendering of labels, widgets, help texts, and field errors. Let's use this new feature to customize the comment form.

We are going to use custom HTML markup to reposition the `name` and `email` form fields using additional HTML elements.

Edit the `blog/post/includes/comment_form.html` template and modify it as follows. The new code is highlighted in bold:

```
<h2>Add a new comment</h2>
<form action="{% url "blog:post_comment" post.id %}" method="post">
```

```
  <div class="left">
    {{ form.name.as_field_group }}
  </div>
  <div class="left">
    {{ form.email.as_field_group }}
  </div>
  {{ form.body.as_field_group }}
  {% csrf_token %}
  <p><input type="submit" value="Add comment"></p>
</form>
```

We have added `<div>` containers for the `name` and `email` fields with a custom CSS class to float both fields to the left. The `as_field_group` method renders each field including help text and errors. This method uses the `django/forms/field.html` template by default. You can see the contents of this template at `https://github.com/django/django/blob/stable/5.0.x/django/forms/templates/django/forms/field.html`. You can also create custom field templates and reuse them by adding the `template_name` attribute to any form field. You can read more about reusable form templates at `https://docs.djangoproject.com/en/5.0/topics/forms/#reusable-field-group-templates`.

Open a blog post and take a look at the comment form. The form should now look like *Figure 2.31*:

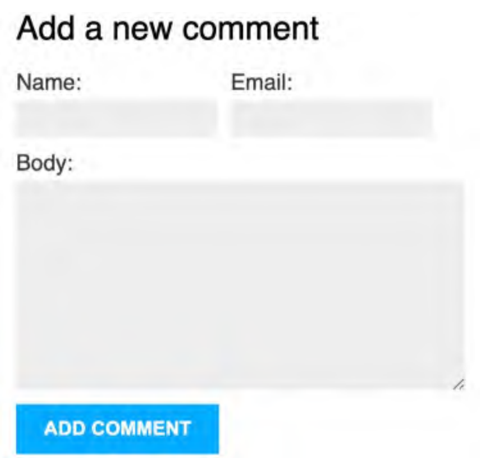

Figure 2.31: The comment form with the new HTML markup

The `name` and `email` fields are now displayed next to each other. Field groups allow you to easily customize form rendering.

Summary

In this chapter, you learned how to define canonical URLs for models. You created SEO-friendly URLs for blog posts, and you implemented object pagination for your post list. You also learned how to work with Django forms and model forms. You created a system to recommend posts by email and created a comment system for your blog.

In the next chapter, you will create a tagging system for the blog. You will learn how to build complex QuerySets to retrieve objects by similarity. You will learn how to create custom template tags and filters. You will also build a custom sitemap and feed for your blog posts and implement full-text search functionality for your posts.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter02`
- URL utility functions: `https://docs.djangoproject.com/en/5.0/ref/urlresolvers/`
- URL path converters: `https://docs.djangoproject.com/en/5.0/topics/http/urls/#path-converters`
- Django paginator class: `https://docs.djangoproject.com/en/5.0/ref/paginator/`
- Introduction to class-based views – `https://docs.djangoproject.com/en/5.0/topics/class-based-views/intro/`
- Sending emails with Django: `https://docs.djangoproject.com/en/5.0/topics/email/`
- The `python-decouple` library: `https://github.com/HBNetwork/python-decouple`
- The `django-anymail` library: `https://anymail.dev/en/stable/installation/`
- The `django-anymail` supported email service providers: `https://anymail.dev/en/stable/esps/`
- Django form field types: `https://docs.djangoproject.com/en/5.0/ref/forms/fields/`
- Working with forms: `https://docs.djangoproject.com/en/5.0/topics/forms/`
- Creating forms from models: `https://docs.djangoproject.com/en/5.0/topics/forms/modelforms/`
- Many-to-one model relationships: `https://docs.djangoproject.com/en/5.0/topics/db/examples/many_to_one/`
- Default form field template: `https://github.com/django/django/blob/stable/5.0.x/django/forms/templates/django/forms/field.html`
- Reusable field group templates: `https://docs.djangoproject.com/en/5.0/topics/forms/#reusable-field-group-templates`

3

Extending Your Blog Application

The previous chapter went through the basics of forms and the creation of a comment system. You also learned how to send emails with Django. In this chapter, you will extend your blog application with other popular features used on blogging platforms, such as tagging, recommending similar posts, providing an RSS feed to readers, and allowing them to search posts. You will learn about new components and functionalities with Django by building these functionalities.

The chapter will cover the following topics:

- Implementing tagging using `django-taggit`
- Retrieving posts by similarity
- Creating custom template tags and filters to display the latest posts and most commented posts
- Adding a sitemap to the site
- Creating feeds for blog posts
- Installing PostgreSQL
- Using fixtures to dump and load data into the database
- Implementing a full-text search engine with Django and PostgreSQL

Functional overview

Figure 3.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

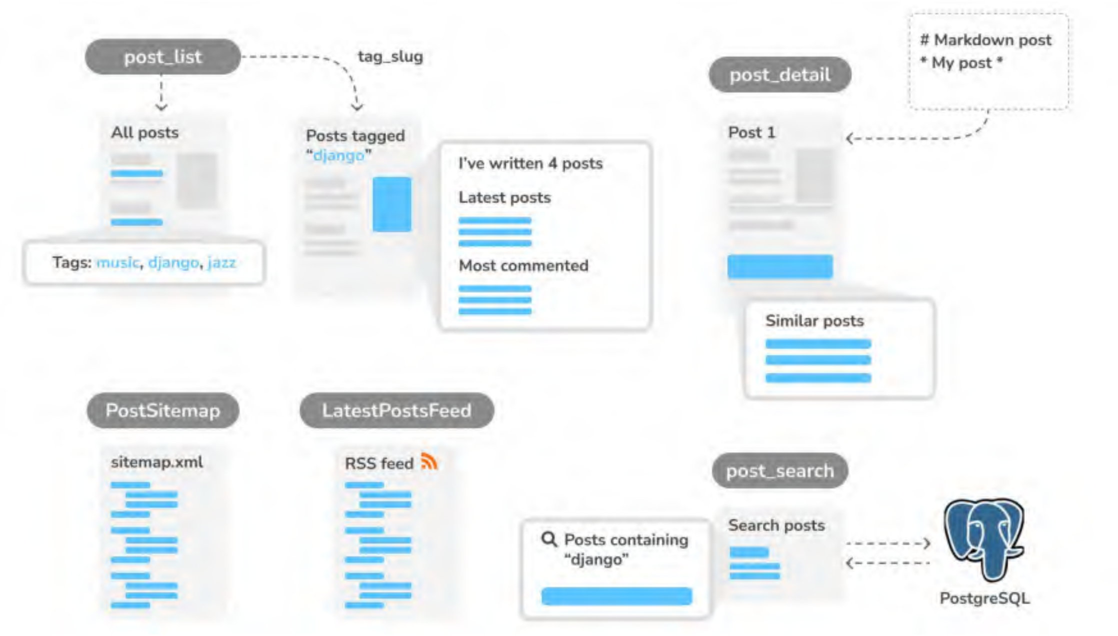

Figure 3.1: Diagram of functionalities built in Chapter 3

In this chapter, we will build the functionality to add tags to posts. We will extend the `post_list` view to filter posts by tag. When loading a single post in the `post_detail` view, we will retrieve similar posts based on common tags. We will also create custom template tags to display a sidebar with the total number of posts, the latest posts published, and the most commented posts.

We will add support to write posts with Markdown syntax and convert the content to HTML. We will create a sitemap for the blog with the `PostSitemap` class and implement an RSS feed with the latest posts in the `LatestPostsFeed` class. Finally, we will implement a search engine with the `post_search` view and use PostgreSQL full-text search capabilities.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter03`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all the requirements at once with the command `python -m pip install -r requirements.txt`.

Implementing tagging with django-taggit

A very common functionality in blogs is categorizing posts using tags. Tags allow you to categorize content in a non-hierarchical manner, using simple keywords. A tag is simply a label or keyword that can be assigned to posts. We will create a tagging system by integrating a third-party Django tagging application into the project.

`django-taggit` is a reusable application that primarily offers you a `Tag` model and a manager to easily add tags to any model. You can take a look at its source code at `https://github.com/jazzband/django-taggit`.

Let's add tagging to our blog. First, you need to install `django-taggit` via `pip` by running the following command:

```
python -m pip install django-taggit==5.0.1
```

Then, open the `settings.py` file of the `mysite` project and add `taggit` to your `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.staticfiles',
    'taggit',
    'blog.apps.BlogConfig',
]
```

It's good practice to keep the Django packages at the top, third-party packages in the middle, and local applications at the end of `INSTALLED_APPS`.

Open the `models.py` file of your `blog` application and add the `TaggableManager` manager provided by `django-taggit` to the `Post` model using the following code:

```
from taggit.managers import TaggableManager

class Post(models.Model):
    # ...
    tags = TaggableManager()
```

The `tags` manager will allow you to add, retrieve, and remove tags from `Post` objects.

The following schema shows the data models defined by `django-taggit` to create tags and store related tagged objects:

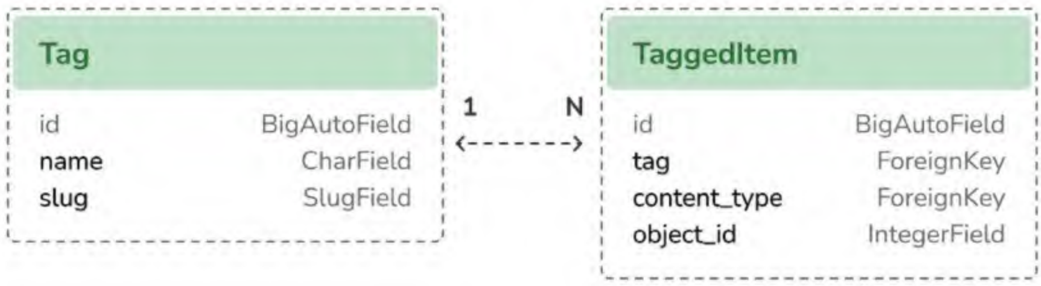

Figure 3.2: Tag models of django-taggit

The `Tag` model is used to store tags. It contains a `name` and a `slug` field.

The `TaggedItem` model is used to store the related tagged objects. It has a `ForeignKey` field for the related `Tag` object. It contains a `ForeignKey` to a `ContentType` object and an `IntegerField` to store the related `id` of the tagged object. The `content_type` and `object_id` fields combined form a generic relationship with any model in your project. This allows you to create relationships between a `Tag` instance and any other model instance of your applications. You will learn about generic relations ship in *Chapter 7*, *Tracking User Actions*.

Run the following command in the shell prompt to create a migration for your model changes:

```
python manage.py makemigrations blog
```

You should get the following output:

```
Migrations for 'blog':
  blog/migrations/0004_post_tags.py
    - Add field tags to post
```

Now, run the following command to create the required database tables for `django-taggit` models and to synchronize your model changes:

```
python manage.py migrate
```

You will see an output indicating that migrations have been applied, as follows:

```
Applying taggit.0001_initial... OK
Applying taggit.0002_auto_20150616_2121... OK
Applying taggit.0003_taggeditem_add_unique_index... OK
Applying taggit.0004_alter_taggeditem_content_type_alter_taggeditem_tag... OK
Applying taggit.0005_auto_20220424_2025... OK
Applying taggit.0006_rename_taggeditem_content_type_object_id_taggit_tagg_
content_8fc721_idx... OK
Applying blog.0004_post_tags... OK
```

The database is now in sync with the `taggit` models and we can start using the functionalities of `django-taggit`.

Let's now explore how to use the `tags` manager.

Open the Django shell by running the following command in the system shell prompt:

```
python manage.py shell
```

Run the following code to retrieve one of the posts (the one with the `1` ID):

```
>>> from blog.models import Post
>>> post = Post.objects.get(id=1)
```

Then, add some tags to it and retrieve its tags to check whether they were successfully added:

```
>>> post.tags.add('music', 'jazz', 'django')
>>> post.tags.all()
<QuerySet [<Tag: jazz>, <Tag: music>, <Tag: django>]>
```

Finally, remove a tag and check the list of tags again:

```
>>> post.tags.remove('django')
>>> post.tags.all()
<QuerySet [<Tag: jazz>, <Tag: music>]>
```

It's really easy to add, retrieve, or remove tags from a model using the manager we have defined.

Start the development server from the shell prompt with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/taggit/tag/` in your browser.

You will see the administration page with the list of `Tag` objects of the `taggit` application:

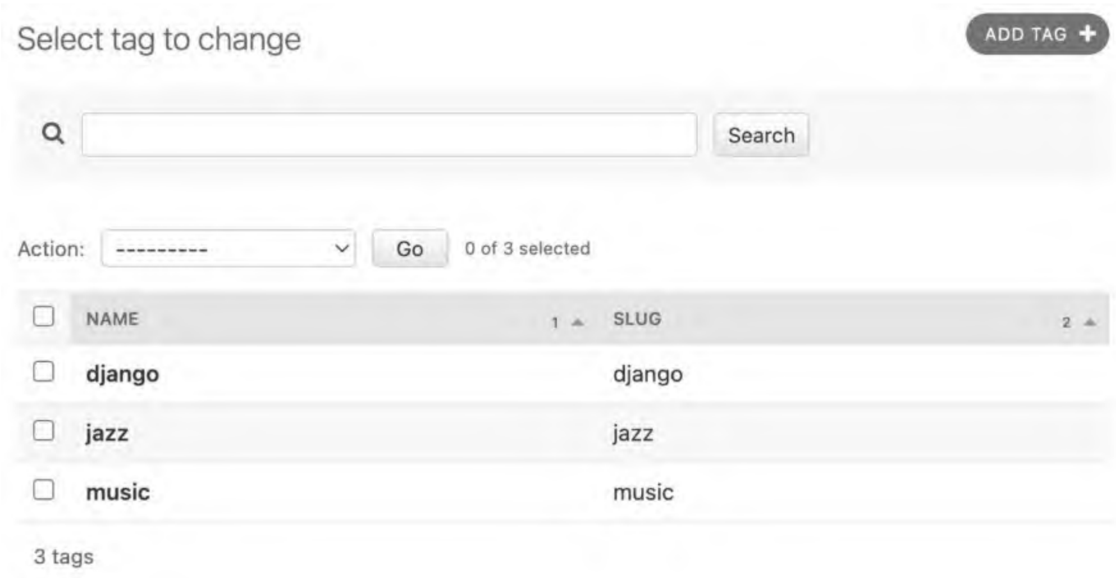

Figure 3.3: The tag change list view on the Django administration site

Click on the **jazz** tag. You will see the following:

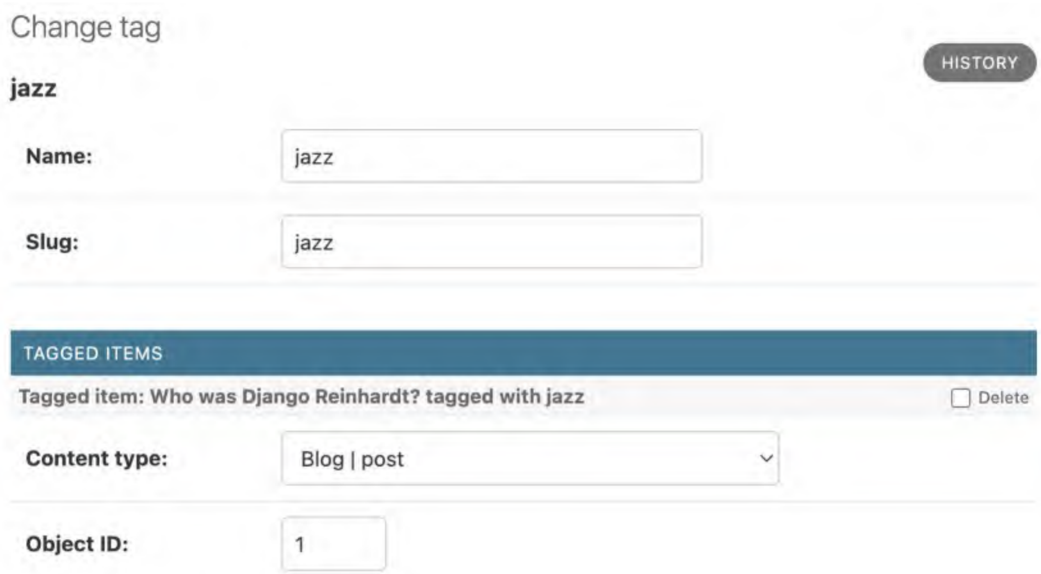

Figure 3.4: The tag edit view on the Django administration site

Navigate to `http://127.0.0.1:8000/admin/blog/post/1/change/` to edit the post with ID 1.

You will see that posts now include a new **Tags** field, as follows, where you can easily edit tags:

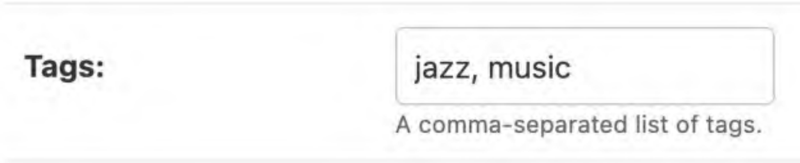

Figure 3.5: The related Tags field of a Post object

Now, you need to edit your blog posts to display tags.

Open the `blog/post/list.html` template and add the following HTML code highlighted in bold:

```
{% extends "blog/base.html" %}

{% block title %}My Blog{% endblock %}

{% block content %}
  <h1>My Blog</h1>
  {% for post in posts %}
    <h2>
      <a href="{{ post.get_absolute_url }}">
        {{ post.title }}
      </a>
    </h2>
    <p class="tags">Tags: {{ post.tags.all|join:", " }}</p>
    <p class="date">
      Published {{ post.publish }} by {{ post.author }}
    </p>
    {{ post.body|truncatewords:30|linebreaks }}
  {% endfor %}
  {% include "pagination.html" with page=page_obj %}
{% endblock %}
```

The `join` template filter works analogously to Python's string `join()` method. You can concatenate a list of items into one string, using a specific character or string to separate each item. For example, a list of tags like `['music', 'jazz', 'piano']` is converted into a single string, `'music, jazz, piano'`, by joining them with `','` as the `join()` separator.

Open `http://127.0.0.1:8000/blog/` in your browser. You should be able to see the list of tags under each post title:

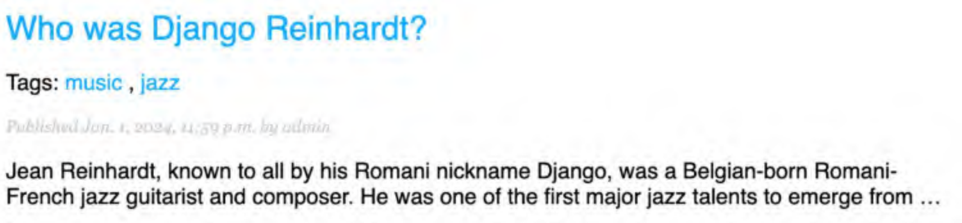

Figure 3.6: The Post list item, including related tags

Next, we will edit the `post_list` view to let users list all posts tagged with a specific tag.

Open the `views.py` file of your `blog` application, import the `Tag` model from `django-taggit`, and change the `post_list` view to optionally filter posts by a tag, as follows. New code is highlighted in bold:

```
from taggit.models import Tag


def post_list(request, tag_slug=None):
    post_list = Post.published.all()
    tag = None
    if tag_slug:
        tag = get_object_or_404(Tag, slug=tag_slug)
        post_list = post_list.filter(tags__in=[tag])
    # Pagination with 3 posts per page
    paginator = Paginator(post_list, 3)
    page_number = request.GET.get('page', 1)
    try:
        posts = paginator.page(page_number)
    except PageNotAnInteger:
        # If page_number is not an integer get the first page
        posts = paginator.page(1)
    except EmptyPage:
        # If page_number is out of range get last page of results
        posts = paginator.page(paginator.num_pages)
    return render(
        request,
        'blog/post/list.html',
        {
            'posts': posts,
            'tag': tag
        }
    )
```

The `post_list` view now works as follows:

1. It takes an optional `tag_slug` parameter that has a `None` default value. This parameter will be passed in the URL.
2. Inside the view, we build the initial QuerySet, retrieving all published posts, and if there is a given tag slug, we get the `Tag` object with the given slug using the `get_object_or_404()` shortcut.
3. Then, we filter the list of posts by the ones that contain the given tag. Since this is a many-to-many relationship, we have to filter posts by tags contained in a given list, which, in this case, contains only one element. We use the `__in` field lookup. Many-to-many relationships occur when multiple objects of a model are associated with multiple objects of another model. In our application, a post can have multiple tags and a tag can be related to multiple posts. You will learn how to create many-to-many relationships in *Chapter 6*, *Sharing Content on Your Website*. You can discover more about many-to-many relationships at `https://docs.djangoproject.com/en/5.0/topics/db/examples/many_to_many/`.
4. Finally, the `render()` function now passes the new `tag` variable to the template.

Remember that QuerySets are lazy. The QuerySets to retrieve posts will only be evaluated when you loop over `post_list` when rendering the template.

Open the `urls.py` file of your `blog` application, comment out the class-based `PostListView` URL pattern, and uncomment the `post_list` view, like this:

```
path('', views.post_list, name='post_list'),
# path('', views.PostListView.as_view(), name='post_list'),
```

Add the following additional URL pattern to list posts by tag:

```
path(
    'tag/<slug:tag_slug>/', views.post_list, name='post_list_by_tag'
    ),
```

As you can see, both patterns point to the same view, but they have different names. The first pattern will call the `post_list` view without any optional parameters, whereas the second pattern will call the view with the `tag_slug` parameter. You use a `slug` path converter to match the parameter as a lowercase string with ASCII letters or numbers, plus the hyphen and underscore characters.

The `urls.py` file of the `blog` application should now look like this:

```
from django.urls import path
from . import views

app_name = 'blog'

urlpatterns = [
    # Post views
    path('', views.post_list, name='post_list'),
```

```
    # path('', views.PostListView.as_view(), name='post_list'),
    path(
        'tag/<slug:tag_slug>/', views.post_list, name='post_list_by_tag'
    ),
    path(
        '<int:year>/<int:month>/<int:day>/<slug:post>/',
        views.post_detail,
        name='post_detail'
    ),
    path('<int:post_id>/share/', views.post_share, name='post_share'),
    path(
        '<int:post_id>/comment/', views.post_comment, name='post_comment'
    ),
]
```

Since you are using the `post_list` view, edit the `blog/post/list.html` template and modify the pagination to use the `posts` object:

```
{% include "pagination.html" with page=posts %}
```

Add the following lines highlighted in bold to the `blog/post/list.html` template:

```
{% extends "blog/base.html" %}

{% block title %}My Blog{% endblock %}

{% block content %}
  <h1>My Blog</h1>
  {% if tag %}
    <h2>Posts tagged with "{{ tag.name }}"</h2>
  {% endif %}
  {% for post in posts %}
    <h2>
      <a href="{{ post.get_absolute_url }}">
        {{ post.title }}
      </a>
    </h2>
    <p class="tags">Tags: {{ post.tags.all|join:", " }}</p>
    <p class="date">
      Published {{ post.publish }} by {{ post.author }}
    </p>
    {{ post.body|truncatewords:30|linebreaks }}
  {% endfor %}
```

```
    {% include "pagination.html" with page=posts %}
{% endblock %}
```

If a user is accessing the blog, they will see the list of all posts. If they filter by posts tagged with a specific tag, they will see the tag that they are filtering by.

Now, edit the `blog/post/list.html` template and change the way tags are displayed, as follows. New lines are highlighted in bold:

```
{% extends "blog/base.html" %}

{% block title %}My Blog{% endblock %}

{% block content %}
  <h1>My Blog</h1>
  {% if tag %}
    <h2>Posts tagged with "{{ tag.name }}"</h2>
  {% endif %}
  {% for post in posts %}
    <h2>
      <a href="{{ post.get_absolute_url }}">
        {{ post.title }}
      </a>
    </h2>
    <p class="tags">
      Tags:
      {% for tag in post.tags.all %}
        <a href="{% url "blog:post_list_by_tag" tag.slug %}">
          {{ tag.name }}
        </a>{% if not forloop.last %}, {% endif %}
      {% endfor %}
   </p>
    <p class="date">
      Published {{ post.publish }} by {{ post.author }}
    </p>
    {{ post.body|truncatewords:30|linebreaks }}
  {% endfor %}
  {% include "pagination.html" with page=posts %}
{% endblock %}
```

In the preceding code, we loop through all the tags of a post displaying a custom link to the URL to filter posts by that tag. We build the URL with `{% url "blog:post_list_by_tag" tag.slug %}`, using the name of the URL and the `slug` tag as its parameter. You separate the tags with commas.

Open `http://127.0.0.1:8000/blog/tag/jazz/` in your browser. You will see the list of posts filtered by that tag, like this:

Figure 3.7: A post filtered by the tag "jazz"

Retrieving posts by similarity

Now that we have implemented tagging for blog posts, you can do many interesting things with tags. Tags allow you to categorize posts in a non-hierarchical manner. Posts about similar topics will have several tags in common. We will build a functionality to display similar posts by the number of tags they share. In this way, when a user reads a post, we can suggest to them that they read other related posts.

In order to retrieve similar posts for a specific post, you need to perform the following steps:

1. Retrieve all tags for the current post.
2. Get all posts that are tagged with any of those tags.
3. Exclude the current post from that list to avoid recommending the same post.
4. Order the results by the number of tags shared with the current post.
5. In the case of two or more posts with the same number of tags, recommend the most recent post.
6. Limit the query to the number of posts you want to recommend.

These steps are translated into a complex QuerySet. Let's edit the `post_detail` view to incorporate these similarity-based post suggestions.

Open the `views.py` file of your `blog` application and add the following import at the top of it:

```
from django.db.models import Count
```

This is the `Count` aggregation function of the Django ORM. This function will allow you to perform aggregated counts of tags. `django.db.models` includes the following aggregation functions:

- `Avg`: The mean value
- `Max`: The maximum value

- `Min`: The minimum value
- `Count`: The total number of objects

You can learn about aggregation at https://docs.djangoproject.com/en/5.0/topics/db/aggregation/.

Open the `views.py` file of your `blog` application and add the following lines to the `post_detail` view. New lines are highlighted in bold:

```
def post_detail(request, year, month, day, post):
    post = get_object_or_404(
        Post,
        status=Post.Status.PUBLISHED,
        slug=post,
        publish__year=year,
        publish__month=month,
        publish__day=day
    )

    # List of active comments for this post
    comments = post.comments.filter(active=True)
    # Form for users to comment
    form = CommentForm()

    # List of similar posts
    post_tags_ids = post.tags.values_list('id', flat=True)
    similar_posts = Post.published.filter(
        tags__in=post_tags_ids
    ).exclude(id=post.id)
    similar_posts = similar_posts.annotate(
        same_tags=Count('tags')
    ).order_by('-same_tags', '-publish')[:4]

    return render(
        request,
        'blog/post/detail.html',
        {
            'post': post,
            'comments': comments,
            'form': form,
            'similar_posts': similar_posts
        }
    )
```

The preceding code is as follows:

1. You retrieve a Python list of IDs for the tags of the current post. The `values_list()` QuerySet returns tuples with the values for the given fields. You pass `flat=True` to it to get single values such as `[1, 2, 3, ...]` instead of one tuple such as `[(1,), (2,), (3,) ...]`.
2. You get all posts that contain any of these tags, excluding the current post itself.
3. You use the `Count` aggregation function to generate a calculated field—`same_tags`—that contains the number of tags shared with all the tags queried.
4. You order the result by the number of shared tags (descending order) and by `publish` to display recent posts first for the posts with the same number of shared tags. You slice the result to retrieve only the first four posts.
5. You pass the `similar_posts` object to the context dictionary for the `render()` function.

Now, edit the `blog/post/detail.html` template and add the following code highlighted in bold:

```
{% extends "blog/base.html" %}

{% block title %}{{ post.title }}{% endblock %}

{% block content %}
  <h1>{{ post.title }}</h1>
  <p class="date">
    Published {{ post.publish }} by {{ post.author }}
  </p>
  {{ post.body|linebreaks }}
  <p>
    <a href="{% url "blog:post_share" post.id %}">
      Share this post
    </a>
  </p>

  <h2>Similar posts</h2>
  {% for post in similar_posts %}
    <p>
      <a href="{{ post.get_absolute_url }}">{{ post.title }}</a>
    </p>
```

```
  {% empty %}
    There are no similar posts yet.
  {% endfor %}

  {% with comments.count as total_comments %}
    <h2>
      {{ total_comments }} comment{{ total_comments|pluralize }}
    </h2>
  {% endwith %}
  {% for comment in comments %}
    <div class="comment">
      <p class="info">
        Comment {{ forloop.counter }} by {{ comment.name }}
        {{ comment.created }}
      </p>
      {{ comment.body|linebreaks }}
    </div>
  {% empty %}
    <p>There are no comments yet.</p>
  {% endfor %}
  {% include "blog/post/includes/comment_form.html" %}
{% endblock %}
```

The post detail page should look like this:

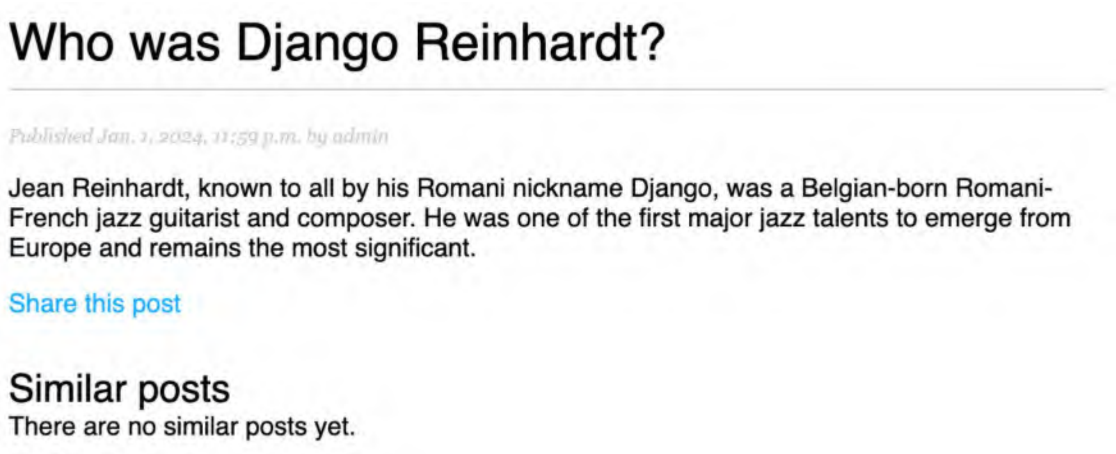

Figure 3.8: The post detail page, including a list of similar posts

Open `http://127.0.0.1:8000/admin/blog/post/` in your browser, edit a post that has no tags, and add the `music` and `jazz` tags, as follows:

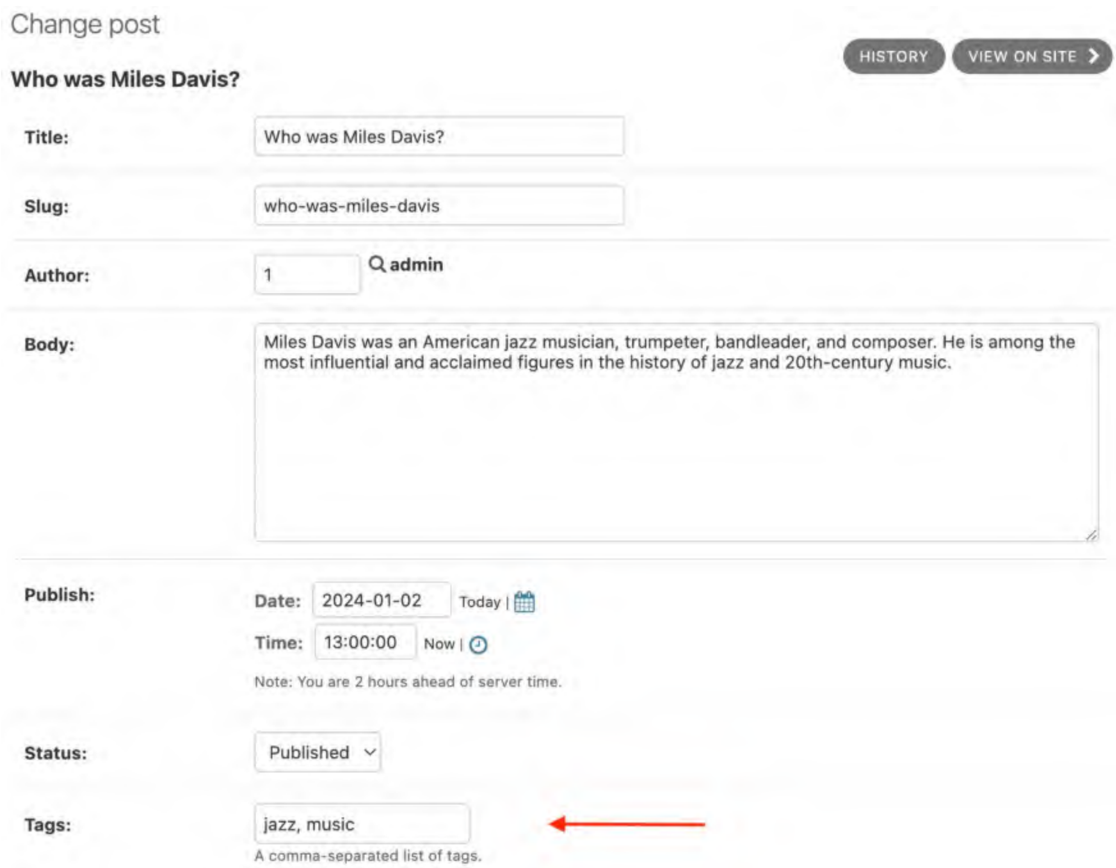

Figure 3.9: Adding the "jazz" and "music" tags to a post

Edit another post and add the `jazz` tag, as follows:

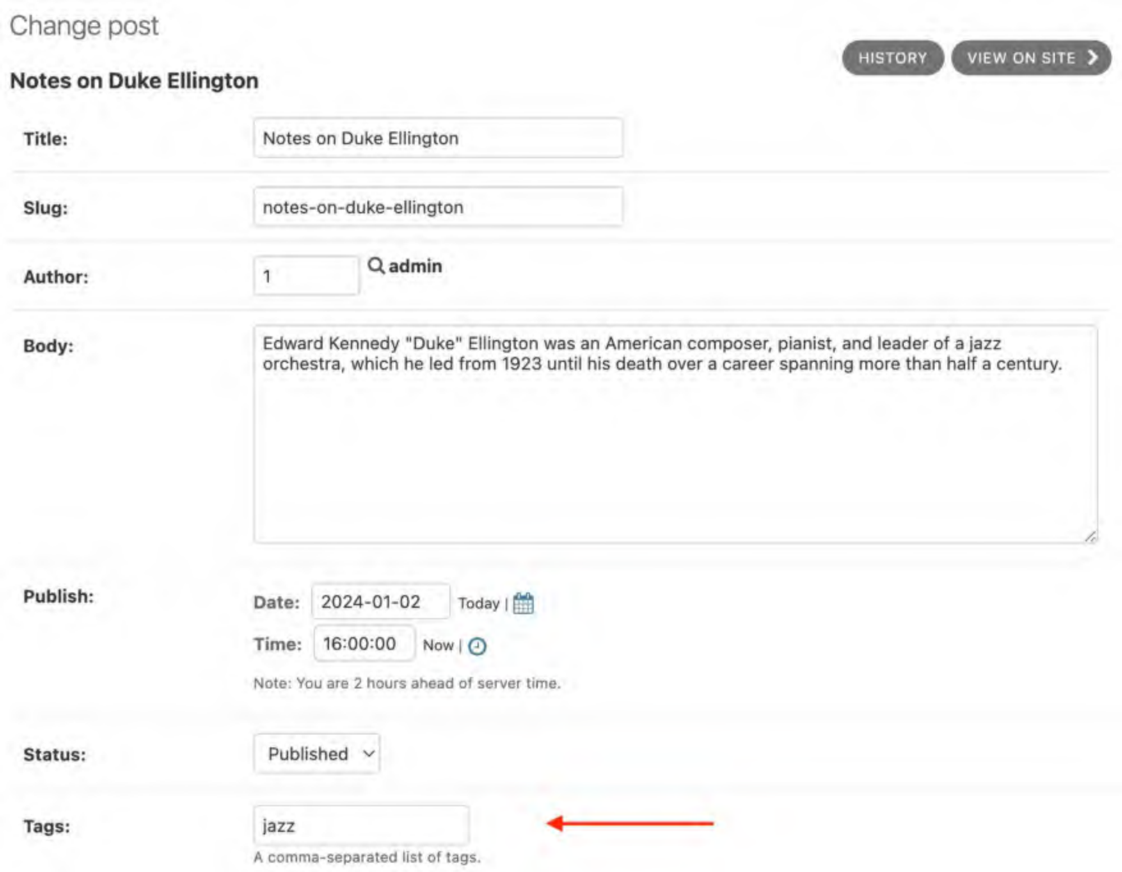

Figure 3.10: Adding the "jazz" tag to a post

The post detail page for the first post should now look like this:

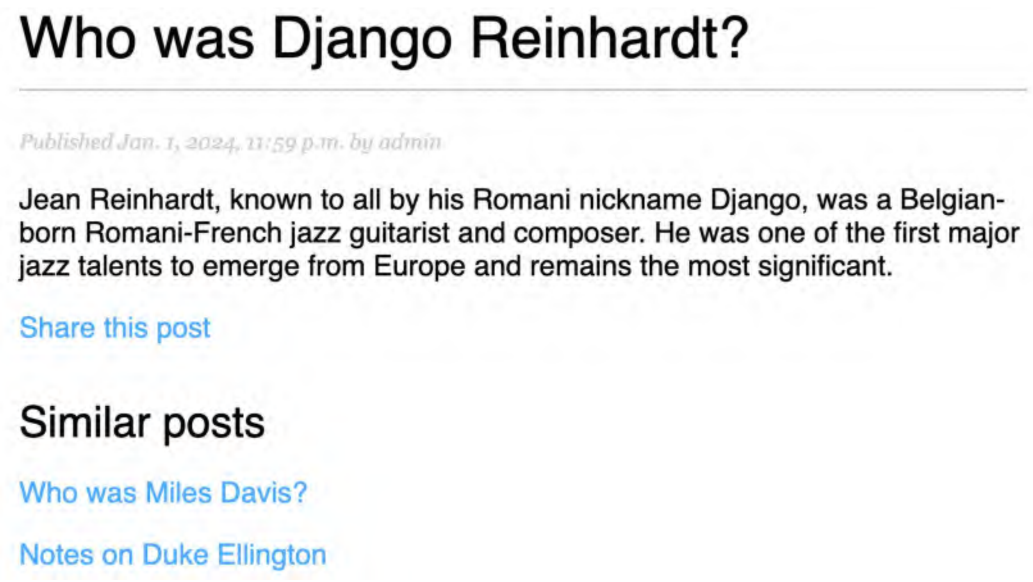

Figure 3.11: The post detail page, including a list of similar posts

The posts recommended in the **Similar posts** section of the page appear in descending order based on the number of shared tags with the original post.

We are now able to successfully recommend similar posts to readers. `django-taggit` also includes a `similar_objects()` manager that you can use to retrieve objects by shared tags. You can take a look at all `django-taggit` managers at `https://django-taggit.readthedocs.io/en/latest/api.html`.

You can also add the list of tags to your post detail template in the same way as you did in the `blog/post/list.html` template.

Creating custom template tags and filters

Django offers a variety of built-in template tags, such as `{% if %}` or `{% block %}`. You used different template tags in *Chapter 1*, *Building a Blog Application*, and *Chapter 2*, *Enhancing Your Blog with Advanced Features*. You can find a complete reference of built-in template tags and filters at `https://docs.djangoproject.com/en/5.0/ref/templates/builtins/`.

Django also allows you to create your own template tags to perform custom actions. Custom template tags come in very handy when you need to add a functionality to your templates that is not covered by the core set of Django template tags. This can be a tag to execute a QuerySet or any server-side processing that you want to reuse across templates. For example, we could build a template tag to display a list of the latest posts published on the blog. We could include this list in the sidebar so that it is always visible, regardless of the view that processes the request.

Implementing custom template tags

Django provides the following helper functions, which allow you to easily create template tags:

- `simple_tag`: Processes the given data and returns a string
- `inclusion_tag`: Processes the given data and returns a rendered template

Template tags must live inside Django applications.

Inside your `blog` application directory, create a new directory, name it `templatetags`, and add an empty `__init__.py` file to it. Create another file in the same folder and name it `blog_tags.py`. The file structure of the blog application should look like the following:

```
blog/
    __init__.py
    models.py
    ...
    templatetags/
        __init__.py
        blog_tags.py
```

The way you name the file is important because you will use the name of this module to load tags in templates.

Creating a simple template tag

Let's start by creating a simple tag to retrieve the total posts that have been published on the blog.

Edit the `templatetags/blog_tags.py` file you just created and add the following code:

```python
from django import template
from ..models import Post

register = template.Library()

@register.simple_tag
def total_posts():
    return Post.published.count()
```

We have created a simple template tag that returns the number of posts published on the blog.

Each module that contains template tags needs to define a variable called `register` to be a valid tag library. This variable is an instance of `template.Library`, and it's used to register the template tags and filters of the application.

In the preceding code, we have defined a tag called `total_posts` with a simple Python function. We have added the `@register.simple_tag` decorator to the function, to register it as a simple tag. Django will use the function's name as the tag name.

If you want to register it using a different name, you can do so by specifying a `name` attribute, such as `@register.simple_tag(name='my_tag')`.

> After adding a new template tags module, you will need to restart the Django development server in order to use the new tags and filters in templates.

Before using custom template tags, we have to make them available for the template using the `{% load %}` tag. As mentioned before, we need to use the name of the Python module containing our template tags and filters.

Edit the `blog/templates/base.html` template and add `{% load blog_tags %}` at the top of it to load your template tags module. Then, use the tag you created to display your total posts, as follows. The new lines are highlighted in bold:

```
{% load blog_tags %}
{% load static %}
<!DOCTYPE html>
<html>
<head>
  <title>{% block title %}{% endblock %}</title>
  <link href="{% static "css/blog.css" %}" rel="stylesheet">
</head>
<body>
  <div id="content">
    {% block content %}
    {% endblock %}
  </div>
  <div id="sidebar">
    <h2>My blog</h2>
    <p>
      This is my blog.
      I've written {% total_posts %} posts so far.
    </p>
  </div>
</body>
</html>
```

You will need to restart the server to keep track of the new files added to the project. Stop the development server with *Ctrl* + *C* and run it again using the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/blog/` in your browser. You should see the total number of posts in the sidebar of the site, as follows:

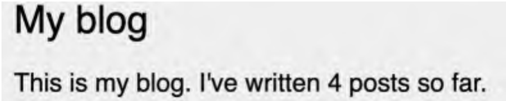

Figure 3.12: The total posts published included in the sidebar

If you see the following error message, it's very likely you didn't restart the development server:

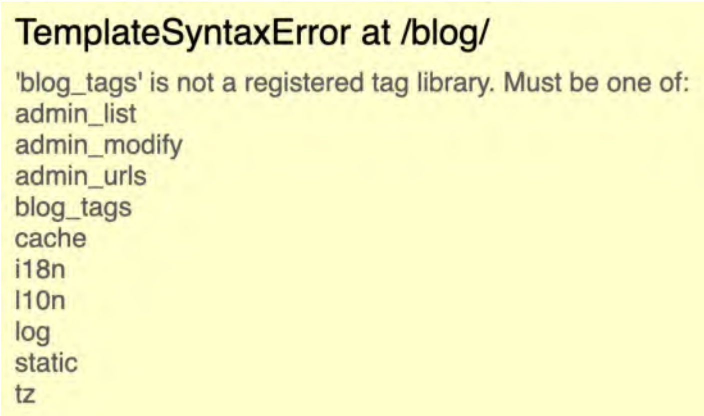

Figure 3.13: The error message when a template tag library is not registered

Template tags allow you to process any data and add it to any template regardless of the view executed. You can perform QuerySets or process any data to display results in your templates.

Creating an inclusion template tag

We will create another tag to display the latest posts in the sidebar of the blog. This time, we will implement an inclusion tag. Using an inclusion tag, you can render a template with context variables returned by your template tag.

Edit the `templatetags/blog_tags.py` file and add the following code:

```
@register.inclusion_tag('blog/post/latest_posts.html')
def show_latest_posts(count=5):
    latest_posts = Post.published.order_by('-publish')[:count]
    return {'latest_posts': latest_posts}
```

In the preceding code, we have registered the template tag using the `@register.inclusion_tag` decorator. We have specified the template that will be rendered with the returned values using `blog/post/latest_posts.html`. The template tag will accept an optional `count` parameter that defaults to `5`. This parameter will allow us to specify the number of posts to display. We use this variable to limit the results of the query `Post.published.order_by('-publish')[:count]`.

Note that the function returns a dictionary of variables instead of a simple value. Inclusion tags have to return a dictionary of values, which is used as the context to render the specified template. The template tag we just created allows us to specify the optional number of posts to display as `{% show_latest_posts 3 %}`.

Now, create a new template file under `blog/post/` and name it `latest_posts.html`.

Edit the new `blog/post/latest_posts.html` template and add the following code to it:

```
<ul>
  {% for post in latest_posts %}
    <li>
      <a href="{{ post.get_absolute_url }}">{{ post.title }}</a>
    </li>
  {% endfor %}
</ul>
```

In the preceding code, you have added an unordered list of posts using the `latest_posts` variable returned by your template tag. Now, edit the `blog/base.html` template and add the new template tag to display the last three posts, as follows. The new lines are highlighted in bold:

```
{% load blog_tags %}
{% load static %}
<!DOCTYPE html>
<html>
<head>
  <title>{% block title %}{% endblock %}</title>
  <link href="{% static "css/blog.css" %}" rel="stylesheet">
</head>
<body>
  <div id="content">
    {% block content %}
    {% endblock %}
  </div>
  <div id="sidebar">
    <h2>My blog</h2>
    <p>
      This is my blog.
      I've written {% total_posts %} posts so far.
    </p>
    <h3>Latest posts</h3>
    {% show_latest_posts 3 %}
  </div>
```

```
</body>
</html>
```

The template tag is called, passing the number of posts to display, and the template is rendered in place with the given context.

Next, return to your browser and refresh the page. The sidebar should now look like this:

Figure 3.14: The blog sidebar, including the latest published posts

Creating a template tag that returns a QuerySet

Finally, we will create a simple template tag that returns a value. We will store the result in a variable that can be reused, rather than outputting it directly. We will create a tag to display the most commented posts.

Edit the `templatetags/blog_tags.py` file and add the following import and template tag to it:

```
from django.db.models import Count

@register.simple_tag
def get_most_commented_posts(count=5):
    return Post.published.annotate(
        total_comments=Count('comments')
    ).order_by('-total_comments')[:count]
```

In the preceding template tag, you build a QuerySet using the `annotate()` function to aggregate the total number of comments for each post. You use the `Count` aggregation function to store the number of comments in the computed `total_comments` field for each `Post` object. You order the QuerySet by the computed field in descending order. You also provide an optional `count` variable to limit the total number of objects returned.

In addition to `Count`, Django offers the aggregation functions `Avg`, `Max`, `Min`, and `Sum`. You can read more about aggregation functions at `https://docs.djangoproject.com/en/5.0/topics/db/aggregation/`.

Next, edit the `blog/base.html` template and add the following code highlighted in bold:

```
{% load blog_tags %}
```

```
{% load static %}
<!DOCTYPE html>
<html>
<head>
  <title>{% block title %}{% endblock %}</title>
  <link href="{% static "css/blog.css" %}" rel="stylesheet">
</head>
<body>
  <div id="content">
    {% block content %}
    {% endblock %}
  </div>
  <div id="sidebar">
    <h2>My blog</h2>
    <p>
      This is my blog.
      I've written {% total_posts %} posts so far.
    </p>
    <h3>Latest posts</h3>
    {% show_latest_posts 3 %}
    <h3>Most commented posts</h3>
    {% get_most_commented_posts as most_commented_posts %}
    <ul>
      {% for post in most_commented_posts %}
        <li>
          <a href="{{ post.get_absolute_url }}">{{ post.title }}</a>
        </li>
      {% endfor %}
    </ul>
  </div>
</body>
</html>
```

In the preceding code, we store the result in a custom variable using the `as` argument followed by the variable name. For the template tag, we use `{% get_most_commented_posts as most_commented_posts %}` to store the result of the template tag in a new variable named `most_commented_posts`. Then, we display the returned posts using an HTML unordered list element.

Now open your browser and refresh the page to see the final result. It should look like the following:

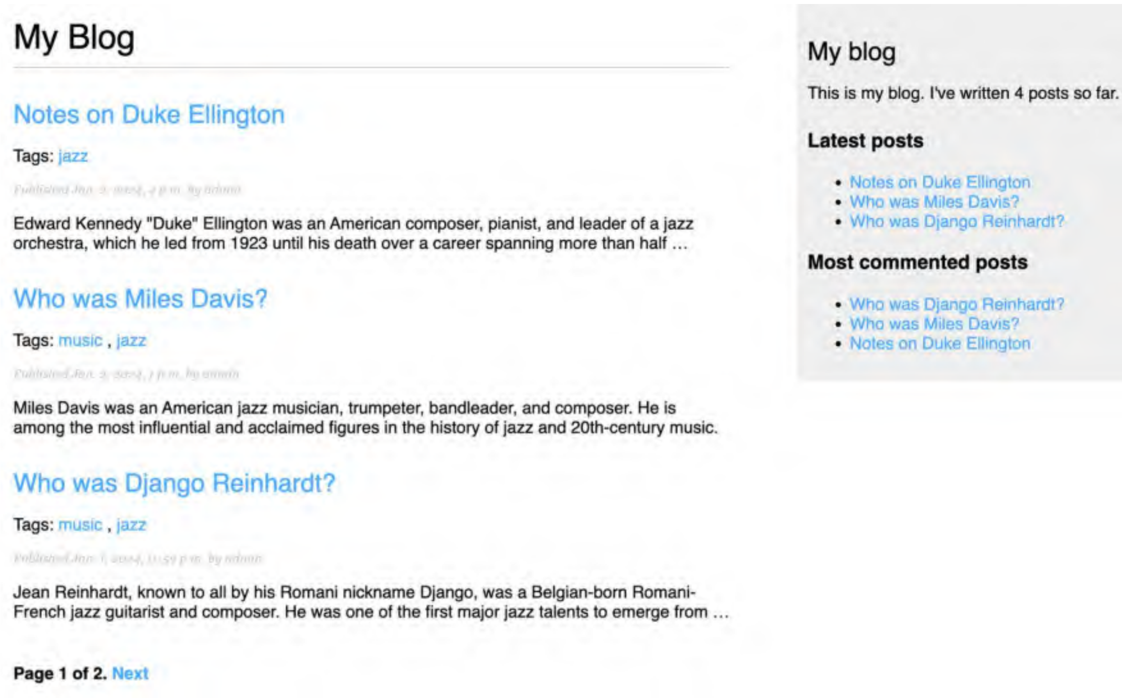

Figure 3.15: The post list view, including the complete sidebar with the latest and most commented posts

You now have a clear idea of how to build custom template tags. You can read more about them at `https://docs.djangoproject.com/en/5.0/howto/custom-template-tags/`.

Implementing custom template filters

Django has a variety of built-in template filters that allow you to alter variables in templates. These are Python functions that take one or two parameters, the value of the variable that the filter is applied to, and an optional argument. They return a value that can be displayed or treated by another filter.

A filter is written like `{{ variable|my_filter }}`. Filters with an argument are written like `{{ variable|my_filter:"foo" }}`. For example, you can use the `capfirst` filter to capitalize the first character of the value, like `{{ value|capfirst }}`. If `value` is `django`, the output will be `Django`. You can apply as many filters as you like to a variable, for example, `{{ variable|filter1|filter2 }}`, and each filter will be applied to the output generated by the preceding filter.

You can find the list of Django's built-in template filters at `https://docs.djangoproject.com/en/5.0/ref/templates/builtins/#built-in-filter-reference`.

Creating a template filter to support Markdown syntax

We will create a custom filter to enable you to use Markdown syntax in your blog posts and then convert the post body to HTML in the templates.

Markdown is a plain-text formatting syntax that is very simple to use, and it's intended to be converted into HTML. You can write posts using simple Markdown syntax and get the content automatically converted into HTML code. Learning Markdown syntax is much easier than learning HTML. By using Markdown, you can get other non-tech-savvy contributors to easily write posts for your blog. You can learn the basics of the Markdown format at `https://daringfireball.net/projects/markdown/basics`.

First, install the Python `markdown` module via `pip` using the following command in the shell prompt:

```
python -m pip install markdown==3.6
```

Then, edit the `templatetags/blog_tags.py` file and include the following code:

```python
import markdown
from django.utils.safestring import mark_safe

@register.filter(name='markdown')
def markdown_format(text):
    return mark_safe(markdown.markdown(text))
```

We register template filters in the same way as template tags. To prevent a name clash between the function name and the `markdown` module, we have named the function `markdown_format` and we have named the filter `markdown` for use in templates, such as `{{ variable|markdown }}`.

Django escapes the HTML code generated by filters; characters of HTML entities are replaced with their HTML-encoded characters. For example, `<p>` is converted to `<p>` (*less than* symbol, *p* character, *greater than* symbol).

We use the `mark_safe` function provided by Django to mark the result as safe HTML to be rendered in the template. By default, Django will not trust any HTML code and will escape it before placing it in the output. The only exceptions are variables that are marked as safe from escaping. This behavior prevents Django from outputting potentially dangerous HTML and allows you to create exceptions for returning safe HTML.

> In Django, HTML content is escaped by default for security. Use `mark_safe` cautiously, only on content you control. Avoid using `mark_safe` on any content submitted by non-staff users to prevent security vulnerabilities.

Edit the `blog/post/detail.html` template and add the following new code highlighted in bold:

```
{% extends "blog/base.html" %}
{% load blog_tags %}

{% block title %}{{ post.title }}{% endblock %}

{% block content %}
```

```
  <h1>{{ post.title }}</h1>
  <p class="date">
    Published {{ post.publish }} by {{ post.author }}
  </p>
  {{ post.body|markdown }}
  <p>
    <a href="{% url "blog:post_share" post.id %}">
      Share this post
    </a>
  </p>
  <h2>Similar posts</h2>
  {% for post in similar_posts %}
    <p>
      <a href="{{ post.get_absolute_url }}">{{ post.title }}</a>
    </p>
  {% empty %}
    There are no similar posts yet.
  {% endfor %}
  {% with comments.count as total_comments %}
    <h2>
      {{ total_comments }} comment{{ total_comments|pluralize }}
    </h2>
  {% endwith %}
  {% for comment in comments %}
    <div class="comment">
      <p class="info">
        Comment {{ forloop.counter }} by {{ comment.name }}
        {{ comment.created }}
      </p>
      {{ comment.body|linebreaks }}
    </div>
  {% empty %}
    <p>There are no comments yet.</p>
  {% endfor %}
  {% include "blog/post/includes/comment_form.html" %}
{% endblock %}
```

We have replaced the `linebreaks` filter of the `{{ post.body }}` template variable with the `markdown` filter. This filter will not only transform line breaks into `<p>` tags; it will also transform Markdown formatting into HTML.

Storing text in Markdown format in the database, rather than HTML, is a wise security strategy. Markdown limits the potential for injecting malicious content. This approach ensures that any text formatting is safely converted to HTML only at the point of rendering the template.

Edit the `blog/post/list.html` template and add the following new code highlighted in bold:

```
{% extends "blog/base.html" %}
{% load blog_tags %}

{% block title %}My Blog{% endblock %}

{% block content %}
  <h1>My Blog</h1>
  {% if tag %}
    <h2>Posts tagged with "{{ tag.name }}"</h2>
  {% endif %}
  {% for post in posts %}
    <h2>
      <a href="{{ post.get_absolute_url }}">
        {{ post.title }}
      </a>
    </h2>
    <p class="tags">
      Tags:
      {% for tag in post.tags.all %}
        <a href="{% url "blog:post_list_by_tag" tag.slug %}">
          {{ tag.name }}
        </a>
        {% if not forloop.last %}, {% endif %}
      {% endfor %}
    </p>
    <p class="date">
      Published {{ post.publish }} by {{ post.author }}
    </p>
    {{ post.body|markdown|truncatewords_html:30 }}
  {% endfor %}
  {% include "pagination.html" with page=posts %}
{% endblock %}
```

We have added the new `markdown` filter to the `{{ post.body }}` template variable. This filter will transform the Markdown content into HTML.

Therefore, we have replaced the previous `truncatewords` filter with the `truncatewords_html` filter. This filter truncates a string after a certain number of words, avoiding unclosed HTML tags.

Now open `http://127.0.0.1:8000/admin/blog/post/add/` in your browser and create a new post with the following body:

```
This is a post formatted with markdown
--------------------------------------

*This is emphasized* and **this is more emphasized**.

Here is a list:

* One
* Two
* Three

And a [link to the Django website](https://www.djangoproject.com/).
```

The form should look like this:

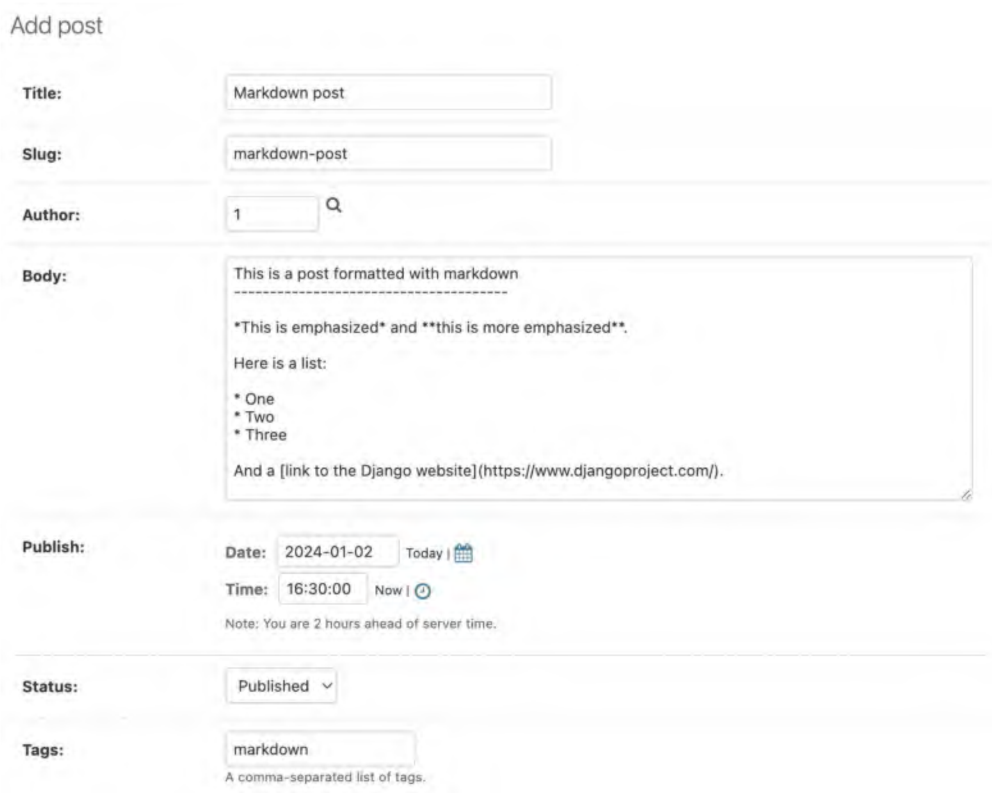

Figure 3.16: The post with Markdown content rendered as HTML

Open `http://127.0.0.1:8000/blog/` in your browser and take a look at how the new post is rendered. You should see the following output:

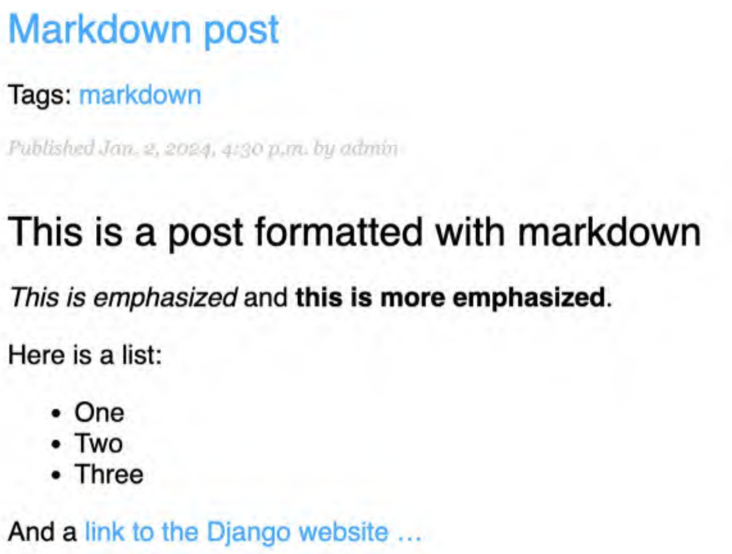

Figure 3.17: The post with Markdown content rendered as HTML

As you can see in *Figure 3.17*, custom template filters are very useful for customizing formatting. You can find more information about custom filters at `https://docs.djangoproject.com/en/5.0/howto/custom-template-tags/#writing-custom-template-filters`.

Adding a sitemap to the site

Django comes with a sitemap framework, which allows you to generate sitemaps for your site dynamically. A sitemap is an XML file that tells search engines the pages of your website, their relevance, and how frequently they are updated. Using a sitemap will make your site more visible in search engine rankings because it helps crawlers to index your website's content.

The Django sitemap framework depends on `django.contrib.sites`, which allows you to associate objects to particular websites that are running with your project. This comes in handy when you want to run multiple sites using a single Django project. To install the sitemap framework, we will need to activate both the `sites` and `sitemap` applications in your project. We are going to build a sitemap for the blog that includes the links to all published posts.

Edit the `settings.py` file of the project and add `django.contrib.sites` and `django.contrib.sitemaps` to the `INSTALLED_APPS` setting. Also, define a new setting for the site ID, as follows. New code is highlighted in bold:

```
# ...

SITE_ID = 1
```

```python
# Application definition

INSTALLED_APPS = [
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.sites',
    'django.contrib.sitemaps',
    'django.contrib.staticfiles',
    'taggit',
    'blog.apps.BlogConfig',
]
```

Now, run the following command from the shell prompt to create the tables of the Django site application in the database:

```
python manage.py migrate
```

You should see an output that contains the following lines:

```
Applying sites.0001_initial... OK
Applying sites.0002_alter_domain_unique... OK
```

The `sites` application is now synced with the database.

Next, create a new file inside your `blog` application directory and name it `sitemaps.py`. Open the file and add the following code to it:

```python
from django.contrib.sitemaps import Sitemap
from .models import Post


class PostSitemap(Sitemap):
    changefreq = 'weekly'
    priority = 0.9

    def items(self):
        return Post.published.all()

    def lastmod(self, obj):
        return obj.updated
```

We have defined a custom sitemap by inheriting the `Sitemap` class of the `sitemaps` module. The `changefreq` and `priority` attributes indicate the change frequency of your post pages and their relevance in your website (the maximum value is `1`).

The `items()` method returns the QuerySet of objects to include in this sitemap. By default, Django calls the `get_absolute_url()` method on each object to retrieve its URL. Remember that we implemented this method in *Chapter 2*, *Enhancing Your Blog with Advanced Features*, to define the canonical URL for posts. If you want to specify the URL for each object, you can add a `location` method to your sitemap class.

The `lastmod` method receives each object returned by `items()` and returns the last time the object was modified.

Both the `changefreq` and `priority` attributes can be either methods or attributes. You can take a look at the complete sitemap reference in the official Django documentation located at `https://docs.djangoproject.com/en/5.0/ref/contrib/sitemaps/`.

We have created the sitemap. Now we just need to create a URL for it.

Edit the main `urls.py` file of the `mysite` project and add the sitemap, as follows. New lines are highlighted in bold:

```
from django.contrib import admin
from django.contrib.sitemaps.views import sitemap
from django.urls import include, path
from blog.sitemaps import PostSitemap


sitemaps = {
    'posts': PostSitemap,
}

urlpatterns = [
    path('admin/', admin.site.urls),
    path('blog/', include('blog.urls', namespace='blog')),
    path(
        'sitemap.xml',
        sitemap,
        {'sitemaps': sitemaps},
        name='django.contrib.sitemaps.views.sitemap'
    )
]
```

In the preceding code, we have included the required imports and defined a `sitemaps` dictionary. Multiple sitemaps can be defined for the site. We have defined a URL pattern that matches the `sitemap.xml` pattern and uses the `sitemap` view provided by Django. The `sitemaps` dictionary is passed to the `sitemap` view.

Start the development server from the shell prompt with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/sitemap.xml` in your browser. You will see an XML output including all of the published posts, like this:

The `lastmod` attribute corresponds to the post `updated` date field, as you specified in your sitemap, and the `changefreq` and `priority` attributes are also taken from the `PostSitemap` class.

The domain used to build the URLs is `example.com`. This domain comes from a `Site` object stored in the database. This default object was created when you synced the site's framework with your database. You can read more about the `sites` framework at `https://docs.djangoproject.com/en/5.0/ref/contrib/sites/`.

Open `http://127.0.0.1:8000/admin/sites/site/` in your browser. You should see something like this:

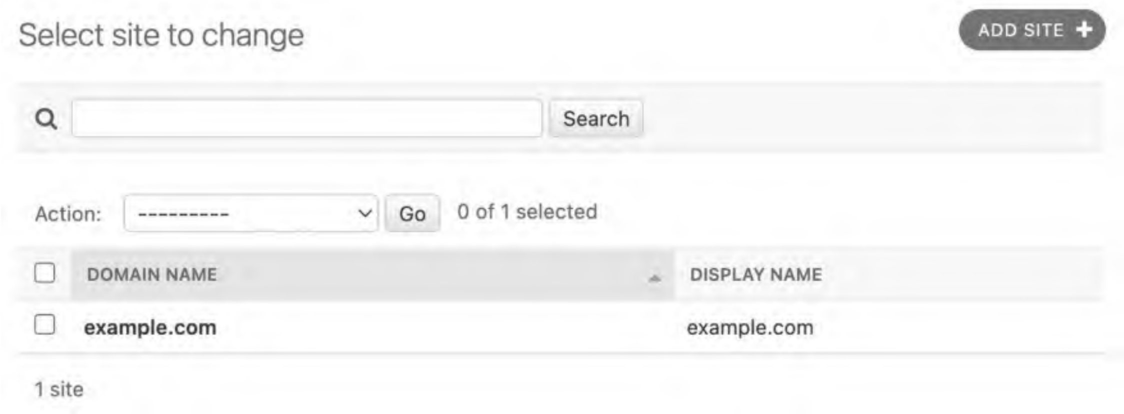

Figure 3.18: The Django administration list view for the Site model of the site's framework

Figure 3.18 contains the list display administration view for the site's framework. Here, you can set the domain or host to be used by the site's framework and the applications that depend on it. To generate URLs that exist in your local environment, change the domain name to `localhost:8000`, as shown in *Figure 3.19*, and save it:

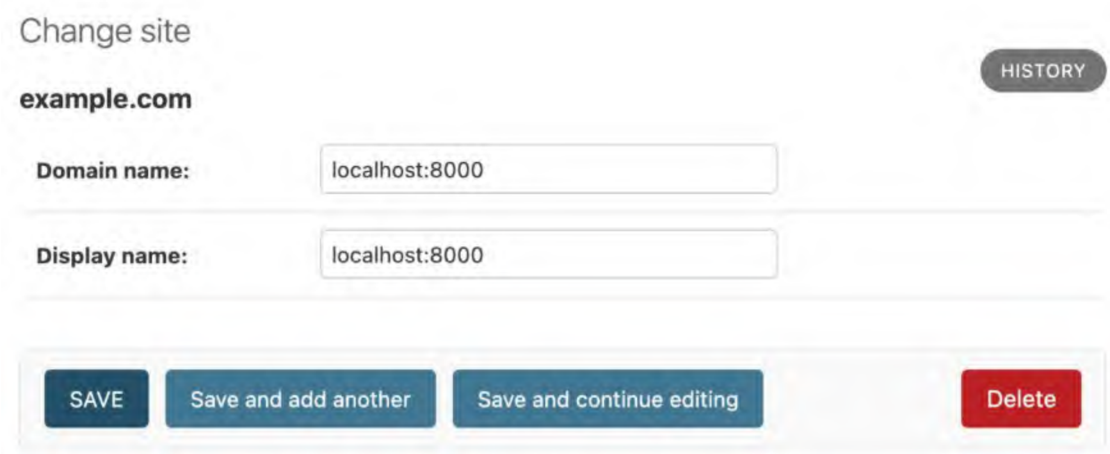

Figure 3.19: The Django administration edit view for the Site model of the site's framework

Open `http://127.0.0.1:8000/sitemap.xml` in your browser again. The URLs displayed in your sitemap will now use the new hostname and look like `http://localhost:8000/blog/2024/1/22/markdown-post/`. Links are now accessible in your local environment. In a production environment, you will have to use your website's domain to generate absolute URLs.

Creating feeds for blog posts

Django has a built-in syndication feed framework that you can use to dynamically generate RSS or Atom feeds in a similar manner to creating sitemaps using the site's framework. A web feed is a data format (usually XML) that provides users with the most recently updated content. Users can subscribe to the feed using a feed aggregator, a software that is used to read feeds and get new content notifications.

Create a new file in your `blog` application directory and name it `feeds.py`. Add the following lines to it:

```
import markdown
from django.contrib.syndication.views import Feed
from django.template.defaultfilters import truncatewords_html
from django.urls import reverse_lazy
from .models import Post

class LatestPostsFeed(Feed):

    title = 'My blog'
    link = reverse_lazy('blog:post_list')
    description = 'New posts of my blog.'

    def items(self):
        return Post.published.all()[:5]

    def item_title(self, item):
        return item.title

    def item_description(self, item):
        return truncatewords_html(markdown.markdown(item.body), 30)

    def item_pubdate(self, item):
        return item.publish
```

In the preceding code, we have defined a feed by subclassing the `Feed` class of the syndication framework. The `title`, `link`, and `description` attributes correspond to the `<title>`, `<link>`, and `<description>` RSS elements, respectively.

We use `reverse_lazy()` to generate the URL for the `link` attribute. The `reverse()` method allows you to build URLs by their name and pass optional parameters. We used `reverse()` in *Chapter 2, Enhancing Your Blog with Advanced Features*.

The `reverse_lazy()` utility function is a lazily evaluated version of `reverse()`. It allows you to use a URL reversal before the project's URL configuration is loaded.

The `items()` method retrieves the objects to be included in the feed. We retrieve the last five published posts to include them in the feed.

The `item_title()`, `item_description()`, and `item_pubdate()` methods will receive each object returned by `items()` and return the title, description, and publication date for each item.

In the `item_description()` method, we use the `markdown()` function to convert Markdown content to HTML and the `truncatewords_html()` template filter function to cut the description of posts after 30 words, avoiding unclosed HTML tags.

Now, edit the `blog/urls.py` file, import the `LatestPostsFeed` class, and instantiate the feed in a new URL pattern, as follows. New lines are highlighted in bold:

```
from django.urls import path
from . import views
from .feeds import LatestPostsFeed


app_name = 'blog'

urlpatterns = [
    # Post views
    path('', views.post_list, name='post_list'),
    # path('', views.PostListView.as_view(), name='post_list'),
    path(
        'tag/<slug:tag_slug>/', views.post_list, name='post_list_by_tag'
    ),
    path(
        '<int:year>/<int:month>/<int:day>/<slug:post>/',
        views.post_detail,
        name='post_detail'
    ),
    path('<int:post_id>/share/', views.post_share, name='post_share'),
    path(
        '<int:post_id>/comment/', views.post_comment, name='post_comment'
    ),
    path('feed/', LatestPostsFeed(), name='post_feed'),
]
```

Navigate to `http://127.0.0.1:8000/blog/feed/` in your browser. You should now see the RSS feed, including the last five blog posts:

```
<?xml version="1.0" encoding="utf-8"?>
```

```
<rss xmlns:atom="http://www.w3.org/2005/Atom" version="2.0">
  <channel>
    <title>My blog</title>
    <link>http://localhost:8000/blog/</link>
    <description>New posts of my blog.</description>
    <atom:link href="http://localhost:8000/blog/feed/" rel="self"/>
    <language>en-us</language>
    <lastBuildDate>Tue, 02 Jan 2024 16:30:00 +0000</lastBuildDate>
    <item>
      <title>Markdown post</title>
      <link>http://localhost:8000/blog/2024/1/2/markdown-post/</link>
      <description>This is a post formatted with ...</description>
      <guid>http://localhost:8000/blog/2024/1/2/markdown-post/</guid>
    </item>
    ...
  </channel>
</rss>
```

If you use Chrome, you will see the XML code. If you use Safari, it will ask you to install an RSS feed reader.

Let's install an RSS desktop client to view the RSS feed with a user-friendly interface. We will use Fluent Reader, which is a multi-platform RSS reader.

Download Fluent Reader for Linux, macOS, or Windows from `https://github.com/yang991178/fluent-reader/releases`.

Install Fluent Reader and open it. You will see the following screen:

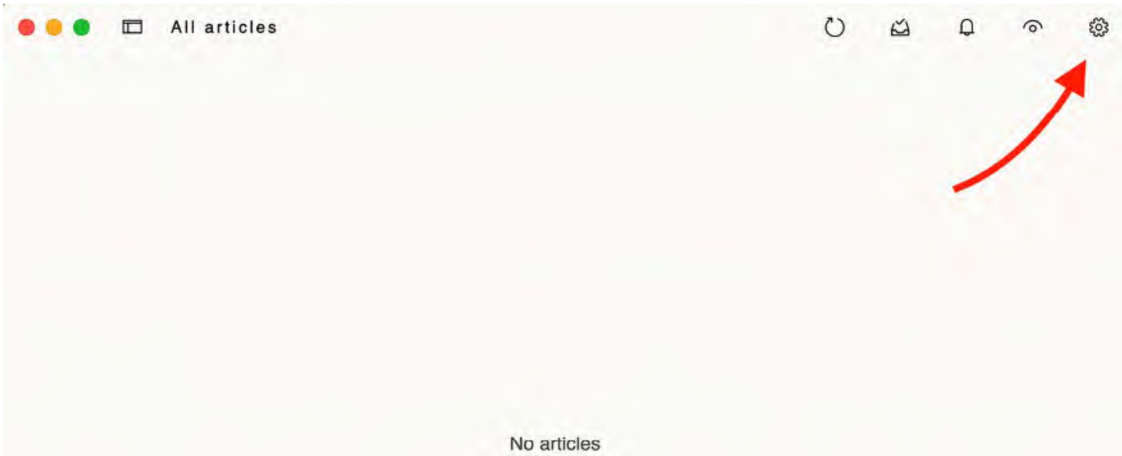

Figure 3.20: Fluent Reader with no RSS feed sources

Click on the settings icon in the top-right corner of the window. You will see a screen to add RSS feed sources like the following one:

Figure 3.21: Adding an RSS feed in Fluent Reader

Enter `http://127.0.0.1:8000/blog/feed/` in the **Add source** field and click on the **Add** button.

You will see a new entry with the RSS feed of the blog in the table below the form, like this:

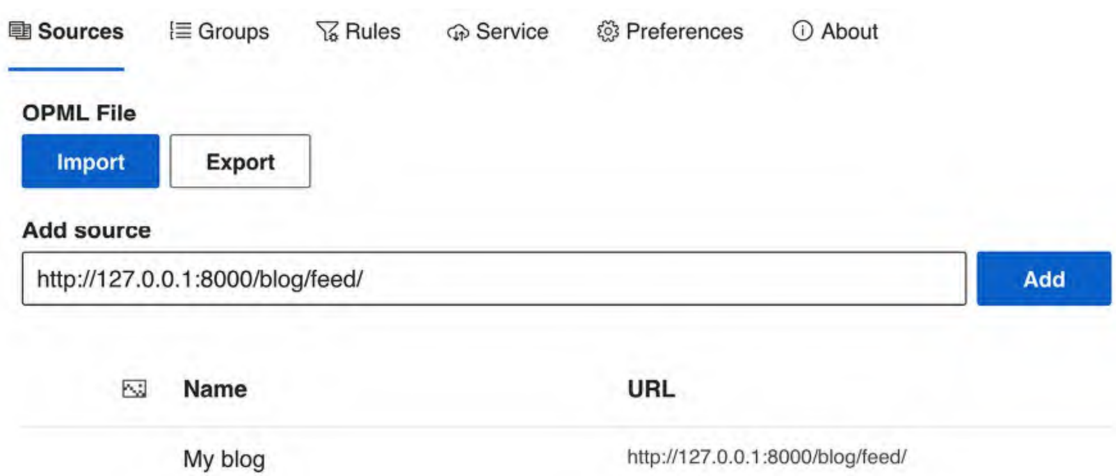

Figure 3.22: RSS feed sources in Fluent Reader

Now, go back to the main screen of Fluent Reader. You should be able to see the posts included in the blog RSS feed, as follows:

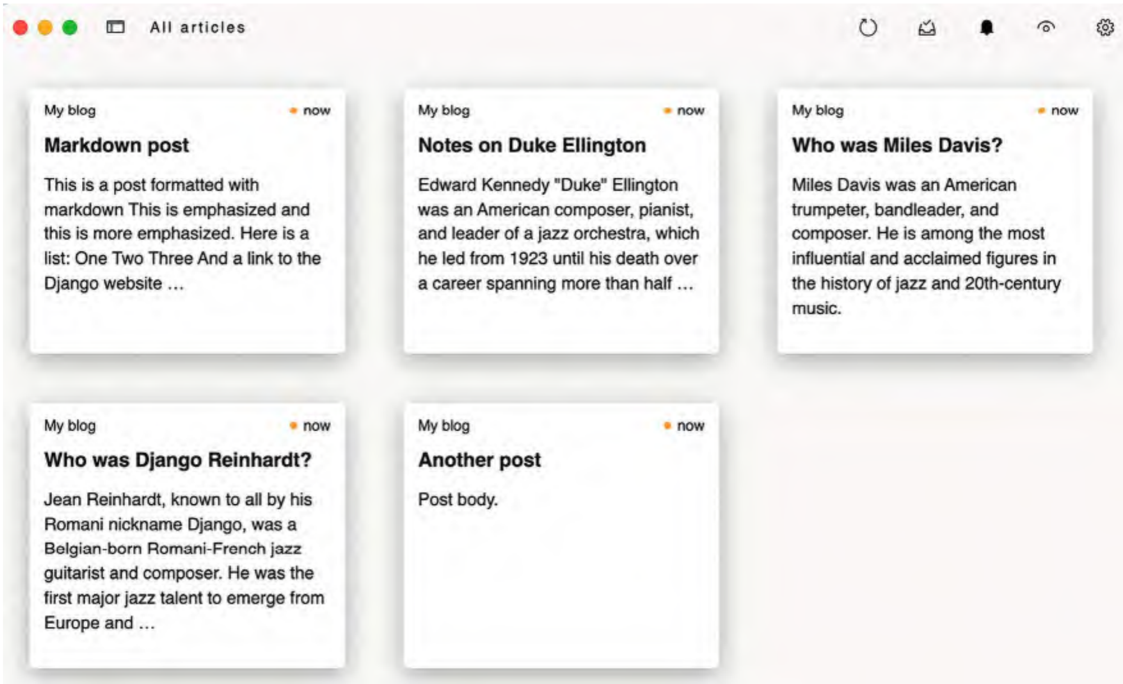

Figure 3.23: RSS feed of the blog in Fluent Reader

Click on a post to see a description:

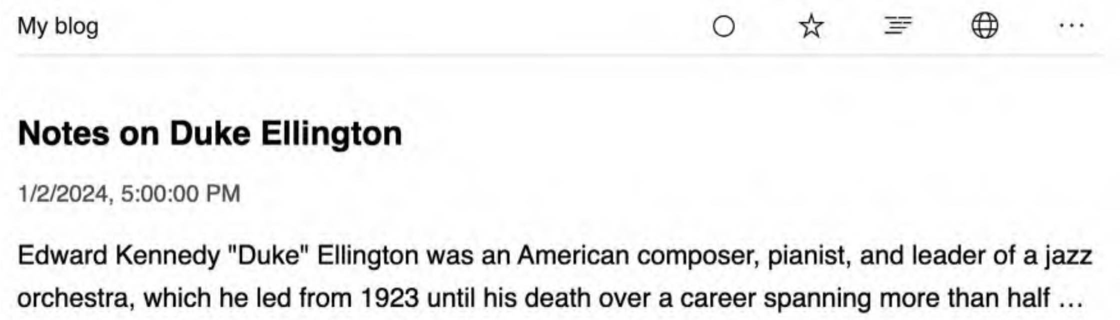

Figure 3.24: The post description in Fluent Reader

Click on the third icon in the top-right corner of the window to load the full content of the post page:

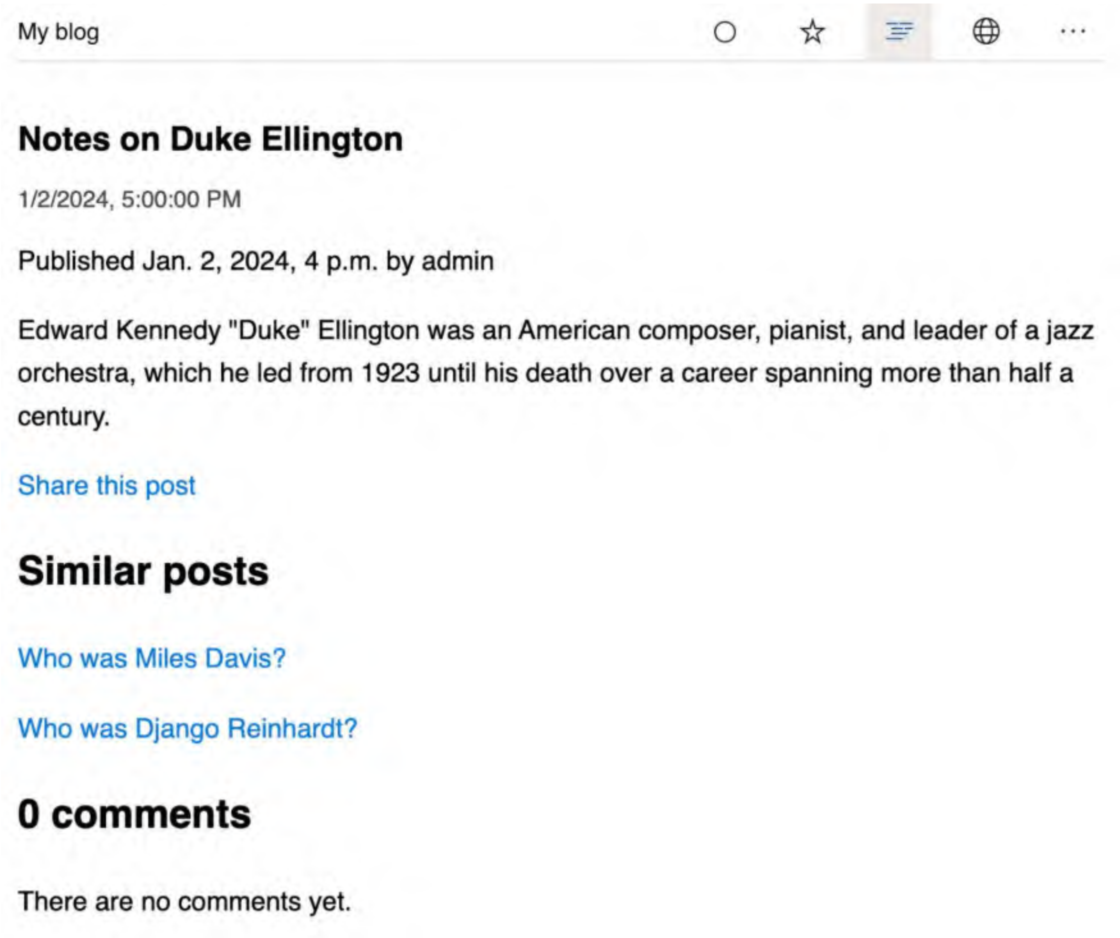

Figure 3.25: The full content of a post in Fluent Reader

The final step is to add an RSS feed subscription link to the blog's sidebar.

Open the `blog/base.html` template and add the following code highlighted in bold:

```
{% load blog_tags %}
{% load static %}
<!DOCTYPE html>
<html>
```

```
<head>
  <title>{% block title %}{% endblock %}</title>
  <link href="{% static "css/blog.css" %}" rel="stylesheet">
</head>
<body>
  <div id="content">
    {% block content %}
    {% endblock %}
  </div>
  <div id="sidebar">
    <h2>My blog</h2>
    <p>
      This is my blog.
      I've written {% total_posts %} posts so far.
    </p>
    <p>
      <a href="{% url "blog:post_feed" %}">
        Subscribe to my RSS feed
      </a>
    </p>
    <h3>Latest posts</h3>
    {% show_latest_posts 3 %}
    <h3>Most commented posts</h3>
    {% get_most_commented_posts as most_commented_posts %}
    <ul>
      {% for post in most_commented_posts %}
        <li>
          <a href="{{ post.get_absolute_url }}">{{ post.title }}</a>
        </li>
      {% endfor %}
    </ul>
  </div>
</body>
</html>
```

Now open `http://127.0.0.1:8000/blog/` in your browser and take a look at the sidebar. The new link will take users to the blog's feed:

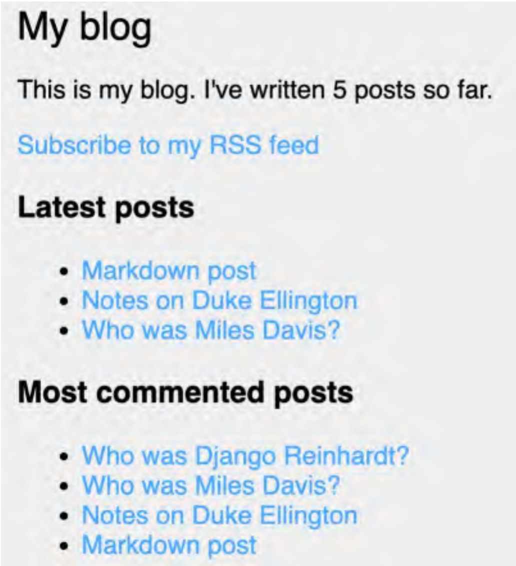

Figure 3.26: The RSS feed subscription link added to the sidebar

You can read more about the Django syndication feed framework at `https://docs.djangoproject.com/en/5.0/ref/contrib/syndication/`.

Adding full-text search to the blog

Next, we will add search capabilities to the blog. Searching for data in the database with user input is a common task for web applications. The Django ORM allows you to perform simple matching operations using, for example, the `contains` filter (or its case-insensitive version, `icontains`). You can use the following query to find posts that contain the word `framework` in their body:

```
from blog.models import Post
Post.objects.filter(body__contains='framework')
```

However, if you want to perform complex search lookups, retrieving results by similarity, or by weighting terms based on how frequently they appear in the text or how important different fields are (for example, the relevancy of the term appearing in the title versus in the body), you will need to use a full-text search engine. When you consider large blocks of text, building queries with operations on a string of characters is not enough. A full-text search examines the actual words against stored content as it tries to match search criteria.

Django provides a powerful search functionality built on top of PostgreSQL database full-text search features. The `django.contrib.postgres` module provides functionalities offered by PostgreSQL that are not shared by the other databases that Django supports. You can learn about PostgreSQL's full-text search support at `https://www.postgresql.org/docs/16/textsearch.html`.

> Although Django is a database-agnostic web framework, it provides a module that supports part of the rich feature set offered by PostgreSQL, which is not offered by other databases that Django supports.

We are currently using an SQLite database for the `mysite` project. SQLite support for full-text search is limited and Django doesn't support it out of the box. However, PostgreSQL is much better suited for full-text search and we can use the `django.contrib.postgres` module to use PostgreSQL's full-text search capabilities. We will migrate our data from SQLite to PostgreSQL to benefit from its full-text search features.

> SQLite is sufficient for development purposes. However, for a production environment, you will need a more powerful database, such as PostgreSQL, MariaDB, MySQL, or Oracle.

PostgreSQL provides a Docker image that makes it very easy to deploy a PostgreSQL server with a standard configuration.

Installing Docker

Docker is a popular open-source containerization platform. It enables developers to package applications into containers, simplifying the process of building, running, managing, and distributing applications.

First, download and install Docker for your OS. You will find instructions for downloading and installing Docker on Linux, macOS, and Windows at `https://docs.docker.com/get-docker/`. The installation includes both Docker Desktop and Docker command-line interface tools.

Installing PostgreSQL

After installing Docker on your Linux, macOS, or Windows machine, you can easily pull the PostgreSQL Docker image. Run the following command from the shell:

```
docker pull postgres:16.2
```

This will download the PostgreSQL Docker image to your local machine. You can find information about the official PostgreSQL Docker image at `https://hub.docker.com/_/postgres`. You can find other PostgreSQL packages and installers at `https://www.postgresql.org/download/`.

Execute the following command in the shell to start the PostgreSQL Docker container:

```
docker run --name=blog_db -e POSRGRES_DB=blog -e POSTGRES_USER=blog -e
POSTGRES_PASSWORD=xxxxx -p 5432:5432 -d postgres:16.2
```

Replace xxxxx with the desired password for your database user.

This command starts a PostgreSQL instance. The `--name` option is used to assign a name to the container, in this case, `blog_db`. The `-e` option is to define environment variables for the instance. We set the following environment variables:

- `POSTGRES_DB`: Name of the PostgreSQL database. If not defined, the value of `POSTGRES_USER` is used for the database name.
- `POSTGRES_USER`: Used in conjunction with `POSTGRES_PASSWORD` to define a username and password. The user is created with superuser power.
- `POSTGRES_PASSWORD`: Sets the superuser password for PostgreSQL.

The `-p` option is used to publish the `5432` port, on which PostgreSQL runs, to the same host interface port. This allows external applications to access the database. The `-d` option is for *detached mode*, which runs the Docker container in the background.

Open the Docker Desktop application. You should see the new container running, as in *Figure 3.27*:

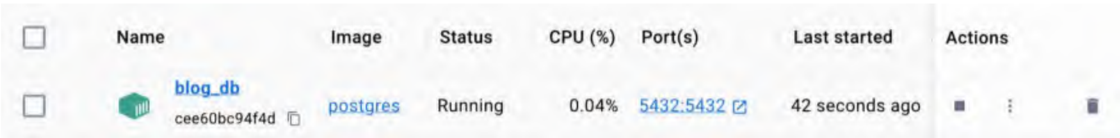

Figure 3.27: PostgreSQL instance running in Docker Desktop

You will see the newly created `blog_db` container, with the status **Running**. Under **Actions**, you can stop or restart the service. You can also delete the container. Note that deleting the container will also eliminate the database and all the data it contains. You will learn how to persist PostgreSQL data in the local filesystem using Docker in *Chapter 17*, *Going Live*.

You also need to install the `psycopg` PostgreSQL adapter for Python. Run the following command in the shell prompt to install it:

```
python -m pip install psycopg==3.1.18
```

Next, we will migrate the existing data in the SQLite database to the new PostgreSQL instance.

Dumping the existing data

Before switching the database in the Django project, we need to dump the existing data from the SQLite database. We will export the data, switch the project's database to PostgreSQL, and import the data into the new database.

Django comes with a simple way to load and dump data from the database into files that are called **fixtures**. Django supports fixtures in JSON, XML, or YAML format. We are going to create a fixture with all data contained in the database.

The `dumpdata` command dumps data from the database into the standard output, serialized in JSON format by default. The resulting data structure includes information about the model and its fields for Django to be able to load it into the database.

You can limit the output to the models of an application by providing the application names to the command, or specifying single models for outputting data using the `app.Model` format. You can also specify the format using the `--format` flag. By default, `dumpdata` outputs the serialized data to the standard output. However, you can indicate an output file using the `--output` flag. The `--indent` flag allows you to specify indentation. For more information on `dumpdata` parameters, run `python manage.py dumpdata --help`.

Execute the following command from the shell prompt:

```
python manage.py dumpdata --indent=2 --output=mysite_data.json
```

All existing data has been exported in JSON format to a new file named `mysite_data.json`. You can view the file contents to see the JSON structure that includes all the different data objects for the different models of your installed applications. If you get an encoding error when running the command, include the `-Xutf8` flag as follows to activate Python UTF-8 mode:

```
python -Xutf8 manage.py dumpdata --indent=2 --output=mysite_data.json
```

We will now switch the database in the Django project and then we will import the data into the new database.

Switching the database in the project

Now you will add the PostgreSQL database configuration to your project settings.

Edit the `settings.py` file of your project and modify the `DATABASES` setting to make it look as follows. New code is highlighted in bold:

```
DATABASES = {
    'default': {
        'ENGINE': 'django.db.backends.postgresql',
        'NAME': config('DB_NAME'),
        'USER': config('DB_USER'),
        'PASSWORD': config('DB_PASSWORD'),
        'HOST': config('DB_HOST'),
    }
}
```

The database engine is now `postgresql`. The database credentials are now loaded from environment variables using `python-decouple`.

Let's add values to the environment variables. Edit the `.env` file of your project and add the following lines highlighted in bold:

```
EMAIL_HOST_USER=your_account@gmail.com
EMAIL_HOST_PASSWORD=xxxxxxxxxxxx
DEFAULT_FROM_EMAIL=My Blog <your_account@gmail.com>
DB_NAME=blog
```

```
DB_USER=blog
DB_PASSWORD=xxxxx
DB_HOST=localhost
```

Replace xxxxxx with the password you used when starting the PostgreSQL container. The new database is empty.

Run the following command to apply all database migrations to the new PostgreSQL database:

```
python manage.py migrate
```

You will see an output, including all the migrations that have been applied, like this:

```
Operations to perform:
  Apply all migrations: admin, auth, blog, contenttypes, sessions, sites,
taggit
Running migrations:
  Applying contenttypes.0001_initial... OK
  Applying auth.0001_initial... OK
  Applying admin.0001_initial... OK
  Applying admin.0002_logentry_remove_auto_add... OK
  Applying admin.0003_logentry_add_action_flag_choices... OK
  Applying contenttypes.0002_remove_content_type_name... OK
  Applying auth.0002_alter_permission_name_max_length... OK
  Applying auth.0003_alter_user_email_max_length... OK
  Applying auth.0004_alter_user_username_opts... OK
  Applying auth.0005_alter_user_last_login_null... OK
  Applying auth.0006_require_contenttypes_0002... OK
  Applying auth.0007_alter_validators_add_error_messages... OK
  Applying auth.0008_alter_user_username_max_length... OK
  Applying auth.0009_alter_user_last_name_max_length... OK
  Applying auth.0010_alter_group_name_max_length... OK
  Applying auth.0011_update_proxy_permissions... OK
  Applying auth.0012_alter_user_first_name_max_length... OK
  Applying taggit.0001_initial... OK
  Applying taggit.0002_auto_20150616_2121... OK
  Applying taggit.0003_taggeditem_add_unique_index... OK
  Applying taggit.0004_alter_taggeditem_content_type_alter_taggeditem_tag... OK
  Applying taggit.0005_auto_20220424_2025... OK
  Applying taggit.0006_rename_taggeditem_content_type_object_id_taggit_tagg_
content_8fc721_idx... OK
  Applying blog.0001_initial... OK
  Applying blog.0002_alter_post_slug... OK
```

```
  Applying blog.0003_comment... OK
  Applying blog.0004_post_tags... OK
  Applying sessions.0001_initial... OK
  Applying sites.0001_initial... OK
  Applying sites.0002_alter_domain_unique... OK
```

The PostgreSQL database is now in sync with your data models and you can run your Django project pointing to the new database. Let's get the database to the same state by loading the data we previously exported from SQLite.

Loading the data into the new database

We are going to load the data fixtures we generated previously into our new PostgreSQL database.

Run the following command to load the previously exported data into the PostgreSQL database:

```
python manage.py loaddata mysite_data.json
```

You will see the following output:

```
Installed 104 object(s) from 1 fixture(s)
```

The number of objects might differ, depending on the users, posts, comments, and other objects that have been created in the database.

Start the development server from the shell prompt with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/blog/post/` in your browser to verify that all posts have been loaded into the new database. You should see all the posts, as follows:

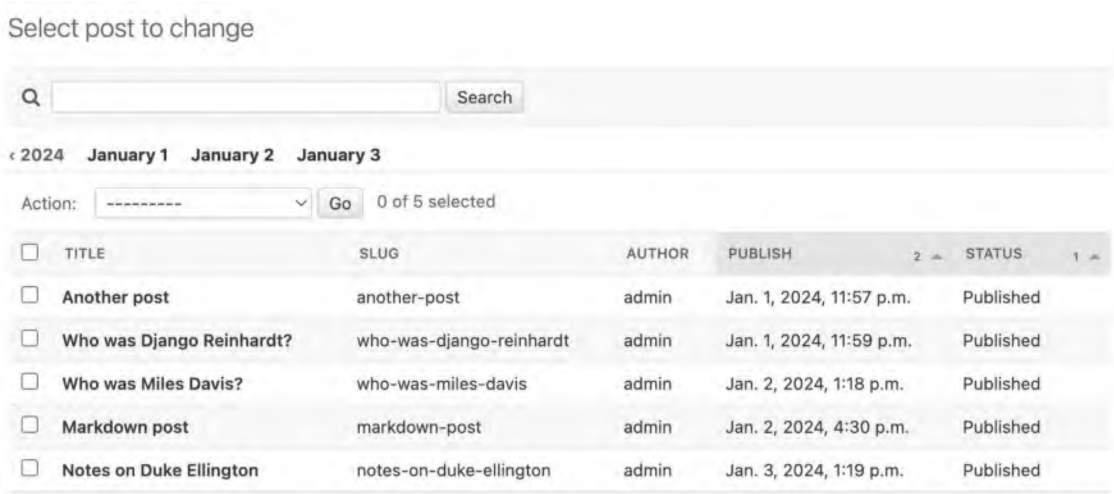

Figure 3.28: The list of posts on the administration site

Simple search lookups

Having enabled PostgreSQL in our project, we can now build a powerful search engine by leveraging PostgreSQL's full-text search capabilities. We will begin with basic search lookups and progressively incorporate more sophisticated features, such as stemming, ranking, or weighting queries, to build a comprehensive full-text search engine.

Edit the `settings.py` file of your project and add `django.contrib.postgres` to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.sites',
    'django.contrib.sitemaps',
    'django.contrib.staticfiles',
    'django.contrib.postgres',
    'taggit',
    'blog.apps.BlogConfig',
]
```

Open the Django shell by running the following command in the system shell prompt:

```
python manage.py shell
```

Now you can search against a single field using the `search` QuerySet lookup.

Run the following code in the Python shell:

```
>>> from blog.models import Post
>>> Post.objects.filter(title__search='django')
<QuerySet [<Post: Who was Django Reinhardt?>]>
```

This query uses PostgreSQL to create a search vector for the `title` field and a search query from the term `django`. Results are obtained by matching the query with the vector.

Searching against multiple fields

You might want to search against multiple fields. In this case, you will need to define a `SearchVector` object. Let's build a vector that allows you to search against the `title` and `body` fields of the `Post` model.

Run the following code in the Python shell:

```
>>> from django.contrib.postgres.search import SearchVector
>>> from blog.models import Post
```

```
>>>
>>> Post.objects.annotate(
...     search=SearchVector('title', 'body'),
... ).filter(search='django')
<QuerySet [<Post: Markdown post>, <Post: Who was Django Reinhardt?>]>
```

Using `annotate` and defining `SearchVector` with both fields, you provide a functionality to match the query against both the `title` and `body` of the posts.

Full-text search is an intensive process. If you are searching for more than a few hundred rows, you should define a functional index that matches the search vector you are using. Django provides a `SearchVectorField` field for your models. You can read more about this at `https://docs.djangoproject.com/en/5.0/ref/contrib/postgres/search/#performance`.

Building a search view

Now, you will create a custom view to allow your users to search posts. First, you will need a search form. Edit the `forms.py` file of the `blog` application and add the following form:

```
class SearchForm(forms.Form):
    query = forms.CharField()
```

You will use the `query` field to let users introduce search terms. Edit the `views.py` file of the `blog` application and add the following code to it:

```
# ...
from django.contrib.postgres.search import SearchVector
from .forms import CommentForm, EmailPostForm, SearchForm

# ...

def post_search(request):
    form = SearchForm()
    query = None
    results = []

    if 'query' in request.GET:
        form = SearchForm(request.GET)
        if form.is_valid():
            query = form.cleaned_data['query']
            results = (
                Post.published.annotate(
                    search=SearchVector('title', 'body'),
                )
```

```
                .filter(search=query)
            )

    return render(
        request,
        'blog/post/search.html',
        {
            'form': form,
            'query': query,
            'results': results
        }
    )
```

In the preceding view, first, we instantiate the `SearchForm` form. To check whether the form is submitted, we look for the `query` parameter in the `request.GET` dictionary. We send the form using the `GET` method instead of `POST` so that the resulting URL includes the `query` parameter and is easy to share. When the form is submitted, we instantiate it with the submitted `GET` data and verify that the form data is valid. If the form is valid, we search for published posts with a custom `SearchVector` instance built with the `title` and `body` fields.

The search view is now ready. We need to create a template to display the form and the results when the user performs a search.

Create a new file inside the `templates/blog/post/` directory, name it `search.html`, and add the following code to it:

```
{% extends "blog/base.html" %}
{% load blog_tags %}

{% block title %}Search{% endblock %}

{% block content %}
  {% if query %}
    <h1>Posts containing "{{ query }}"</h1>
    <h3>
      {% with results.count as total_results %}
        Found {{ total_results }} result{{ total_results|pluralize }}
      {% endwith %}
    </h3>
    {% for post in results %}
      <h4>
        <a href="{{ post.get_absolute_url }}">
          {{ post.title }}
        </a>
```

```
        </h4>
        {{ post.body|markdown|truncatewords_html:12 }}
      {% empty %}
        <p>There are no results for your query.</p>
      {% endfor %}
      <p><a href="{% url "blog:post_search" %}">Search again</a></p>
    {% else %}
      <h1>Search for posts</h1>
      <form method="get">
        {{ form.as_p }}
        <input type="submit" value="Search">
      </form>
    {% endif %}
  {% endblock %}
```

As in the search view, we distinguish whether the form has been submitted by the presence of the `query` parameter. Before the query is submitted, we display the form and a submit button. When the search form is submitted, we display the query performed, the total number of results, and the list of posts that match the search query.

Finally, edit the `urls.py` file of the `blog` application and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    # Post views
    path('', views.post_list, name='post_list'),
    # path('', views.PostListView.as_view(), name='post_list'),
    path(
        'tag/<slug:tag_slug>/', views.post_list, name='post_list_by_tag'
    ),
    path(
        '<int:year>/<int:month>/<int:day>/<slug:post>/',
        views.post_detail,
        name='post_detail'
    ),
    path('<int:post_id>/share/', views.post_share, name='post_share'),
    path(
        '<int:post_id>/comment/', views.post_comment, name='post_comment'
    ),
    path('feed/', LatestPostsFeed(), name='post_feed'),
    path('search/', views.post_search, name='post_search'),
]
```

Next, open `http://127.0.0.1:8000/blog/search/` in your browser. You should see the following search form:

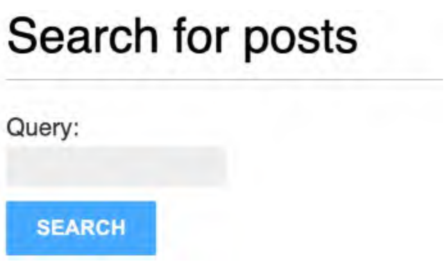

Figure 3.29: The form with the query field to search for posts

Enter a query and click on the **SEARCH** button. You will see the results of the search query, as follows:

Figure 3.30: Search results for the term "jazz"

Congratulations! You have created a basic search engine for your blog.

Stemming and ranking results

Stemming is the process of reducing words to their word stem, base, or root form. Stemming is used by search engines to reduce indexed words to their stem, and to be able to match inflected or derived words. For example, the words "music," "musical," and "musicality" can be considered similar words by a search engine. The stemming process normalizes each search token into a lexeme, a unit of lexical meaning that underlies a set of words that are related through inflection. The words "music," "musical," and "musicality" would convert to "music" when creating a search query.

Django provides a `SearchQuery` class to translate terms into a search query object. By default, the terms are passed through stemming algorithms, which helps you to obtain better matches.

The PostgreSQL search engine also removes stop words, such as "a," "the," "on," and "of." Stop words are a set of commonly used words in a language. They are removed when creating a search query because they appear too frequently to be relevant to searches. You can find the list of stop words used by PostgreSQL for the English language at `https://github.com/postgres/postgres/blob/master/src/backend/snowball/stopwords/english.stop`.

We also want to order results by relevancy. PostgreSQL provides a ranking function that orders results based on how often the query terms appear and how close together they are.

Edit the `views.py` file of the `blog` application and add the following imports:

```
from django.contrib.postgres.search import (
    SearchVector,
    SearchQuery,
    SearchRank
)
```

Then, edit the `post_search` view, as follows. New code is highlighted in bold:

```
def post_search(request):
    form = SearchForm()
    query = None
    results = []

    if 'query' in request.GET:
        form = SearchForm(request.GET)
        if form.is_valid():
            query = form.cleaned_data['query']
            search_vector = SearchVector('title', 'body')
            search_query = SearchQuery(query)
            results = (
                Post.published.annotate(
                    search=search_vector,
                    rank=SearchRank(search_vector, search_query)
                )
                .filter(search=search_query)
                .order_by('-rank')
            )

    return render(
        request,
        'blog/post/search.html',
        {
            'form': form,
```

```
            'query': query,
            'results': results
        }
    )
```

In the preceding code, we create a SearchQuery object, filter results by it, and use SearchRank to order the results by relevancy.

You can open http://127.0.0.1:8000/blog/search/ in your browser and test different searches to test stemming and ranking. The following is an example of ranking by the number of occurrences of the word django in the title and body of the posts:

Figure 3.31: Search results for the term "django"

Stemming and removing stop words in different languages

We can set up SearchVector and SearchQuery to execute stemming and remove stop words in any language. We can pass a config attribute to SearchVector and SearchQuery to use a different search configuration. This allows us to use different language parsers and dictionaries. The following example executes stemming and removes stop words in Spanish:

```
search_vector = SearchVector('title', 'body', config='spanish')
search_query = SearchQuery(query, config='spanish')
results = (
    Post.published.annotate(
        search=search_vector,
        rank=SearchRank(search_vector, search_query)
    )
```

```
        .filter(search=search_query)
        .order_by('-rank')
    )
```

You can find the Spanish stop words dictionary used by PostgreSQL at `https://github.com/postgres/postgres/blob/master/src/backend/snowball/stopwords/spanish.stop`.

Weighting queries

We can boost specific vectors so that more weight is attributed to them when ordering results by relevancy. For example, we can use this to give more relevance to posts that are matched by title rather than by content.

Edit the `views.py` file of the `blog` application and modify the `post_search` view as follows. New code is highlighted in bold:

```
def post_search(request):
    form = SearchForm()
    query = None
    results = []

    if 'query' in request.GET:
        form = SearchForm(request.GET)
        if form.is_valid():
            query = form.cleaned_data['query']
            search_vector = SearchVector(
                'title', weight='A'
            ) + SearchVector('body', weight='B')
            search_query = SearchQuery(query)
            results = (
                Post.published.annotate(
                    search=search_vector,
                    rank=SearchRank(search_vector, search_query)
                )
                .filter(rank__gte=0.3)
                .order_by('-rank')
            )

    return render(
        request,
        'blog/post/search.html',
        {
            'form': form,
            'query': query,
```

```
            'results': results
        }
    )
```

In the preceding code, we apply different weights to the search vectors built using the `title` and `body` fields. The default weights are `D`, `C`, `B`, and `A`, and they refer to the numbers `0.1`, `0.2`, `0.4`, and `1.0`, respectively. We apply a weight of `1.0` to the `title` search vector (`A`) and a weight of `0.4` to the `body` vector (`B`). Title matches will prevail over body content matches. We filter the results to display only the ones with a rank higher than `0.3`.

Searching with trigram similarity

Another search approach is trigram similarity. A trigram is a group of three consecutive characters. You can measure the similarity of two strings by counting the number of trigrams that they share. This approach turns out to be very effective for measuring the similarity of words in many languages.

To use trigrams in PostgreSQL, you will need to install the `pg_trgm` database extension first. Django provides database migration operations to create PostgreSQL extensions. Let's add a migration that creates the extension in the database.

First, execute the following command in the shell prompt to create an empty migration:

```
python manage.py makemigrations --name=trigram_ext --empty blog
```

This will create an empty migration for the `blog` application. You will see the following output:

```
Migrations for 'blog':
  blog/migrations/0005_trigram_ext.py
```

Edit the file `blog/migrations/0005_trigram_ext.py` and add the following lines highlighted in bold:

```
from django.contrib.postgres.operations import TrigramExtension
from django.db import migrations


class Migration(migrations.Migration):

    dependencies = [
        ('blog', '0004_post_tags'),
    ]

    operations = [
        TrigramExtension()
    ]
```

You have added the `TrigramExtension` operation to the database migration. This operation executes the SQL statement `CREATE EXTENSION pg_trgm` to create the extension in PostgreSQL.

You can find more information about database migration operations at https://docs.djangoproject.com/en/5.0/ref/contrib/postgres/operations/.

Now execute the migration with the following command:

```
python manage.py migrate blog
```

You will see the following output:

```
Running migrations:
  Applying blog.0005_trigram_ext... OK
```

The pg_trgm extension has been created in the database. Let's modify post_search to search for trigrams.

Edit the views.py file of your blog application and add the following import:

```
from django.contrib.postgres.search import TrigramSimilarity
```

Then, modify the post_search view as follows. New code is highlighted in bold:

```
def post_search(request):
    form = SearchForm()
    query = None
    results = []

    if 'query' in request.GET:
        form = SearchForm(request.GET)
        if form.is_valid():
            query = form.cleaned_data['query']
            results = (
                Post.published.annotate(
                    similarity=TrigramSimilarity('title', query),
                )
                .filter(similarity__gt=0.1)
                .order_by('-similarity')
            )

    return render(
        request,
        'blog/post/search.html',
        {
            'form': form,
            'query': query,
            'results': results
        }
    )
```

Open `http://127.0.0.1:8000/blog/search/` in your browser and test different searches for trigrams. The following example displays a hypothetical typo in the `django` term, showing search results for `yango`:

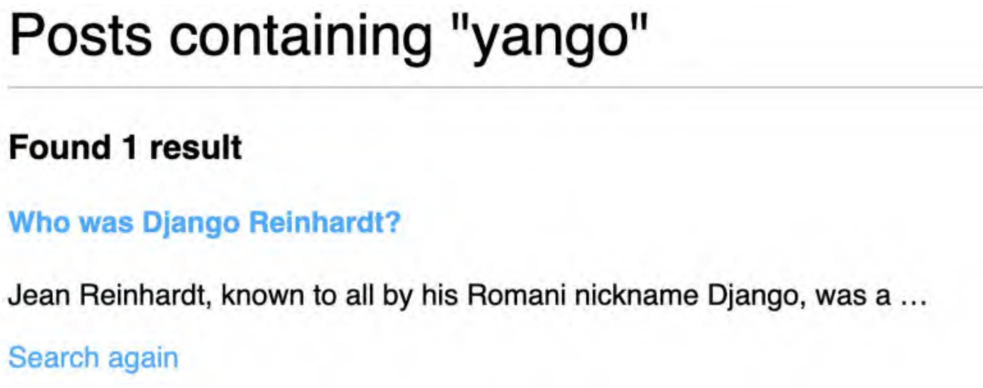

Figure 3.32: Search results for the term "yango"

We have added a powerful search engine to the blog application.

You can find more information about full-text search with Django and PostgreSQL at `https://docs.djangoproject.com/en/5.0/ref/contrib/postgres/search/`.

Summary

In this chapter, you implemented a tagging system by integrating a third-party application into your project. You generated post recommendations using complex QuerySets. You also learned how to create custom Django template tags and filters to provide templates with custom functionalities. You also created a sitemap for search engines to crawl your site and an RSS feed for users to subscribe to your blog. You then built a search engine for your blog using the full-text search engine of PostgreSQL.

In the next chapter, you will learn how to build a social website using the Django authentication framework and how to implement user account functionalities and custom user profiles.

Expanding your project using AI

Having completed the blog application, you likely have numerous ideas for adding new functionalities to your blog. This section aims to provide some insights into exploring new functionalities to incorporate into your project with the assistance of ChatGPT. ChatGPT is a sophisticated AI **Large Language Model** (**LLM**) created by OpenAI that generates human-like responses based on the prompts it receives. In this section, you will be presented with a task to extend your project, accompanied by a sample prompt for ChatGPT to assist you.

Engage with ChatGPT at `https://chat.openai.com/`. You will find similar guidance after completing each Django project within this book, in *Chapter 7, Tracking User Actions*, *Chapter 11*, *Adding Internationalization to Your Shop*, and *Chapter 17*, *Going Live*.

Let's further enhance your blog with the help of ChatGPT. Your blog currently allows filtering posts by tags. Adding these tags to our sitemap could significantly improve the SEO optimization of the blog. Use the prompt provided at `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter03/prompts/task.md` for adding tag pages to the sitemap. This challenge is an excellent opportunity to refine your project and deepen your understanding of Django, while learning to interact with ChatGPT.

> ChatGPT is ready to assist with code issues. Simply share your code along with any errors you're facing, and ChatGPT can help you identify and resolve the issues.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter03`
- `django-taggit`: `https://github.com/jazzband/django-taggit`
- `django-taggit` ORM managers: `https://django-taggit.readthedocs.io/en/latest/api.html`
- Many-to-many relationships: `https://docs.djangoproject.com/en/5.0/topics/db/examples/many_to_many/`
- Django aggregation functions: `https://docs.djangoproject.com/en/5.0/topics/db/aggregation/`
- Built-in template tags and filters: `https://docs.djangoproject.com/en/5.0/ref/templates/builtins/`
- Writing custom template tags: `https://docs.djangoproject.com/en/5.0/howto/custom-template-tags/`
- Markdown format reference: `https://daringfireball.net/projects/markdown/basics`
- Django sitemap framework: `https://docs.djangoproject.com/en/5.0/ref/contrib/sitemaps/`
- Django sites framework: `https://docs.djangoproject.com/en/5.0/ref/contrib/sites/`
- Django syndication feed framework: `https://docs.djangoproject.com/en/5.0/ref/contrib/syndication/`
- Docker download and installation instructions: `https://docs.docker.com/get-docker/`
- PostgreSQL Docker image: `https://hub.docker.com/_/postgres`
- PostgreSQL downloads: `https://www.postgresql.org/download/`
- PostgreSQL full-text search capabilities: `https://www.postgresql.org/docs/16/textsearch.html`
- Database migration operations: `https://docs.djangoproject.com/en/5.0/ref/contrib/postgres/operations/`.

- Django support for PostgreSQL full-text search – `https://docs.djangoproject.com/en/5.0/ref/contrib/postgres/search/`
- ChatGPT interface – `https://chat.openai.com/`
- Sample ChatGPT prompt to add tag pages to the sitemap – `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter03/prompts/task.md`

4

Building a Social Website

In the preceding chapter, you learned how to implement a tagging system and how to recommend similar posts. You implemented custom template tags and filters. You also learned how to create sitemaps and feeds for your site, and you built a full-text search engine using PostgreSQL.

In this chapter, you will learn how to develop user account functionalities to create a social website, including user registration, password management, profile editing, and authentication. We will implement social features on this site in the next few chapters, to let users share images and interact with each other. Users will be able to bookmark any image on the internet and share it with other users. They will also be able to see activity on the platform from the users they follow and like/unlike the images shared by them.

This chapter will cover the following topics:

- Creating a login view
- Using the Django authentication framework
- Creating templates for Django login, logout, password change, and password reset views
- Creating user registration views
- Extending the user model with a custom profile model
- Configuring the project for media file uploads

Functional overview

Figure 4.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

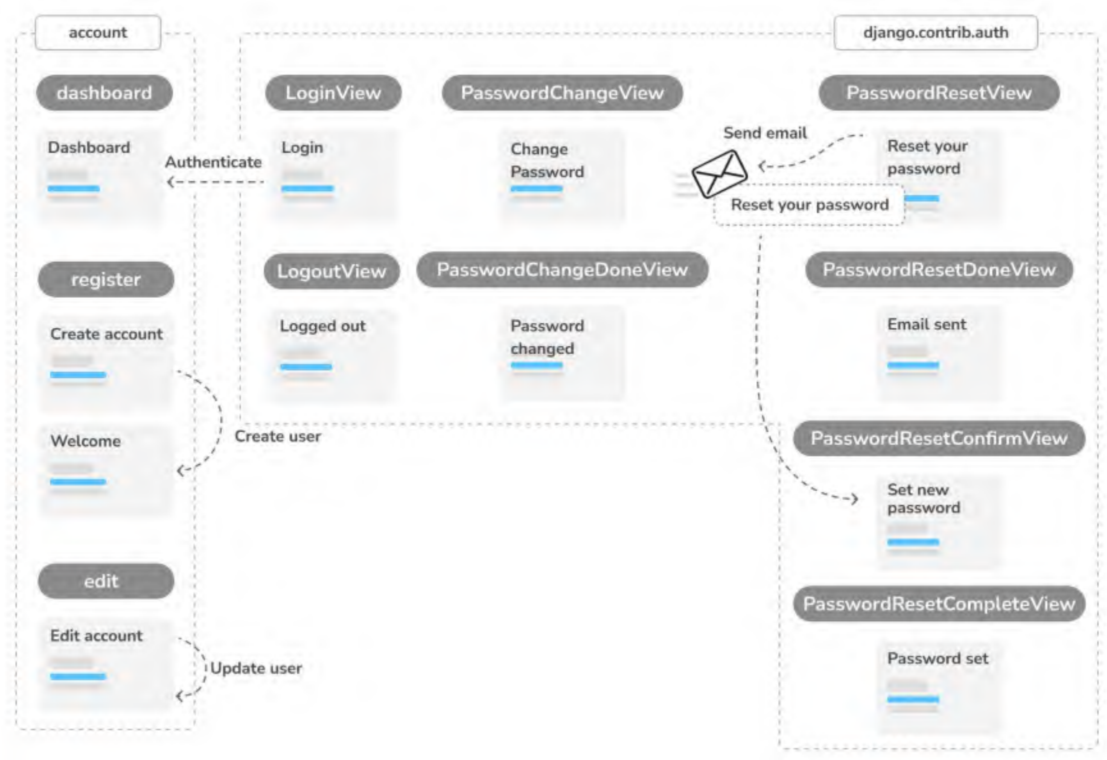

Figure 4.1: Diagram of functionalities built in Chapter 4

In this chapter, you will create a new project and use the login, logout, password change, and password recovery views provided by Django in the `django.contrib.auth` package. You will create templates for the authentication views, and you will create a `dashboard` view that users will have access to when they successfully authenticate. You will implement user registration with the `register` view. Finally, you will extend the user model with a custom `Profile` model and create the `edit` view to allow users to edit their profile.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter04`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all requirements at once with the command `python -m pip install -r requirements.txt`.

Creating a social website project

We are going to create a social application that will allow users to share images that they find on the internet. This project is relevant because it will help you understand how to build social capabilities into your site, as well as how to implement advanced functionalities with Django and JavaScript.

For our image-sharing website, we will need to build the following elements:

- An authentication system for users to register, log in, edit their profile, and change or reset their password
- Social authentication to sign in with services such as Google
- Functionality to display shared images and a system for users to share images from any website
- An activity stream that allows users to see the content uploaded by the people that they follow
- A follow system to allow users to follow each other on the website

This chapter will address the first point on the list. The rest of the points will be covered in *Chapters* 5 to 7.

Starting the social website project

We will start by setting up the virtual environment for the project and creating the initial project structure.

Open the terminal and use the following commands to create a virtual environment for your project:

```
mkdir env
python -m venv env/bookmarks
```

If you are using Linux or macOS, run the following command to activate your virtual environment:

```
source env/bookmarks/bin/activate
```

If you are using Windows, use the following command instead:

```
.\env\bookmarks\Scripts\activate
```

The shell prompt will display your active virtual environment, as follows:

```
(bookmarks)laptop:~ zenx$
```

Install Django in your virtual environment with the following command:

```
python -m pip install Django~=5.0.4
```

Run the following command to create a new project:

```
django-admin startproject bookmarks
```

The initial project structure has been created. Use the following commands to get into your project directory and create a new application named `account`:

```
cd bookmarks/
django-admin startapp account
```

Remember that you should add the new application to your project by adding the application's name to the `INSTALLED_APPS` setting in the `settings.py` file.

Edit `settings.py` and add the following line highlighted in bold to the `INSTALLED_APPS` list before any of the other installed apps:

```
INSTALLED_APPS = [
    'account.apps.AccountConfig',
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.staticfiles',
]
```

Django looks for templates in the application template directories by order of appearance in the `INSTALLED_APPS` setting. The `django.contrib.admin` app includes standard authentication templates, which we will override in the `account` application. Usually, we place our own apps at the end of the list. In this case, we place the application first in the `INSTALLED_APPS` setting to ensure that our custom authentication templates will be used, instead of the authentication templates contained in `django.contrib.admin`.

Run the following command to sync the database with the models of the default applications included in the `INSTALLED_APPS` setting:

```
python manage.py migrate
```

You will see that all the initial Django database migrations get applied. The database tables corresponding to the Django models of the installed applications have been created. Next, we will build an authentication system into our project using the Django authentication framework.

Using the Django authentication framework

Django comes with a built-in authentication framework that can handle user authentication, sessions, permissions, and user groups. The authentication system includes views for common user actions such as logging in, logging out, password change, and password reset.

The authentication framework is located at `django.contrib.auth` and is used by other Django `contrib` packages. Remember that we already used the authentication framework in *Chapter 1*, *Building a Blog Application*, to create a superuser for the blog application to access the administration site.

When we create a new Django project using the `startproject` command, the authentication framework is included in the default settings of our project. It consists of the `django.contrib.auth` application and the following two middleware classes found in the `MIDDLEWARE` setting of our project:

- `AuthenticationMiddleware`: Associates users with requests using sessions
- `SessionMiddleware`: Handles the current session across requests

Middleware is classes with methods that are globally executed during the request or response phase. You will use middleware classes on several occasions throughout this book, and you will learn how to create custom middleware in *Chapter 17*, *Going Live*.

The authentication framework also includes the following models that are defined in `django.contrib.auth.models`:

- `User`: A user model with basic fields; the main fields of this model are `username`, `password`, `email`, `first_name`, `last_name`, and `is_active`
- `Group`: A group model to categorize users
- `Permission`: Flags for users or groups to perform certain actions

The framework also includes default authentication views and forms, which you will use later.

Creating a login view

We will start this section by using the Django authentication framework to allow users to log in to the website. We will create a view that will perform the following actions to log in a user:

1. Present the user with a login form
2. Get the username and password provided by the user when they submit the form
3. Authenticate the user against the data stored in the database
4. Check whether the user is active
5. Log the user into the website and start an authenticated session

We will start by creating the login form.

Create a new `forms.py` file in the `account` application directory and add the following lines to it:

```
from django import forms


class LoginForm(forms.Form):
    username = forms.CharField()
    password = forms.CharField(widget=forms.PasswordInput)
```

This form will be used to authenticate users against the database. The `PasswordInput` widget is used to render the `password` HTML element. This will include `type="password"` in the HTML so that the browser treats it as a password input.

Edit the `views.py` file of the `account` application and add the following code to it:

```
from django.contrib.auth import authenticate, login
from django.http import HttpResponse
from django.shortcuts import render
from .forms import LoginForm


def user_login(request):
    if request.method == 'POST':
        form = LoginForm(request.POST)
        if form.is_valid():
            cd = form.cleaned_data
            user = authenticate(
                request,
                username=cd['username'],
                password=cd['password']
            )
            if user is not None:
                if user.is_active:
                    login(request, user)
                    return HttpResponse('Authenticated successfully')
                else:
                    return HttpResponse('Disabled account')
            else:
                return HttpResponse('Invalid login')
    else:
        form = LoginForm()
    return render(request, 'account/login.html', {'form': form})
```

This is what the basic login view does:

When the `user_login` view is called with a `GET` request, a new login form is instantiated with `form = LoginForm()`. The form is then passed to the template.

When the user submits the form via `POST`, the following actions are performed:

The form is instantiated with the submitted data with `form = LoginForm(request.POST)`.

The form is validated with `form.is_valid()`. If it is not valid, the form errors will be displayed later in the template (for example, if the user didn't fill in one of the fields).

If the submitted data is valid, the user gets authenticated against the database using the `authenticate()` method. This method takes the `request` object, the `username`, and the `password` parameters and returns the `User` object if the user has been successfully authenticated, or `None` otherwise. If the user has not been successfully authenticated, a raw `HttpResponse`

If the user is successfully authenticated, the user status is checked by accessing the `is_active` attribute. This is an attribute of Django's user model. If the user is not active, an `HttpResponse` is returned with a **Disabled account** message.

If the user is active, the user is logged into the site. The user is set in the session by calling the `login()` method. An **Authenticated successfully** message is returned.

> Note the difference between `authenticate()` and `login()`: `authenticate()` verifies the user's credentials and, upon validation, returns a `User` object representing the authenticated user. In contrast, `login()` sets the user in the current session by incorporating the authenticated `User` object into the current session context.

Now, we will create a URL pattern for this view:

Create a new `urls.py` file in the `account` application directory and add the following code to it:

```
from django.urls import path
from . import views

urlpatterns = [
    path('login/', views.user_login, name='login'),
]
```

Edit the main `urls.py` file located in your `bookmarks` project directory, import `include`, and add the URL patterns of the `account` application, as follows. The new code is highlighted in bold:

```
from django.contrib import admin
from django.urls import include, path

urlpatterns = [
    path('admin/', admin.site.urls),
    path('account/', include('account.urls')),
]
```

The login view can now be accessed with a URL.

Let's create a template for this view. Since there are no templates in the project yet, we will start by creating a base template that will be extended by the login template:

Create the following files and directories inside the `account` application directory:

```
templates/
    account/
        login.html
    base.html
```

Edit the `base.html` template and add the following code to it:

```
{% load static %}
<!DOCTYPE html>
<html>
<head>
  <title>{% block title %}{% endblock %}</title>
  <link href="{% static "css/base.css" %}" rel="stylesheet">
</head>
<body>
  <div id="header">
    <span class="logo">Bookmarks</span>
  </div>
  <div id="content">
    {% block content %}
    {% endblock %}
  </div>
</body>
</html>
```

This will be the base template for the website. As you did in your previous project, include the CSS styles in the main template. You can find these static files in the code that comes with this chapter. Copy the `static/` directory of the `account` application from the chapter's source code to the same location in your project so that you can use the static files. You can find the directory's contents at `https://github.com/PacktPublishing/Django-5-by-Example/tree/master/Chapter04/bookmarks/account/static`.

The base template defines a `title` block and a `content` block that can be filled with content by the templates that extend from it.

Let's fill in the template for your login form.

Open the `account/login.html` template and add the following code to it:

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

{% block title %}Log-in{% endblock %}

{% block content %}
  <h1>Log-in</h1>
  <p>Please, use the following form to log-in:</p>
  <form method="post">
    {{ form.as_p }}
    {% csrf_token %}
    <p><input type="submit" value="Log in"></p>
```

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

This template includes the form that is instantiated in the view. Since your form will be submitted via `POST`, you will include the `{% csrf_token %}` template tag for **cross-site request forgery** (**CSRF**) protection. You learned about CSRF protection in *Chapter 2*, *Enhancing Your Blog with Advanced Features*.

There are no users in the database yet. You will need to create a superuser first to access the administration site to manage other users.

Execute the following command in the shell prompt:

```
python manage.py createsuperuser
```

You will see the following output. Enter your desired username, email, and password, as follows:

```
Username (leave blank to use 'admin'): admin
Email address: admin@admin.com
Password: ********
Password (again): ********
```

Then, you will see the following success message:

```
Superuser created successfully.
```

Run the development server using the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/` in your browser. Access the administration site using the credentials of the user you just created. You will see the Django administration site, including the `User` and `Group` models of the Django authentication framework.

It will look as follows:

Figure 4.2: The Django administration site index page including Users and Groups

In the **Users** row, click on the **Add** link.

Create a new user using the administration site as follows:

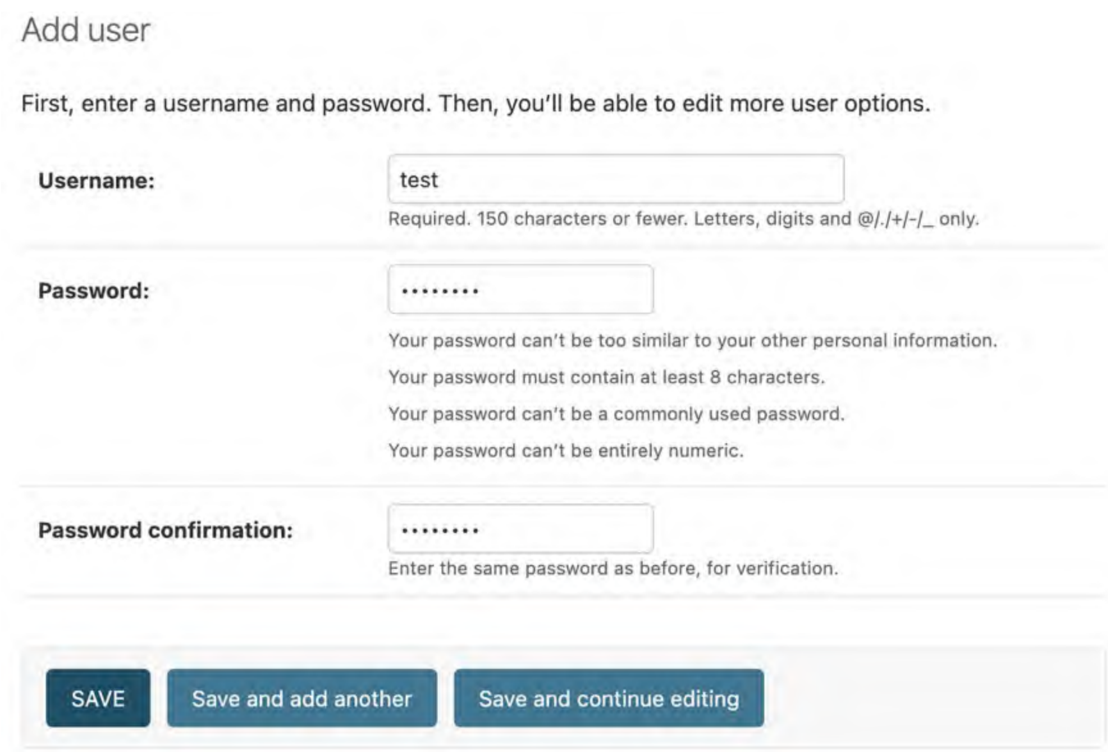

Figure 4.3: The Add user form on the Django administration site

Enter the user details and click on the **SAVE** button to save the new user in the database.

Then, in **Personal info**, fill in the **First name**, **Last name**, and **Email address** fields as follows, and then click on the **SAVE** button to save the changes:

Figure 4.4: The user editing form on the Django administration site

Open `http://127.0.0.1:8000/account/login/` in your browser. You should see the rendered template, including the login form:

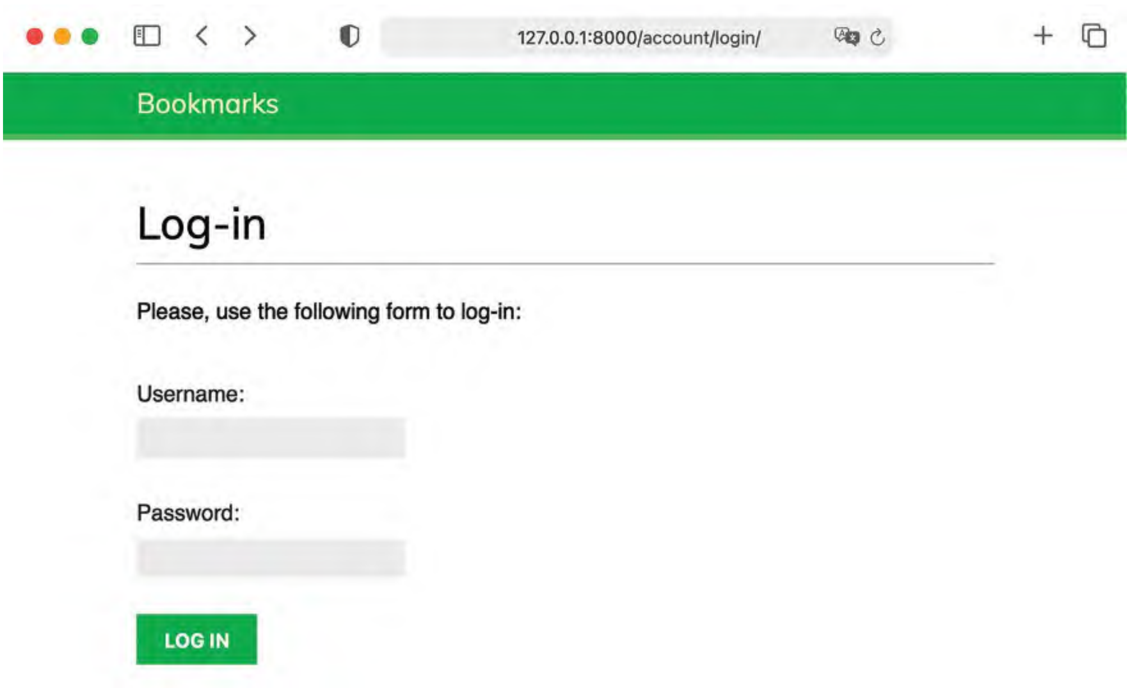

Figure 4.5: The user Log-in page

Enter invalid credentials and submit the form. You should get the following **Invalid login** response:

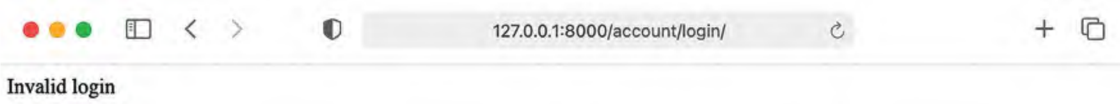

Figure 4.6: The invalid login plain text response

Enter valid credentials; you will get the following **Authenticated successfully** response:

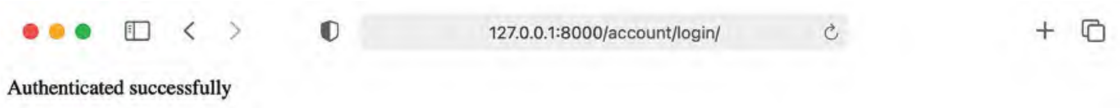

Figure 4.7: The successful authentication plain text response

Now, you have learned how to authenticate users and create your own authentication view. You can build your own auth views, but Django ships with ready-to-use authentication views that you can leverage.

Using Django's built-in authentication views

Django includes several forms and views in the authentication framework that you can use right away. The login view we have created is a good exercise to understand the process of user authentication in Django. However, you can use the default Django authentication views in most cases.

Django provides the following class-based views to deal with authentication. All of them are located in `django.contrib.auth.views`:

- `LoginView`: Handles a login form and logs in a user
- `LogoutView`: Logs out a user

Django provides the following views to handle password changes:

- `PasswordChangeView`: Handles a form to change the user's password
- `PasswordChangeDoneView`: The success view that the user is redirected to after a successful password change

Django also includes the following views to allow users to reset their password:

- `PasswordResetView`: Allows users to reset their password. It generates a one-time-use link with a token and sends it to a user's email account
- `PasswordResetDoneView`: Tells users that an email—including a link to reset their password—has been sent to them
- `PasswordResetConfirmView`: Allows users to set a new password
- `PasswordResetCompleteView`: The success view that the user is redirected to after successfully resetting their password

These views can save you a lot of time when building any web application with user accounts. The views use default values that can be overridden, such as the location of the template to be rendered, or the form to be used by the view.

You can get more information about the built-in authentication views at `https://docs.djangoproject.com/en/5.0/topics/auth/default/#all-authentication-views`.

Login and logout views

To learn how to use Django's authentication views, we will substitute our custom login view with Django's built-in equivalent and also integrate a logout view.

Edit the `urls.py` file of the `account` application and add the code highlighted in bold:

```
from django.contrib.auth import views as auth_views
from django.urls import path
from . import views


urlpatterns = [
    # previous login url
    # path('login/', views.user_login, name='login'),
    # login / logout urls
    path('login/', auth_views.LoginView.as_view(), name='login'),
```

```
    path('logout/', auth_views.LogoutView.as_view(), name='logout'),
]
```

In the preceding code, we have commented out the URL pattern for the `user_login` view that we created previously. We'll now use the `LoginView` view of Django's authentication framework. We have also added a URL pattern for the `LogoutView` view.

Create a new directory inside the `templates/` directory of the `account` application and name it `registration`. This is the default path where the Django authentication views expect your authentication templates to be.

The `django.contrib.admin` module includes authentication templates that are used for the administration site, like the login template. By placing the `account` application at the top of the `INSTALLED_APPS` setting when configuring the project, we ensured that Django would use our authentication templates instead of the ones defined in any other application.

Create a new file inside the `templates/registration/` directory, name it `login.html`, and add the following code to it:

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

{% block title %}Log-in{% endblock %}

{% block content %}
  <h1>Log-in</h1>
  {% if form.errors %}
    <p>
      Your username and password didn't match.
      Please try again.
    </p>
  {% else %}
    <p>Please, use the following form to log-in:</p>
  {% endif %}
  <div class="login-form">
    <form action="{% url 'login' %}" method="post">
      {{ form.as_p }}
      {% csrf_token %}
      <input type="hidden" name="next" value="{{ next }}" />
      <p><input type="submit" value="Log-in"></p>
    </form>
  </div>
{% endblock %}
```

This login template is quite similar to the one we created before. Django uses the `AuthenticationForm` form located at `django.contrib.auth.forms` by default. This form tries to authenticate the user and raises a validation error if the login is unsuccessful. We use `{% if form.errors %}` in the template to check whether the credentials provided are wrong.

We have added a hidden HTML `<input>` element to submit the value of a variable called `next`. This variable is provided to the login view if you pass a parameter named `next` to the request, for example, by accessing `http://127.0.0.1:8000/account/login/?next=/account/`.

The `next` parameter has to be a URL. If this parameter is given, the Django login view will redirect the user to the given URL after a successful login.

Now, create a `logged_out.html` template inside the `templates/registration/` directory and make it look like this:

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

{% block title %}Logged out{% endblock %}

{% block content %}
  <h1>Logged out</h1>
  <p>
    You have been successfully logged out.
    You can <a href="{% url "login" %}">log-in again</a>.
  </p>
{% endblock %}
```

This is the template that Django will display after the user logs out.

We have added the URL patterns and templates for the login and logout views. Users can now log in and out using Django's authentication views.

Now, we will create a new view to display a dashboard when users log in to their accounts.

Edit the `views.py` file of the `account` application and add the following code to it:

```python
from django.contrib.auth.decorators import login_required

@login_required
def dashboard(request):
    return render(
        request,
        'account/dashboard.html',
        {'section': 'dashboard'}
    )
```

We have created the `dashboard` view, and we have applied to it the `login_required` decorator of the authentication framework. The `login_required` decorator checks whether the current user is authenticated.

If the user is authenticated, it executes the decorated view; if the user is not authenticated, it redirects the user to the login URL, with the originally requested URL as a `GET` parameter named `next`.

By doing this, the login view redirects users to the URL that they were trying to access after they successfully logged in. Remember that we added a hidden `<input>` HTML element named `next` in the login template for this purpose.

We have also defined a `section` variable. We will use this variable to highlight the current section in the main menu of the site.

Next, we need to create a template for the dashboard view.

Create a new file inside the `templates/account/` directory and name it `dashboard.html`. Add the following code to it:

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

{% block title %}Dashboard{% endblock %}

{% block content %}
  <h1>Dashboard</h1>
  <p>Welcome to your dashboard.</p>
{% endblock %}
```

Edit the `urls.py` file of the `account` application and add the following URL pattern for the view. The new code is highlighted in bold:

```
urlpatterns = [
    # previous login url
    # path('login/', views.user_login, name='login'),

    # login / logout urls
    path('login/', auth_views.LoginView.as_view(), name='login'),
    path('logout/', auth_views.LogoutView.as_view(), name='logout'),

    path('', views.dashboard, name='dashboard'),
]
```

Edit the `settings.py` file of the project and add the following code to it:

```
LOGIN_REDIRECT_URL = 'dashboard'
LOGIN_URL = 'login'
LOGOUT_URL = 'logout'
```

We have defined the following settings:

- `LOGIN_REDIRECT_URL`: Tells Django which URL to redirect the user to after a successful login if no `next` parameter is present in the request
- `LOGIN_URL`: The URL to redirect the user to log in (for example, views using the `login_required` decorator)
- `LOGOUT_URL`: The URL to redirect the user to log out

We have used the names of the URLs that we previously defined with the `name` attribute of the `path()` function in the URL patterns. Hardcoded URLs instead of URL names can also be used for these settings.

Let's summarize what we have done so far:

- We have added the built-in Django authentication login and logout views to the project.
- We have created custom templates for both views and defined a simple dashboard view to redirect users after they log in.
- Finally, we have added settings for Django to use these URLs by default.

Now, we will add a link to the login URL and a button to log out to the base template. In order to do this, we have to determine whether the current user is logged in or not to display the appropriate action for each case. The current user is set in the `HttpRequest` object by the authentication middleware. You can access it with `request.user`. The `request` object contains a `User` object even if the user is not authenticated. A non-authenticated user is set in the request as an instance of `AnonymousUser`. The best way to check if the current user is authenticated is by accessing the read-only attribute, `is_authenticated`.

Edit the `templates/base.html` template by adding the following lines highlighted in bold:

```
{% load static %}
<!DOCTYPE html>
<html>
<head>
  <title>{% block title %}{% endblock %}</title>
  <link href="{% static "css/base.css" %}" rel="stylesheet">
</head>
<body>
  <div id="header">
    <span class="logo">Bookmarks</span>
    {% if request.user.is_authenticated %}
      <ul class="menu">
        <li {% if section == "dashboard" %}class="selected"{% endif %}>
          <a href="{% url "dashboard" %}">My dashboard</a>
        </li>
        <li {% if section == "images" %}class="selected"{% endif %}>
          <a href="#">Images</a>
        </li>
        <li {% if section == "people" %}class="selected"
```

```
            <a href="#">People</a>
          </li>
        </ul>
      {% endif %}
      <span class="user">
        {% if request.user.is_authenticated %}
          Hello {{ request.user.first_name|default:request.user.username }},
          <form action="{% url "logout" %}" method="post">
            <button type="submit">Logout</button>
            {% csrf_token %}
          </form>
        {% else %}
          <a href="{% url "login" %}">Log-in</a>
        {% endif %}
      </span>
    </div>
    <div id="content">
      {% block content %}
      {% endblock %}
    </div>
  </body>
</html>
```

The site's menu is only displayed to authenticated users. The `section` variable is checked to add a `selected` class attribute to the menu `<li>` list item of the current section. By doing so, the menu item that corresponds to the current section will be highlighted using CSS. The user's first name and a button to log out are displayed if the user is authenticated; a link to log in is displayed otherwise. If the user's name is empty, the username is displayed instead by using `request.user.first_name|default:request.user.username`. Note that for the logout action, we use a form with the method `POST` and a button to submit the form. This is because the `LogoutView` requires `POST` requests.

Open `http://127.0.0.1:8000/account/login/` in your browser. You should see the **Log-in** page. Enter a valid username and password and click on the **Log-in** button. You should see the following screen:

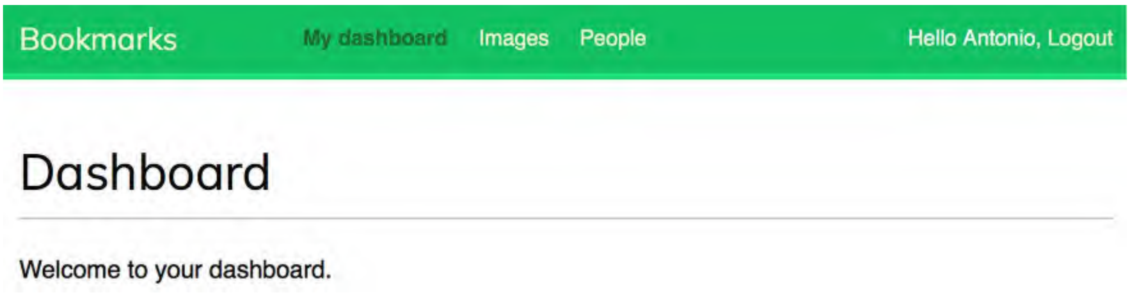

Figure 4.8: The Dashboard page

The **My dashboard** menu item is highlighted with CSS because it has a `selected` class. Since the user is authenticated, the first name of the user is displayed on the right side of the header. Click on the **Logout** button. You should see the following page:

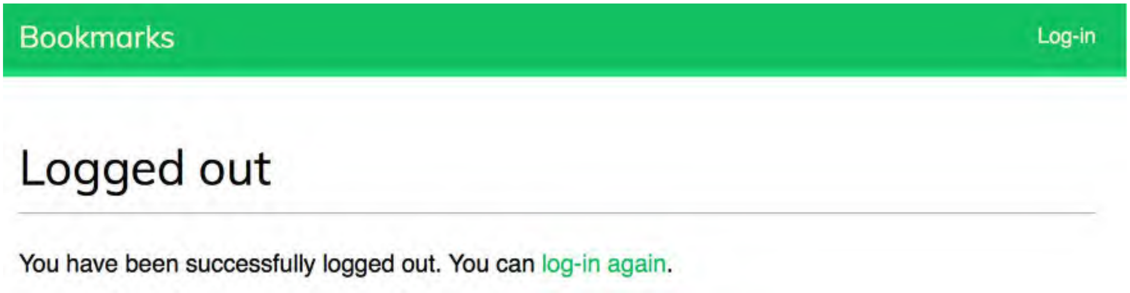

Figure 4.9: The Logged out page

On this page, you can see that the user is logged out, and therefore, the menu of the website is not displayed. The link displayed on the right side of the header is now **Log-in**.

> If you see the **Logged out** page of the Django administration site instead of your own **Logged out** page, check the `INSTALLED_APPS` setting of your project and make sure that `django.contrib.admin` comes after the `account` application. Both applications contain logged-out templates located in the same relative path. The Django template loader will go through the different applications in the `INSTALLED_APPS` list and use the first template it finds.

Change password views

We need users to be able to change their password after they log in to the site. We will integrate the Django authentication views to change passwords.

Open the `urls.py` file of the `account` application and add the following URL patterns highlighted in bold:

```
urlpatterns = [
    # previous login url
    # path('login/', views.user_login, name='login'),

    # login / logout urls
    path('login/', auth_views.LoginView.as_view(), name='login'),
    path('logout/', auth_views.LogoutView.as_view(), name='logout'),

    # change password urls
    path(
        'password-change/',
        auth_views.PasswordChangeView.as_view(),
        name='password_change'
```

```
    ),
    path(
        'password-change/done/',
        auth_views.PasswordChangeDoneView.as_view(),
        name='password_change_done'
    ),

    path('', views.dashboard, name='dashboard'),
]
```

The `PasswordChangeView` view will handle the form to change the password, and the `PasswordChangeDoneView` view will display a success message after the user has successfully changed their password. Let's create a template for each view.

Add a new file inside the `templates/registration/` directory of the `account` application and name it `password_change_form.html`. Add the following code to it:

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

{% block title %}Change your password{% endblock %}

{% block content %}
  <h1>Change your password</h1>
  <p>Use the form below to change your password.</p>
  <form method="post">
    {{ form.as_p }}
    <p><input type="submit" value="Change"></p>
    {% csrf_token %}
  </form>
{% endblock %}
```

The `password_change_form.html` template includes the form to change the password.

Now, create another file in the same directory and name it `password_change_done.html`. Add the following code to it:

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

{% block title %}Password changed{% endblock %}

{% block content %}
  <h1>Password changed</h1>
  <p>Your password has been successfully changed.</p>
{% endblock %}
```

The `password_change_done.html` template only contains the success message to be displayed when the user has successfully changed their password.

Open `http://127.0.0.1:8000/account/password-change/` in your browser. If you are not logged in, the browser will redirect you to the **Log-in** page. After you are successfully authenticated, you will see the following change password page:

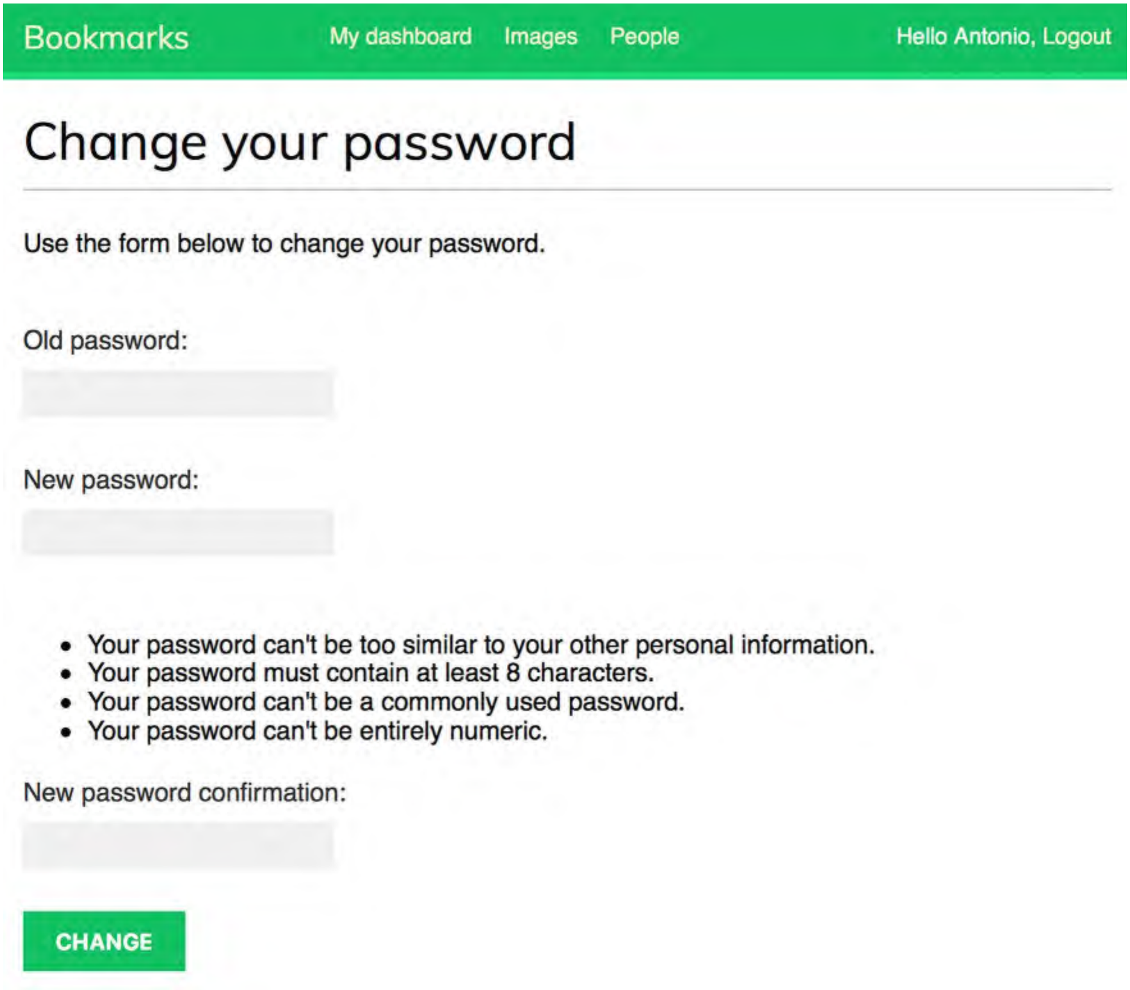

Figure 4.10: The change password form

Fill in the form with your current password and your new password, and then click on the **CHANGE** button. You will see the following success page:

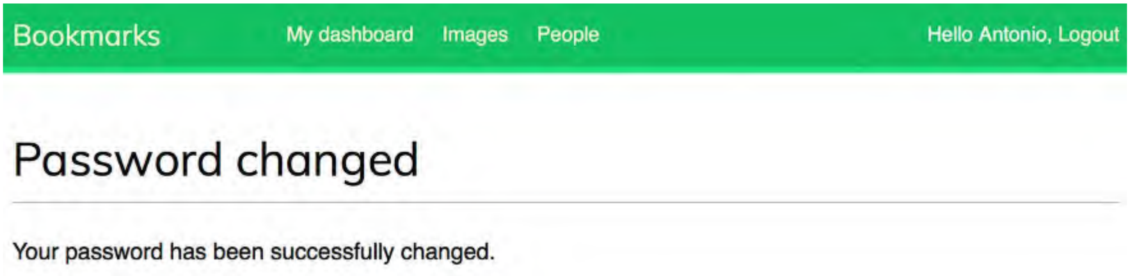

Figure 4.11: The successful change password page

Log out and log in again using your new password to verify that everything works as expected.

Reset password views

If users forget their password, they should be able to recover their account. We will implement a password reset feature. This will enable users to regain access to their account by receiving a password reset email that contains a secure link, generated with a unique token, allowing them to create a new password.

Edit the `urls.py` file of the `account` application and add the following URL patterns highlighted in bold:

```
urlpatterns = [
    # previous login url
    # path('login/', views.user_login, name='login'),

    # login / logout urls
    path('login/', auth_views.LoginView.as_view(), name='login'),
    path('logout/', auth_views.LogoutView.as_view(), name='logout'),

    # change password urls
    path(
        'password-change/',
        auth_views.PasswordChangeView.as_view(),
        name='password_change'
    ),
    path(
        'password-change/done/',
        auth_views.PasswordChangeDoneView.as_view(),
        name='password_change_done'
    ),

    # reset password urls
    path(
        'password-reset/',
```

```
        auth_views.PasswordResetView.as_view(),
        name='password_reset'
    ),
    path(
        'password-reset/done/',
        auth_views.PasswordResetDoneView.as_view(),
        name='password_reset_done'
    ),
    path(
        'password-reset/<uidb64>/<token>/',
        auth_views.PasswordResetConfirmView.as_view(),
        name='password_reset_confirm'
    ),
    path('password-reset/complete/',
        auth_views.PasswordResetCompleteView.as_view(),
        name='password_reset_complete'
    ),

    path('', views.dashboard, name='dashboard'),
]
```

Add a new file to the `templates/registration/` directory of the `account` application and name it `password_reset_form.html`. Add the following code to it:

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

{% block title %}Reset your password{% endblock %}

{% block content %}
  <h1>Forgotten your password?</h1>
  <p>Enter your e-mail address to obtain a new password.</p>
  <form method="post">
    {{ form.as_p }}
    <p><input type="submit" value="Send e-mail"></p>
    {% csrf_token %}
  </form>
{% endblock %}
```

Now, create another file in the same directory and name it `password_reset_email.html`. Add the following code to it:

```
Someone asked for password reset for email {{ email }}. Follow the link below:
```

```
{{ protocol }}://{{ domain }}{% url "password_reset_confirm" uidb64=uid
token=token %}
Your username, in case you've forgotten: {{ user.get_username }}
```

The `password_reset_email.html` template will be used to render the email sent to users to reset their password. It includes a reset token that is generated by the view.

Create another file in the same directory and name it `password_reset_done.html`. Add the following code to it:

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

{% block title %}Reset your password{% endblock %}

{% block content %}
  <h1>Reset your password</h1>
  <p>We've emailed you instructions for setting your password.</p>
  <p>If you don't receive an email, please make sure you've entered the address
you registered with.</p>
{% endblock %}
```

Create another template in the same directory and name it `password_reset_confirm.html`. Add the following code to it:

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

{% block title %}Reset your password{% endblock %}

{% block content %}
  <h1>Reset your password</h1>
  {% if validlink %}
    <p>Please enter your new password twice:</p>
    <form method="post">
      {{ form.as_p }}
      {% csrf_token %}
      <p><input type="submit" value="Change my password" /></p>
    </form>
  {% else %}
    <p>The password reset link was invalid, possibly because it has already
been used. Please request a new password reset.</p>
  {% endif %}
{% endblock %}
```

In this template, we confirm whether the link to reset the password is valid by checking the `validlink` variable. The view `PasswordResetConfirmView` checks the validity of the token provided in the URL and passes the `validlink` variable to the template. If the link is valid, the user password reset form is displayed. Users can only set a new password if they have a valid reset password link.

Create another template and name it `password_reset_complete.html`. Enter the following code into it:

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

{% block title %}Password reset{% endblock %}

{% block content %}
  <h1>Password set</h1>
  <p>Your password has been set. You can <a href="{% url "login" %}">log in
now</a></p>
{% endblock %}
```

Finally, edit the `registration/login.html` template of the `account` application, and add the following lines highlighted in bold:

```
{% extends "base.html" %}
{% block title %}Log-in{% endblock %}
{% block content %}
  <h1>Log-in</h1>
  {% if form.errors %}
    <p>
      Your username and password didn't match.
      Please try again.
    </p>
  {% else %}
    <p>Please, use the following form to log-in:</p>
  {% endif %}
  <div class="login-form">
    <form action="{% url 'login' %}" method="post">
      {{ form.as_p }}
      {% csrf_token %}
      <input type="hidden" name="next" value="{{ next }}" />
      <p><input type="submit" value="Log-in"></p>
    </form>
    <p>
      <a href="{% url "password_reset" %}">
        Forgotten your password?
      </a>
```

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

Now, open `http://127.0.0.1:8000/account/login/` in your browser. The **Log-in** page should now include a link to the reset password page, as follows:

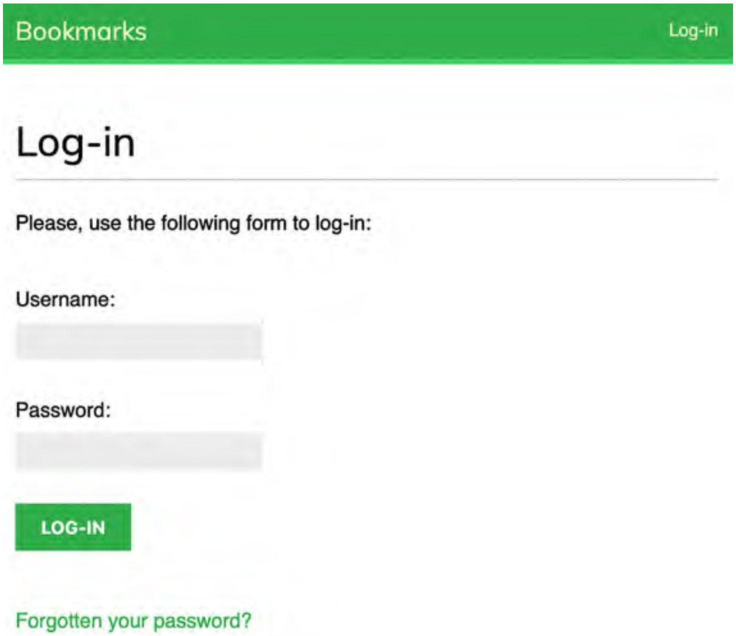

Figure 4.12: The Log-in page, including a link to the reset password page

Click on the **Forgotten your password?** link. You should see the following page:

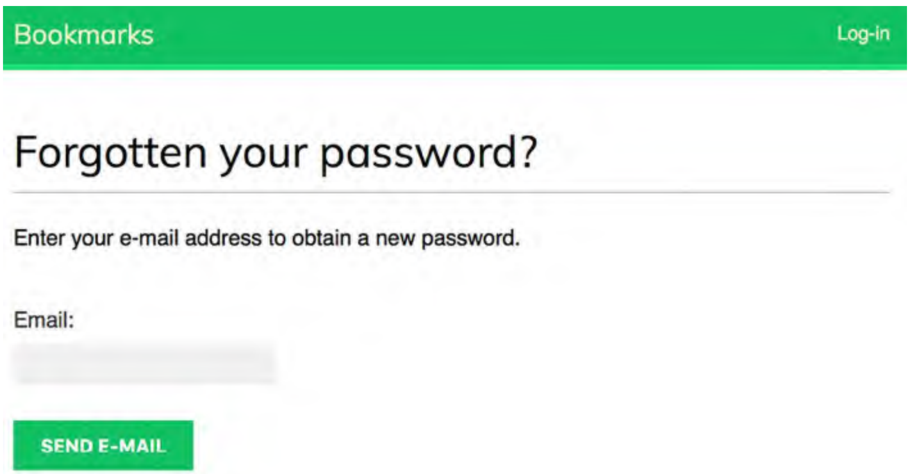

Figure 4.13: The restore password form

At this point, we need to add a **Simple Mail Transfer Protocol** (**SMTP**) configuration to the `settings.py` file of your project so that Django is able to send emails. You learned how to add email settings to your project in *Chapter 2*, *Enhancing Your Blog with Advanced Features*. However, during development, you can configure Django to write emails to the standard output instead of sending them through an SMTP server. Django provides an email backend to write emails to the console.

Edit the `settings.py` file of your project, and add the following line to it:

```
EMAIL_BACKEND = 'django.core.mail.backends.console.EmailBackend'
```

The `EMAIL_BACKEND` setting indicates the class that will be used to send emails.

Return to your browser, enter the email address of an existing user, and click on the **SEND E-MAIL** button. You should see the following page:

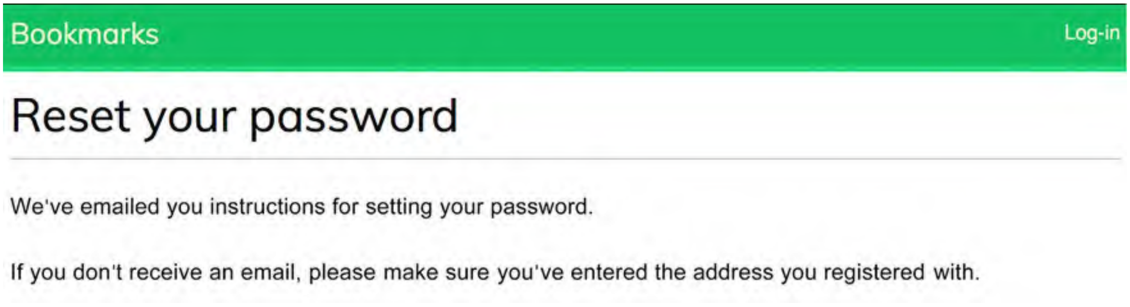

Figure 4.14: The reset password email sent page

Take a look at the shell prompt, where you are running the development server. You will see the generated email, as follows:

```
Content-Type: text/plain; charset="utf-8"
MIME-Version: 1.0
Content-Transfer-Encoding: 7bit
Subject: Password reset on 127.0.0.1:8000
From: webmaster@localhost
To: test@gmail.com
Date: Mon, 10 Jan 2024 19:05:18 -0000
Message-ID: <162896791878.58862.14771487060402279558@MBP-amele.local>
Someone asked for password reset for email test@gmail.com. Follow the link
below:
http://127.0.0.1:8000/account/password-reset/MQ/ardx0u-
b4973cfa2c70d652a190e79054bc479a/
Your username, in case you've forgotten: test
```

The email is rendered using the `password_reset_email.html` template that you created earlier. The URL to reset the password includes a token that was generated dynamically by Django.

Copy the URL from the email, which should look similar to `http://127.0.0.1:8000/account/password-reset/MQ/ardx0u-b4973cfa2c70d652a190e79054bc479a/`, and open it in your browser. You should see the following page:

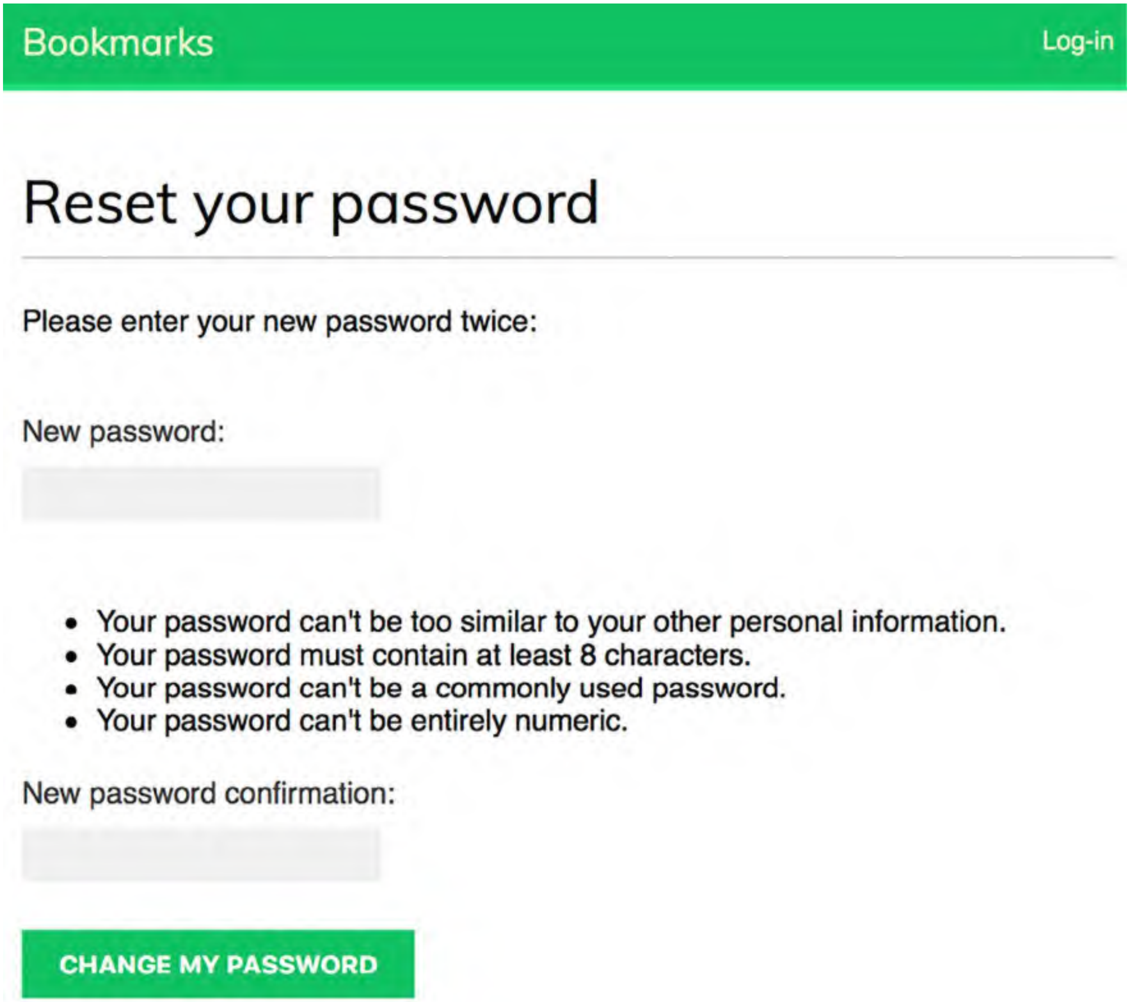

Figure 4.15: The reset password form

The page to set a new password uses the `password_reset_confirm.html` template. Fill in a new password and click on the **CHANGE MY PASSWORD** button.

Django will create a new hashed password and save it in the database. You will see the following success page:

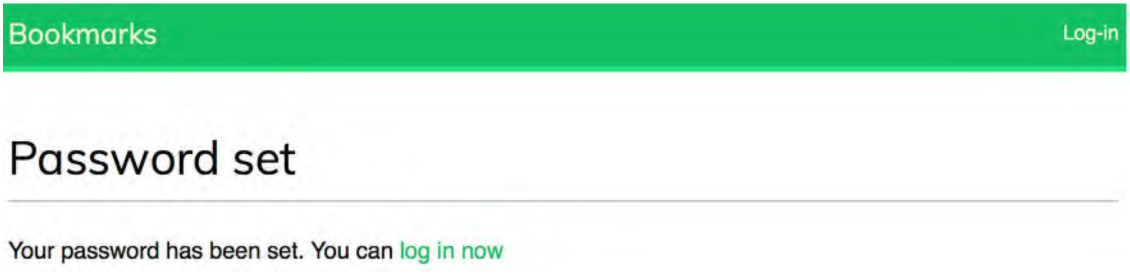

Figure 4.16: The successful password reset page

Now, you can log back into the user account using the new password.

Each token to set a new password can be used only once. If you open the link that you received again, you will get a message stating that the token is invalid.

We have now integrated the views of the Django authentication framework into the project. These views are suitable for most cases. However, you can create your own views if you need different behavior.

Django provides URL patterns for the authentication views that are equivalent to the ones we just created. We will replace the authentication URL patterns with the ones provided by Django.

Comment out the authentication URL patterns that you added to the `urls.py` file of the `account` application and include `django.contrib.auth.urls` instead, as follows. The new code is highlighted in bold:

```
from django.urls import include, path
from django.contrib.auth import views as auth_views
from . import views

urlpatterns = [
    # previous login view
    # path('login/', views.user_login, name='login'),

    # path('login/', auth_views.LoginView.as_view(), name='login'),
    # path('logout/', auth_views.LogoutView.as_view(), name='logout'),

    # change password urls
    # path(
    #     'password-change/',
    #     auth_views.PasswordChangeView.as_view(),
    #     name='password_change'
    # ),
    # path(
```

```
    #     'password-change/done/',
    #     auth_views.PasswordChangeDoneView.as_view(),
    #     name='password_change_done'
    # ),
    # reset password urls
    # path(
    #     'password-reset/',
    #     auth_views.PasswordResetView.as_view(),
    #     name='password_reset'
    # ),
    # path(
    #     'password-reset/done/',
    #     auth_views.PasswordResetDoneView.as_view(),
    #     name='password_reset_done'
    # ),
    # path(
    #     'password-reset/<uidb64>/<token>/',
    #     auth_views.PasswordResetConfirmView.as_view(),
    #     name='password_reset_confirm'
    # ),
    # path(
    #     'password-reset/complete/',
    #     auth_views.PasswordResetCompleteView.as_view(),
    #     name='password_reset_complete'
    # ),

    path('', include('django.contrib.auth.urls')),
    path('', views.dashboard, name='dashboard'),
]
```

You can see the authentication URL patterns included at `https://github.com/django/django/blob/stable/5.0.x/django/contrib/auth/urls.py`.

We have now added all the necessary authentication views to our project. Next, we will implement user registration.

User registration and user profiles

Site users can now log in, log out, change their password, and reset their password. However, we need to build a view to allow visitors to create a user account. They should be able to register and create a profile on our site. Once registered, users will be able to log in to our site using their credentials.

User registration

Let's create a simple view to allow user registration on your website. Initially, you have to create a form to let the user enter a username, their real name, and a password.

Edit the `forms.py` file located inside the `account` application directory and add the following lines highlighted in bold:

```
from django import forms
from django.contrib.auth import get_user_model


class LoginForm(forms.Form):
    username = forms.CharField()
    password = forms.CharField(widget=forms.PasswordInput)


class UserRegistrationForm(forms.ModelForm):
    password = forms.CharField(
        label='Password',
        widget=forms.PasswordInput
    )
    password2 = forms.CharField(
        label='Repeat password',
        widget=forms.PasswordInput
    )

    class Meta:
        model = get_user_model()
        fields = ['username', 'first_name', 'email']
```

We have created a model form for the user model. This form includes the fields `username`, `first_name`, and `email` of the user model. We retrieve the user model dynamically by using the `get_user_model()` function provided by the `auth` application. This retrieves the user model, which could be a custom model instead of the default `auth` `User` model, since Django allows you to define custom user models. These fields will be validated according to the validations of their corresponding model fields. For example, if the user chooses a username that already exists, they will get a validation error because `username` is a field defined with `unique=True`.

In order to keep your code generic, use the `get_user_model()` method to retrieve the user model and the `AUTH_USER_MODEL` setting to refer to it when defining a model's relationship with in to it, instead of referring to the `auth` user model directly. You can read more information about this at `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#django.contrib.auth.get_user_model`.

We have also added two additional fields—`password` and `password2`—for users to set a password and to repeat it. Let's add the field validation to check that both passwords are the same.

Edit the `forms.py` file in the `account` application and add the following `clean_password2()` method to the `UserRegistrationForm` class. The new code is highlighted in bold:

```
class UserRegistrationForm(forms.ModelForm):
    password = forms.CharField(
        label='Password',
        widget=forms.PasswordInput
    )
    password2 = forms.CharField(
        label='Repeat password',
        widget=forms.PasswordInput
    )

    class Meta:
        model = get_user_model()
        fields = ['username', 'first_name', 'email']

    def clean_password2(self):
        cd = self.cleaned_data
        if cd['password'] != cd['password2']:
            raise forms.ValidationError("Passwords don't match.")
        return cd['password2']
```

We have defined a `clean_password2()` method to compare the second password against the first one and raise a validation error if the passwords don't match. This method is executed when the form is validated by calling its `is_valid()` method. You can provide a `clean_<fieldname>()` method to any of your form fields to clean the value or raise form validation errors for a specific field. Forms also include a general `clean()` method to validate the entire form, which is useful to validate fields that depend on each other. In this case, we use the field-specific `clean_password2()` validation instead of overriding the `clean()` method of the form. This avoids overriding other field-specific checks that the `ModelForm` gets from the restrictions set in the model (for example, validating that the username is unique).

Django also provides a `UserCreationForm` form that resides in `django.contrib.auth.forms` and is very similar to the one we have created.

Edit the `views.py` file of the `account` application and add the following code highlighted in bold:

```
from django.contrib.auth import authenticate, login
from django.contrib.auth.decorators import login_required
from django.http import HttpResponse
from django.shortcuts import render
```

```
from .forms import LoginForm, UserRegistrationForm

# ...

def register(request):
    if request.method == 'POST':
        user_form = UserRegistrationForm(request.POST)
        if user_form.is_valid():
            # Create a new user object but avoid saving it yet
            new_user = user_form.save(commit=False)
            # Set the chosen password
            new_user.set_password(
                user_form.cleaned_data['password']
            )
            # Save the User object
            new_user.save()
            return render(
                request,
                'account/register_done.html',
                {'new_user': new_user}
            )
    else:
        user_form = UserRegistrationForm()
    return render(
        request,
        'account/register.html',
        {'user_form': user_form}
    )
```

The view for creating user accounts is quite simple. For security reasons, instead of saving the raw password entered by the user, we use the `set_password()` method of the user model. This method handles password hashing before storing the password in the database.

Django doesn't store clear text passwords; it stores hashed passwords instead. Hashing is the process of transforming a given key into another value. A hash function is used to generate a fixed-length value according to a mathematical algorithm. By hashing passwords with secure algorithms, Django ensures that user passwords stored in the database require massive amounts of computing time to break.

By default, Django uses the `PBKDF2` hashing algorithm with a SHA256 hash to store all passwords. However, Django not only supports checking existing passwords hashed with `PBKDF2` but also supports checking stored passwords hashed with other algorithms, such as `PBKDF2SHA1`, `argon2`, `bcrypt`, and `scrypt`.

The `PASSWORD_HASHERS` setting defines the password hashers that the Django project supports. The following is the default `PASSWORD_HASHERS` list:

```
PASSWORD_HASHERS = [
    'django.contrib.auth.hashers.PBKDF2PasswordHasher',
    'django.contrib.auth.hashers.PBKDF2SHA1PasswordHasher',
    'django.contrib.auth.hashers.Argon2PasswordHasher',
    'django.contrib.auth.hashers.BCryptSHA256PasswordHasher',
    'django.contrib.auth.hashers.ScryptPasswordHasher',
]
```

Django uses the first entry of the list (in this case, `PBKDF2PasswordHasher`) to hash all passwords. The rest of the hashers can be used by Django to check existing passwords.

> The `scrypt` hasher was introduced in Django 4.0. It is more secure and recommended over `PBKDF2`. However, `PBKDF2` is still the default hasher, as `scrypt` requires OpenSSL 1.1+ and more memory.

You can learn more about how Django stores passwords and about the password hashers included at `https://docs.djangoproject.com/en/5.0/topics/auth/passwords/`.

Now, edit the `urls.py` file of the `account` application and add the following URL pattern highlighted in bold:

```
urlpatterns = [

    # ...

    path('', include('django.contrib.auth.urls')),
    path('', views.dashboard, name='dashboard'),
    path('register/', views.register, name='register'),
]
```

Finally, create a new template in the `templates/account/` template directory of the `account` application, name it `register.html`, and make it look as follows:

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

{% block title %}Create an account{% endblock %}

{% block content %}
  <h1>Create an account</h1>
  <p>Please, sign up using the following form:</p>
  <form method="post">
```

```
    {{ user_form.as_p }}
    {% csrf_token %}
    <p><input type="submit" value="Create my account"></p>
  </form>
{% endblock %}
```

Create an additional template file in the same directory and name it `register_done.html`. Add the following code to it:

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

{% block title %}Welcome{% endblock %}

{% block content %}
  <h1>Welcome {{ new_user.first_name }}!</h1>
  <p>
    Your account has been successfully created.
    Now you can <a href="{% url "login" %}">log in</a>.
  </p>
{% endblock %}
```

Open `http://127.0.0.1:8000/account/register/` in your browser. You will see the registration page you have created:

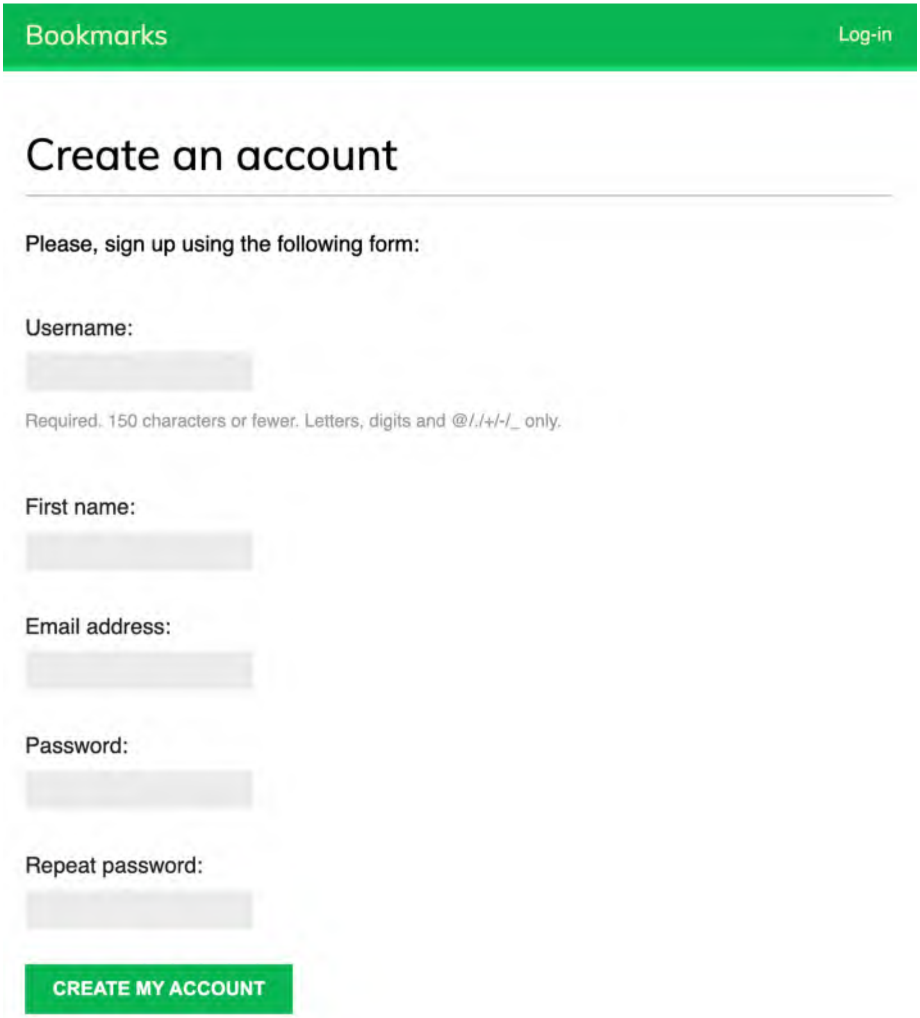

Figure 4.17: The account creation form

Fill in the details for a new user and click on the **CREATE MY ACCOUNT** button.

If all fields are valid, the user will be created, and you will see the following success message:

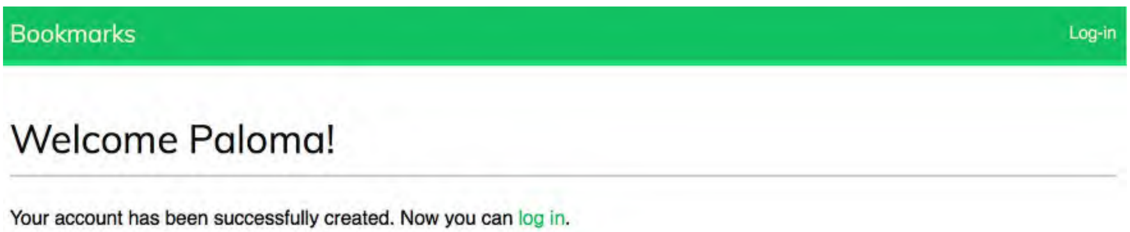

Figure 4.18: The account is successfully created page

Click on the **log in** link and enter your username and password to verify that you can access your newly created account.

Let's add a link to register on the login template. Edit the `registration/login.html` template and find the following line:

```
<p>Please, use the following form to log-in:</p>
```

Replace it with the following lines:

```
<p>
  Please, use the following form to log-in.
  If you don't have an account <a href="{% url "register" %}">register here</
a>.
</p>
```

Open `http://127.0.0.1:8000/account/login/` in your browser. The page should now look as follows:

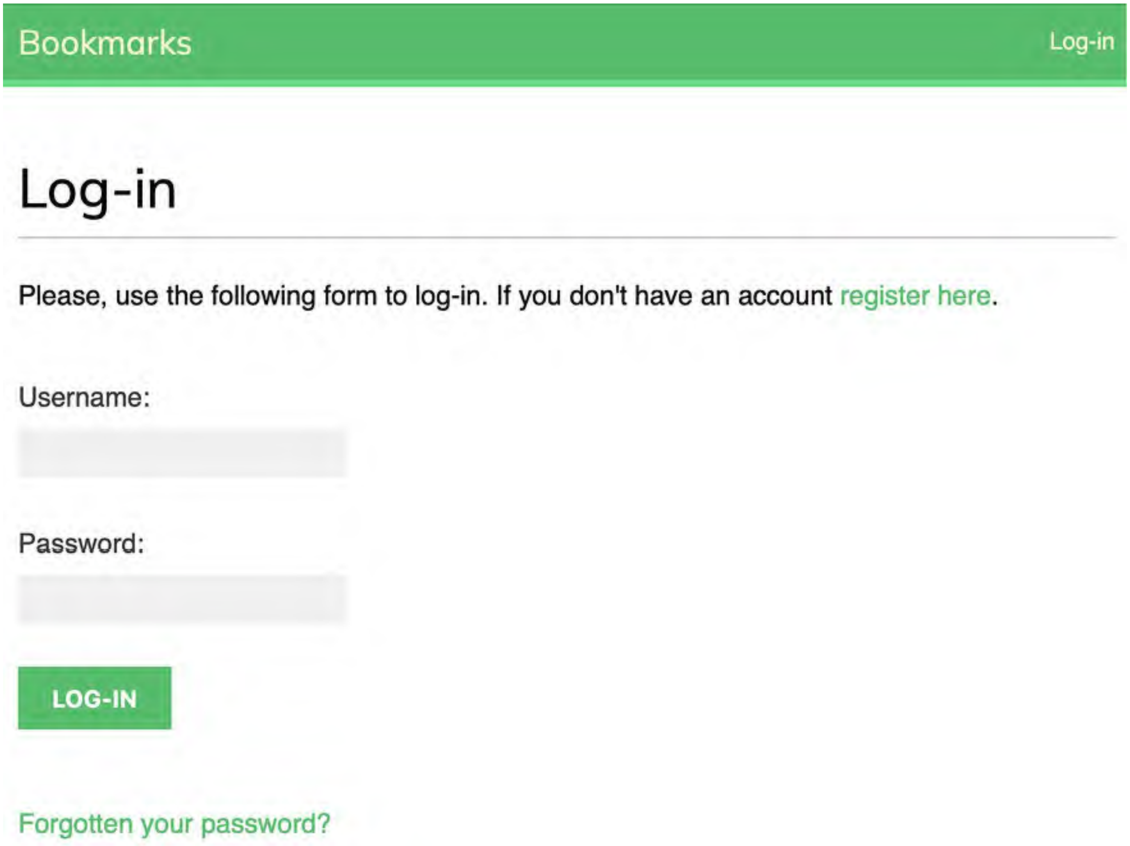

Figure 4.19: The Log-in page including a link to register

We have now made the registration page accessible from the **Log-in** page.

Extending the user model

While the user model provided by Django's authentication framework is sufficient for most typical scenarios, it does have a limited set of predefined fields. If you want to capture additional details relevant to your application, you may want to extend the default user model. For example, the default user model comes with the `first_name` and `last_name` fields, a structure that may not align with naming conventions in various countries. Additionally, you may want to store further user details or construct a more comprehensive user profile.

A simple way to extend the user model is by creating a profile model that contains a one-to-one relationship with the Django user model, and any additional fields. A one-to-one relationship is similar to a `ForeignKey` field with the parameter `unique=True`. The reverse side of the relationship is an implicit one-to-one relationship with the related model instead of a manager for multiple elements. From each side of the relationship, you access a single related object.

Edit the `models.py` file of your `account` application and add the following code highlighted in bold:

```
from django.db import models
from django.conf import settings


class Profile(models.Model):
    user = models.OneToOneField(
        settings.AUTH_USER_MODEL,
        on_delete=models.CASCADE
    )
    date_of_birth = models.DateField(blank=True, null=True)
    photo = models.ImageField(
        upload_to='users/%Y/%m/%d/',
        blank=True
    )

    def __str__(self):
        return f'Profile of {self.user.username}'
```

Our user profile will include the user's date of birth and an image of the user.

The one-to-one field `user` will be used to associate profiles with users. We use `AUTH_USER_MODEL` to refer to the user model instead of pointing to the `auth.User` model directly. This makes our code more generic, as it can operate with custom-defined user models. With `on_delete=models.CASCADE`, we force the deletion of the related `Profile` object when a `User` object gets deleted.

The `date_of_birth` field is a `DateField`. We have made this field optional with `blank=True`, and we allow `null` values with `null=True`.

The `photo` field is an `ImageField`. We have made this field optional with `blank=True`. An `ImageField` field manages the storage of image files. It validates that the file provided is a valid image, stores the image file in the directory indicated with the `upload_to` parameter, and stores the relative path to the file in the related database field. An `ImageField` field is translated to a `VARHAR(100)` column in the database by default. A blank string will be stored if the value is left empty.

Installing Pillow and serving media files

We need to install the Pillow library to manage images. Pillow is the de facto standard library for image processing in Python. It supports multiple image formats and provides powerful image processing functions. Pillow is required by Django to handle images with `ImageField`.

Install Pillow by running the following command from the shell prompt:

```
python -m pip install Pillow==10.3.0
```

Edit the `settings.py` file of the project and add the following lines:

```
MEDIA_URL = 'media/'
MEDIA_ROOT = BASE_DIR / 'media'
```

This will enable Django to manage file uploads and serve media files. `MEDIA_URL` is the base URL used to serve the media files uploaded by users. `MEDIA_ROOT` is the local path where they reside. Paths and URLs for files are built dynamically by prepending the project path or the media URL to them for portability.

Now, edit the main `urls.py` file of the `bookmarks` project and modify the code, as follows. The new lines are highlighted in bold:

```
from django.conf import settings
from django.conf.urls.static import static
from django.contrib import admin
from django.urls import path, include

urlpatterns = [
    path('admin/', admin.site.urls),
    path('account/', include('account.urls')),
]

if settings.DEBUG:
    urlpatterns += static(
        settings.MEDIA_URL,
        document_root=settings.MEDIA_ROOT
    )
```

We have added the `static()` helper function to serve media files with the Django development server during development (that is, when the `DEBUG` setting is set to `True`).

> The `static()` helper function is suitable for development but not for production use. Django is very inefficient at serving static files. Never serve your static files with Django in a production environment. You will learn how to serve static files in a production environment in *Chapter 17, Going Live*.

Creating migrations for the profile model

Let's create the database table for the new `Profile` model. Open the shell and run the following command to create the database migration for the new model:

```
python manage.py makemigrations
```

You will get the following output:

```
Migrations for 'account':
  account/migrations/0001_initial.py
    - Create model Profile
```

Next, sync the database with the following command in the shell prompt:

```
python manage.py migrate
```

You will see output that includes the following line:

```
Applying account.0001_initial... OK
```

Edit the `admin.py` file of the `account` application and register the `Profile` model in the administration site by adding the code in bold:

```
from django.contrib import admin
from .models import Profile


@admin.register(Profile)
class ProfileAdmin(admin.ModelAdmin):
    list_display = ['user', 'date_of_birth', 'photo']
    raw_id_fields = ['user']
```

Run the development server using the following command from the shell prompt:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/` in your browser. Now, you should be able to see the `Profile` model on the administration site of your project, as follows:

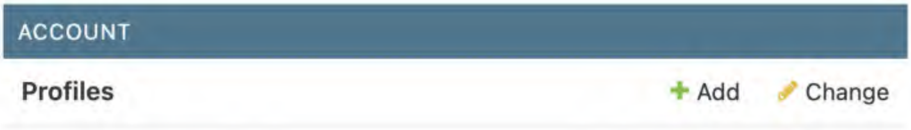

Figure 4.20: The ACCOUNT block on the administration site index page

Click on the **Add** link of the **Profiles** row. You will see the following form to add a new profile:

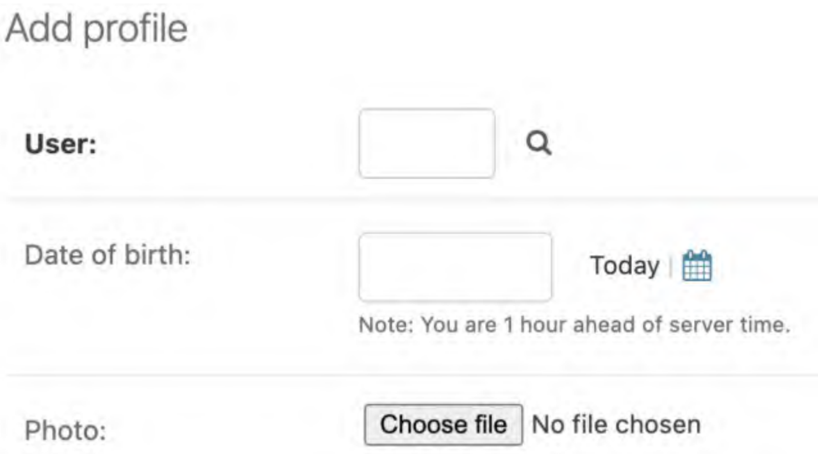

Figure 4.21: The Add profile form

Create a `Profile` object manually for each of the existing users in the database.

Next, we will let users edit their profiles on the website.

Edit the `forms.py` file of the `account` application and add the following lines highlighted in bold:

```
# ...
from .models import Profile

# ...

class UserEditForm(forms.ModelForm):
    class Meta:
        model = get_user_model()
        fields = ['first_name', 'last_name', 'email']


class ProfileEditForm(forms.ModelForm):
    class Meta:
```

```
        model = Profile
        fields = ['date_of_birth', 'photo']
```

These forms are as follows:

- `UserEditForm`: This will allow users to edit their first name, last name, and email, which are attributes of the built-in Django user model.
- `ProfileEditForm`: This will allow users to edit the profile data that is saved in the custom `Profile` model. Users will be able to edit their date of birth and upload an image for their profile picture.

Edit the `views.py` file of the `account` application and add the following lines highlighted in bold:

```
# ...
from .models import Profile

# ...

def register(request):
    if request.method == 'POST':
        user_form = UserRegistrationForm(request.POST)
        if user_form.is_valid():
            # Create a new user object but avoid saving it yet
            new_user = user_form.save(commit=False)
            # Set the chosen password
            new_user.set_password(
                user_form.cleaned_data['password']
            )
            # Save the User object
            new_user.save()
            # Create the user profile
            Profile.objects.create(user=new_user)
            return render(
                request,
                'account/register_done.html',
                {'new_user': new_user}
            )
    else:
        user_form = UserRegistrationForm()
    return render(
        request,
        'account/register.html',
        {'user_form': user_form}
    )
```

When users register on the site, a corresponding `Profile` object will be automatically created and associated with the `User` object created. However, users created through the administration site won't automatically get an associated `Profile` object. Both users with and without a profile (for example, staff users) can co-exist.

If you want to force profile creation for all users, you can use Django signals to trigger the creation of a `Profile` object whenever a user is created. You will learn about signals in *Chapter 7*, *Tracking User Actions*, where you will engage in an exercise to implement this feature in the section *Expanding your project using AI*.

Now, we will let users edit their profiles.

Edit the `views.py` file of the `account` application and add the following code highlighted in bold:

```
from django.contrib.auth import authenticate, login
from django.contrib.auth.decorators import login_required
from django.http import HttpResponse
from django.shortcuts import render
from .forms import (
    LoginForm,
    UserRegistrationForm,
    UserEditForm,
    ProfileEditForm
)
from .models import Profile

# ...

@login_required
def edit(request):
    if request.method == 'POST':
        user_form = UserEditForm(
            instance=request.user,
            data=request.POST
        )
        profile_form = ProfileEditForm(
            instance=request.user.profile,
            data=request.POST,
            files=request.FILES
        )
        if user_form.is_valid() and profile_form.is_valid():
            user_form.save()
            profile_form.save()
    else:
```

```
        user_form = UserEditForm(instance=request.user)
        profile_form = ProfileEditForm(instance=request.user.profile)
    return render(
        request,
        'account/edit.html',
        {
            'user_form': user_form,
            'profile_form': profile_form
        }
    )
```

We have added the new `edit` view to allow users to edit their personal information. We have added the `login_required` decorator to the view because only authenticated users will be able to edit their profiles. For this view, we use two model forms: `UserEditForm` to store the data of the built-in user model and `ProfileEditForm` to store the additional personal data in the custom `Profile` model. To validate the data submitted, we call the `is_valid()` method of both forms. If both forms contain valid data, we save both forms by calling the `save()` method to update the corresponding objects in the database.

Add the following URL pattern to the `urls.py` file of the `account` application:

```
urlpatterns = [
    #...
    path('', include('django.contrib.auth.urls')),
    path('', views.dashboard, name='dashboard'),
    path('register/', views.register, name='register'),
    path('edit/', views.edit, name='edit'),
]
```

Finally, create a template for this view in the `templates/account/` directory and name it `edit.html`. Add the following code to it:

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

{% block title %}Edit your account{% endblock %}

{% block content %}
  <h1>Edit your account</h1>
  <p>You can edit your account using the following form:</p>
  <form method="post" enctype="multipart/form-data">
    {{ user_form.as_p }}
    {{ profile_form.as_p }}
    {% csrf_token %}
    <p><input type="submit" value="Save changes"></p>
  </form>
{% endblock %}
```

In the preceding code, we have added enctype="multipart/form-data" to the <form> HTML element to enable file uploads. We use an HTML form to submit both the user_form and profile_form forms.

Open the URL http://127.0.0.1:8000/account/register/ and register a new user. Then, log in with the new user and open the URL http://127.0.0.1:8000/account/edit/. You should see the following page:

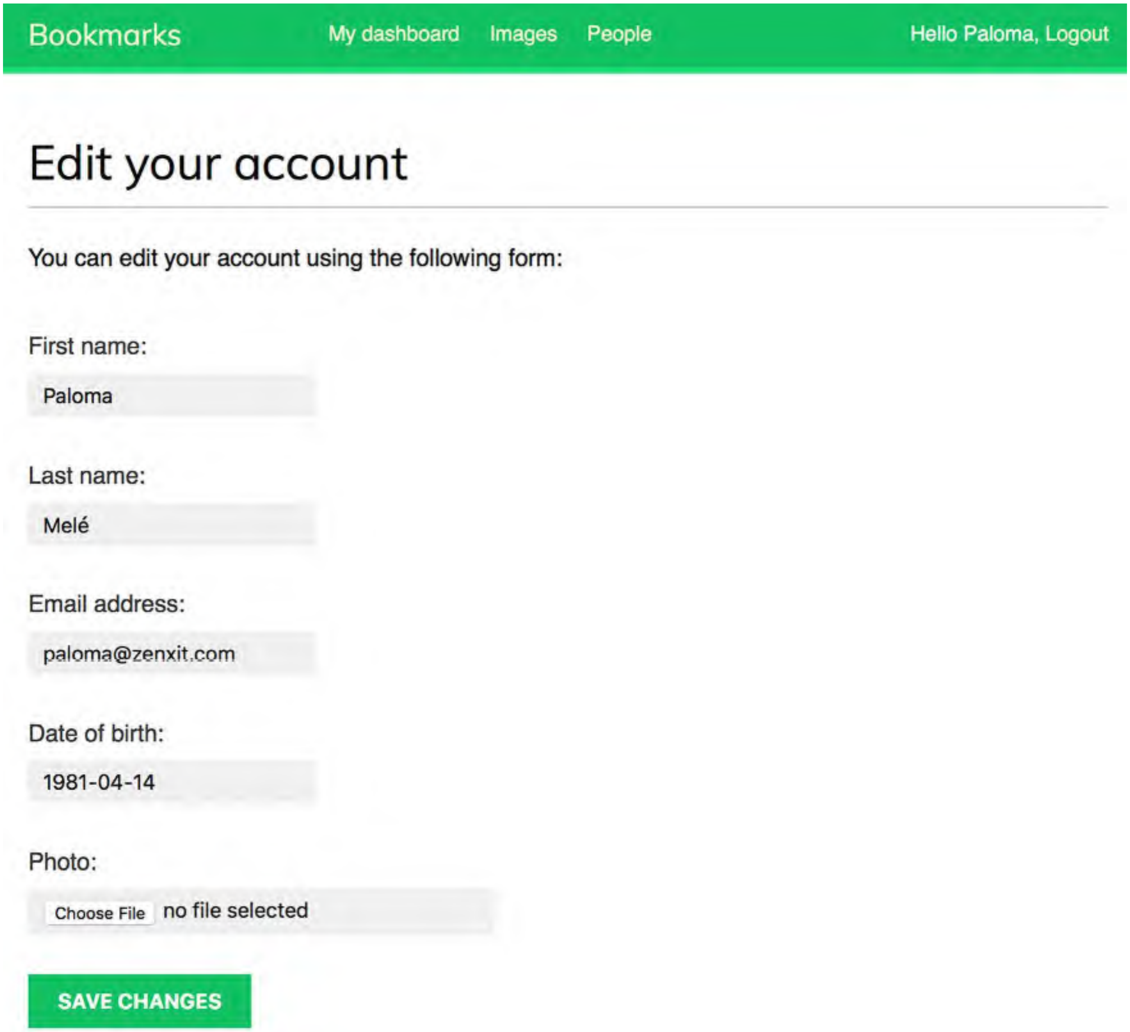

Figure 4.22: The profile edit form

You can now add the profile information and save the changes.

We will edit the dashboard template to include links to the edit profile and change password pages.

Open the templates/account/dashboard.html template and add the following lines highlighted in bold:

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

{% block title %}Dashboard{% endblock %}

{% block content %}
  <h1>Dashboard</h1>
  <p>
    Welcome to your dashboard. You can <a href="{% url "edit" %}">edit your profile</a> or <a href="{% url "password_change" %}">change your password</a>.
  </p>
{% endblock %}
```

Users can now access the form to edit their profile from the dashboard. Open `http://127.0.0.1:8000/account/` in your browser and test the new link to edit a user's profile. The dashboard should now look like this:

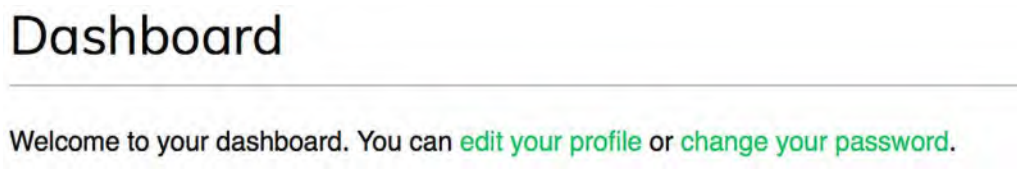

Figure 4.23: Dashboard page content, including links to edit a profile and change a password

Using a custom user model

Django also offers a way to substitute the user model with a custom model. The `User` class should inherit from Django's `AbstractUser` class, which provides the full implementation of the default user as an abstract model. You can read more about this method at `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#substituting-a-custom-user-model`.

Using a custom user model will give you more flexibility, but it might also result in more difficult integration with pluggable applications that interact directly with Django's `auth` user model.

Summary

In this chapter, you learned how to build an authentication system for your site. You implemented all the necessary views for users to register, log in, log out, edit their password, and reset their password. You also built a model to store custom user profiles.

In the next chapter, you will improve the user experience by providing feedback on user's actions through the Django messages framework. You will also broaden the scope of authentication methods, enabling users to authenticate with their email address, and integrate social authentication via Google. You will also learn how to serve the development server over HTTPS using Django Extensions, and you will customize the authentication pipeline to create user profiles automatically.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter04`
- Built-in authentication views: `https://docs.djangoproject.com/en/5.0/topics/auth/default/#all-authentication-views`
- Authentication URL patterns: `https://github.com/django/django/blob/stable/3.0.x/django/contrib/auth/urls.py`
- How Django manages passwords and available password hashers: `https://docs.djangoproject.com/en/5.0/topics/auth/passwords/`
- Generic user model and the `get_user_model()` method: `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#django.contrib.auth.get_user_model`
- Using a custom user model: `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#substituting-a-custom-user-model`

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`https://packt.link/Django5ByExample`

5

Implementing Social Authentication

In the previous chapter, you built user registration and authentication into your website. You implemented password change, reset, and recovery functionalities, and you learned how to create a custom profile model for your users.

In this chapter, you will add social authentication to your site using Google. You will use **Python Social Auth for Django** to implement social authentication using OAuth 2.0, the industry-standard protocol for authorization. You will also modify the social authentication pipeline to create a user profile for new users automatically.

This chapter will cover the following points:

- Using the messages framework
- Building a custom authentication backend
- Preventing users from using an existing email
- Adding social authentication with Python Social Auth
- Running the development server through HTTPS using Django Extensions
- Adding authentication using Google
- Creating a profile for users that register with social authentication

Functional overview

Figure 5.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

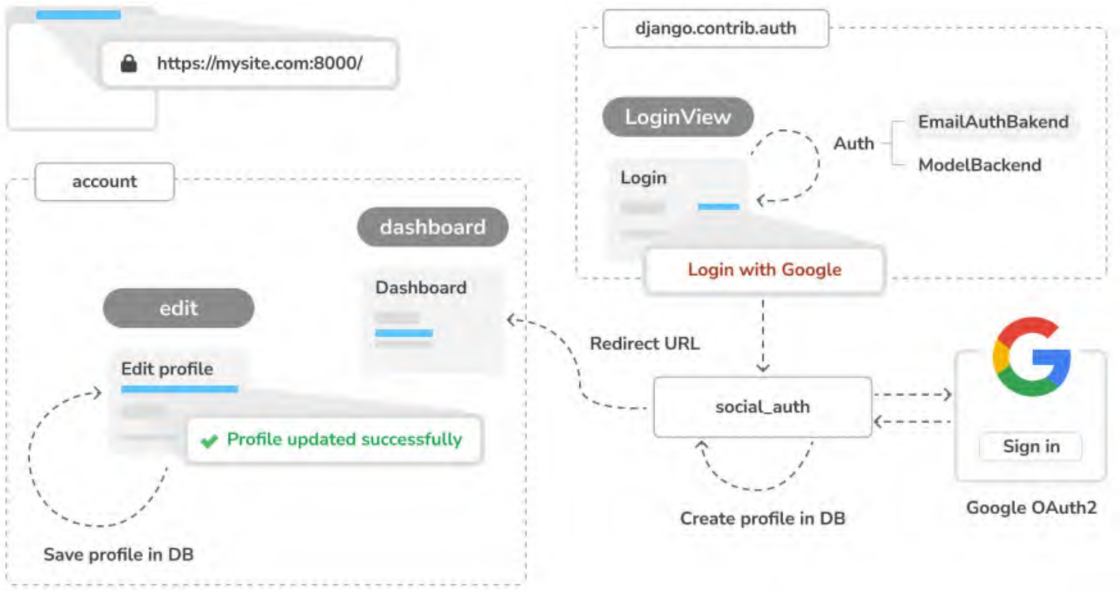

Figure 5.1: Diagram of functionalities built in Chapter 5

In this chapter, you will generate success and error messages in the `edit` view using the Django messages framework. You will build a new authentication backend named `EmailAuthBackend` for users to authenticate using their email addresses. You will serve your site over HTTPS during development using Django Extensions, and you will implement social authentication with Google on your site using Python Social Auth. Users will be redirected to the `dashboard` view after successful authentication. You will customize the authentication pipeline to create user profiles automatically when a new user is created with social authentication.

Technical requirements

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter05`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all requirements at once with the `python -m pip install -r requirements.txt` command.

Using the messages framework

When users are interacting with the platform, there are many cases where you might want to inform them about the result of specific actions, such as successfully creating an object in the database or successfully submitting a form.

Django has a built-in messages framework that allows you to display one-time notifications to your users. This enhances user experience by providing immediate feedback on their actions, making the interface more intuitive and user friendly.

The messages framework is located at `django.contrib.messages` and is included in the default `INSTALLED_APPS` list of the `settings.py` file when you create new projects using `python manage.py startproject`. The settings file also contains the `django.contrib.messages.middleware.MessageMiddleware` middleware in the `MIDDLEWARE` setting.

The messages framework provides a simple way to add messages to users. Messages are stored in a cookie by default (falling back to session storage), and they are displayed and cleared in the next request from the user. You can use the messages framework in your views by importing the `messages` module and adding new messages with simple shortcuts, as follows:

```
from django.contrib import messages
messages.error(request, 'Something went wrong')
```

You can create new messages using the `add_message()` method or any of the following shortcut methods:

- `success()`: Success messages are used to display when an action was successful
- `info()`: Informational messages
- `warning()`: This shows that a failure has not yet occurred but it may be imminent
- `error()`: This shows that an action was not successful or a failure occurred
- `debug()`: This shows debug messages that will be removed or ignored in a production environment

Let's add messages to the project. The messages framework applies globally to the project. We will use the base template to display any available messages to the client. This will allow us to notify the client of the results of any action on any page.

Open the `templates/base.html` template of the `account` application and add the following code highlighted in bold:

```
{% load static %}
<!DOCTYPE html>
<html>
<head>
  <title>{% block title %}{% endblock %}</title>
  <link href="{% static "css/base.css" %}" rel="stylesheet">
</head>
<body>
  <div id="header">
    ...
  </div>
  {% if messages %}
```

```
    <ul class="messages">
      {% for message in messages %}
        <li class="{{ message.tags }}">
          {{ message|safe }}
          <a href="#" class="close">x</a>
        </li>
      {% endfor %}
    </ul>
  {% endif %}
  <div id="content">
    {% block content %}
    {% endblock %}
  </div>
</body>
</html>
```

The messages framework includes the `django.contrib.messages.context_processors.messages` context processor, which adds a `messages` variable to the request context. You can find it in the `context_processors` list in the `TEMPLATES` setting of your project. You can use the `messages` variable in templates to display all existing messages to the user.

A context processor is a Python function that takes the request object as an argument and returns a dictionary that gets added to the request context. You will learn how to create your own context processors in *Chapter 8*, *Building an Online Shop*.

Let's modify the `edit` view to use the messages framework.

Edit the `views.py` file of the `account` application and add the following lines highlighted in bold:

```
from django.contrib import messages

# ...

@login_required
def edit(request):
    if request.method == 'POST':
        user_form = UserEditForm(
            instance=request.user,
            data=request.POST
        )
        profile_form = ProfileEditForm(
            instance=request.user.profile,
```

```
            data=request.POST,
            files=request.FILES
        )
        if user_form.is_valid() and profile_form.is_valid():
            user_form.save()
            profile_form.save()
            messages.success(
                request,
                'Profile updated successfully'
            )
        else:
            messages.error(request, 'Error updating your profile')
    else:
        user_form = UserEditForm(instance=request.user)
        profile_form = ProfileEditForm(
                                    instance=request.user.profile)
    return render(
        request,
        'account/edit.html',
        {'user_form': user_form, 'profile_form': profile_form}
    )
```

A success message is generated when users successfully update their profile. If any of the forms contain invalid data, an error message is generated instead.

Open `http://127.0.0.1:8000/account/edit/` in your browser and edit the profile of the user. You should see the following message when the profile is successfully updated:

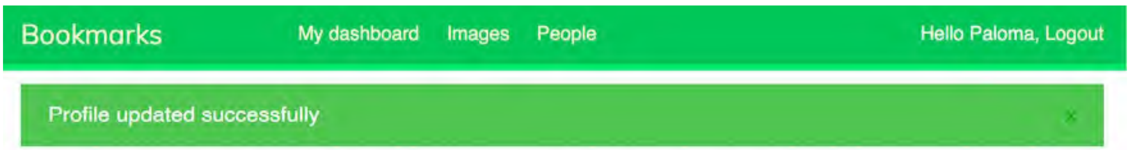

Figure 5.2: The successfully edited profile message

Enter an invalid date in the **Date of birth** field and submit the form again. You should see the following message:

Figure 5.3: The error updating profile message

Generating messages to inform your users about the results of their actions is straightforward. You can easily add messages to other views as well.

You can learn more about the messages framework at `https://docs.djangoproject.com/en/5.0/ref/contrib/messages/`.

Now that we've built all the functionality related to user authentication and profile editing, we will dig deeper into customizing authentication. We will learn how to build custom backend authentication so that users can log in to the site using their email addresses.

Building a custom authentication backend

Django allows you to authenticate users against different sources, such as the built-in Django authentication system, external authentication systems like **Lightweight Directory Access Protocol** (**LDAP**) servers, or even third-party providers. The `AUTHENTICATION_BACKENDS` setting includes a list of authentication backends available in the project. Django enables you to specify multiple authentication backends for flexible authentication schemes. The default value of the `AUTHENTICATION_BACKENDS` setting is the following:

```
['django.contrib.auth.backends.ModelBackend']
```

The default `ModelBackend` authenticates users against the database using the `User` model of `django.contrib.auth`. This is suitable for most web projects. However, you can create custom backends to authenticate your users against other sources.

You can read more information about customizing authentication at `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#other-authentication-sources`.

Whenever the `authenticate()` function of `django.contrib.auth` is used, Django tries to authenticate the user against each of the backends defined in `AUTHENTICATION_BACKENDS` one by one, until one of them successfully authenticates the user. Only if all of the backends fail to authenticate will the user not be authenticated.

Django provides a simple way to define your own authentication backends. An authentication backend is a class that provides the following two methods:

- `authenticate()`: It takes the `request` object and user credentials as parameters. It has to return a `user` object that matches those credentials if the credentials are valid, or `None` otherwise. The `request` parameter is an `HttpRequest` object, or `None` if it's not provided to the `authenticate()` function.
- `get_user()`: It takes a user ID parameter and has to return a `user` object.

Creating a custom authentication backend is as simple as writing a Python class that implements both methods. Let's create an authentication backend to allow users to authenticate on the site using their email address instead of their username.

Create a new file inside the `account` application directory and name it `authentication.py`. Add the following code to it:

```python
from django.contrib.auth.models import User
```

```
class EmailAuthBackend:
    """
    Authenticate using an e-mail address.
    """
    def authenticate(self, request, username=None, password=None):
        try:
            user = User.objects.get(email=username)
            if user.check_password(password):
                return user
            return None
        except (User.DoesNotExist, User.MultipleObjectsReturned):
            return None

    def get_user(self, user_id):
        try:
            return User.objects.get(pk=user_id)
        except User.DoesNotExist:
            return None
```

The preceding code is a simple authentication backend. The `authenticate()` method receives a `request` object and the `username` and `password` optional parameters. We could use different parameters, but we use `username` and `password` to make our backend work with the authentication framework views right away. The preceding code works as follows:

- `authenticate()`: The user with the given email address is retrieved, and the password is checked using the built-in `check_password()` method of the user model. This method handles the password hashing to compare the given password with the password stored in the database. Two different QuerySet exceptions are captured: `DoesNotExist` and `MultipleObjectsReturned`. The `DoesNotExist` exception is raised if no user is found with the given email address. The `MultipleObjectsReturned` exception is raised if multiple users are found with the same email address. We will modify the registration and edit views later to prevent users from using an existing email address.
- `get_user()`: You get a user through the ID provided in the `user_id` parameter. Django uses the backend that authenticated the user to retrieve the `User` object for the duration of the user session. **pk** is a short for **primary key**, which is a unique identifier for each record in the database. Every Django model has a field that serves as its primary key. By default, the primary key is the automatically generated ID field. You can find more information about automatic primary key fields at `https://docs.djangoproject.com/en/5.0/topics/db/models/#automatic-primary-key-fields`.

Edit the `settings.py` file of your project and add the following code:

```
AUTHENTICATION_BACKENDS = [
```

```
    'django.contrib.auth.backends.ModelBackend',
    'account.authentication.EmailAuthBackend',
]
```

In the preceding setting, we keep the default `ModelBackend` that is used to authenticate with the username and password and include our own email-based authentication backend `EmailAuthBackend`.

Open `http://127.0.0.1:8000/account/login/` in your browser. Remember that Django will try to authenticate the user against each of the backends, so now you should be able to log in seamlessly using your username or email account.

The user credentials will be checked using `ModelBackend`, and if no user is returned, the credentials will be checked using `EmailAuthBackend`.

> The order of the backends listed in the `AUTHENTICATION_BACKENDS` setting matters. If the same credentials are valid for multiple backends, Django will authenticate the user using the first backend in the list that successfully validates these credentials. This means Django does not proceed to check the remaining backends once a match is found.

Preventing users from using an existing email address

The `User` model of the authentication framework does not prevent creating users with the same email address. If two or more user accounts share the same email address, we won't be able to discern which user is authenticating. Now that users can log in using their email address, we have to prevent users from registering with an existing email address.

We will now change the user registration form to prevent multiple users from registering with the same email address.

Edit the `forms.py` file of the `account` application and add the following lines highlighted in bold to the `UserRegistrationForm` class:

```
class UserRegistrationForm(forms.ModelForm):
    password = forms.CharField(
        label='Password',
        widget=forms.PasswordInput
    )
    password2 = forms.CharField(
        label='Repeat password',
        widget=forms.PasswordInput
    )

    class Meta:
        model = User
        fields = ['username', 'first_name', 'email']
```

```
    def clean_password2(self):
        cd = self.cleaned_data
        if cd['password'] != cd['password2']:
            raise forms.ValidationError('Passwords don\'t match.')
        return cd['password2']

    def clean_email(self):
        data = self.cleaned_data['email']
        if User.objects.filter(email=data).exists():
            raise forms.ValidationError('Email already in use.')
        return data
```

We have added validation for the `email` field that prevents users from registering with an existing email address. We build a QuerySet to look up existing users with the same email address. We check whether there are any results with the `exists()` method. The `exists()` method returns `True` if the QuerySet contains any results, and `False` otherwise.

Now, add the following lines highlighted in bold to the `UserEditForm` class:

```
class UserEditForm(forms.ModelForm):
    class Meta:
        model = User
        fields = ['first_name', 'last_name', 'email']

    def clean_email(self):
        data = self.cleaned_data['email']
        qs = User.objects.exclude(
            id=self.instance.id
        ).filter(
            email=data
        )
        if qs.exists():
            raise forms.ValidationError('Email already in use.')
        return data
```

In this case, we have added validation for the `email` field that prevents users from changing their existing email address to an existing email address of another user. We exclude the current user from the QuerySet. Otherwise, the current email address of the user would be considered an existing email address, and the form won't validate.

Adding social authentication to your site

Social authentication is a widely used feature that allows users to authenticate using their existing account of a service provider using **single sign-on** (**SSO**). The authentication process allows users to authenticate into the site using their existing account from social services like Google, Facebook, or Twitter. In this section, we will add social authentication to the site using Google.

To implement social authentication, we will use the **OAuth 2.0** industry-standard protocol for authorization. **OAuth** stands for **Open Authorization**. OAuth 2.0 is a standard designed to allow a website or application to access resources hosted by other web apps on behalf of a user. Google uses the OAuth 2.0 protocol for authentication and authorization.

Python Social Auth is a Python module that simplifies the process of adding social authentication to your website. Using this module, you can let your users log in to your website using their accounts from other services. You can find the code for this module at `https://github.com/python-social-auth/social-app-django`.

This module comes with authentication backends for different Python frameworks, including Django.

Run the following command in the shell:

```
python -m pip install social-auth-app-django==5.4.0
```

This will install Python Social Auth.

Then, add `social_django` to the `INSTALLED_APPS` setting in the `settings.py` file of the project as follows:

```
INSTALLED_APPS = [
    # ...
    'social_django',
]
```

This is the default application to add Python Social Auth to Django projects. Now, run the following command to sync Python Social Auth models with your database:

```
python -m python manage.py migrate
```

You should see that the migrations for the default application are applied as follows:

```
Applying social_django.0001_initial... OK
...
Applying social_django .0015_rename_extra_data_new_usersocialauth_extra_data...
OK
```

Python Social Auth includes authentication backends for multiple services. You can find the list with all available backends at `https://python-social-auth.readthedocs.io/en/latest/backends/index.html#supported-backends`.

We will add social authentication to our project, allowing our users to authenticate with the Google backend.

First, we need to add the social login URL patterns to the project.

Open the main `urls.py` file of the `bookmarks` project and include the `social_django` URL patterns as follows. The new lines are highlighted in bold:

```
urlpatterns = [
    path('admin/', admin.site.urls),
    path('account/', include('account.urls')),
    path(
        'social-auth/',
        include('social_django.urls', namespace='social')
    ),
]
```

Our web application is currently accessible via the localhost IP, `127.0.0.1`, or using the `localhost` hostname. Google allows the redirection of users to `localhost` after successful authentication, but other social services expect a domain name for the URL redirect. In this project, we will simulate a real environment by serving our site under a domain name in our local machine.

Locate the `hosts` file of your machine. If you are using Linux or macOS, the `hosts` file is located at `/etc/hosts`. If you are using Windows, the `hosts` file is located at `C:\Windows\System32\Drivers\etc\hosts`.

Edit the `hosts` file of your machine and add the following line to it:

```
127.0.0.1 mysite.com
```

This will tell your computer to point the `mysite.com` hostname to your own machine.

Let's verify that the hostname association worked. Run the development server using the following command from the shell prompt:

```
python manage.py runserver
```

Open `http://mysite.com:8000/account/login/` in your browser. You will see the following error:

DisallowedHost at /account/login/

Invalid HTTP_HOST header: 'mysite.com:8000'. You may need to add 'mysite.com' to ALLOWED_HOSTS.

Figure 5.4: The invalid host header message

Django controls the hosts that can serve the application using the `ALLOWED_HOSTS` setting. This is a security measure to prevent HTTP host header attacks. Django will only allow the hosts included in this list to serve the application.

You can learn more about the `ALLOWED_HOSTS` setting at `https://docs.djangoproject.com/en/5.0/ref/settings/#allowed-hosts`.

Edit the `settings.py` file of the project and modify the `ALLOWED_HOSTS` setting as follows. The new code is highlighted in bold:

```
ALLOWED_HOSTS = ['mysite.com', 'localhost', '127.0.0.1']
```

Besides the `mysite.com` host, we have explicitly included `localhost` and `127.0.0.1`. This allows access to the site through `localhost` and `127.0.0.1`, which is the default Django behavior when `DEBUG` is `True` and `ALLOWED_HOSTS` is empty.

Open `http://mysite.com:8000/account/login/` again in your browser. Now, you should see the login page of the site instead of an error.

Running the development server through HTTPS

Next, we are going to run the development server through HTTPS to simulate a real environment where the content exchanged with the browser is secured. This will help us later in *Chapter 6*, *Sharing Content on Your Website*, to serve our site securely and load our image bookmarking tool on top of any secure website. The **Transport Layer Security** (**TLS**) protocol is the standard for serving websites through a secure connection. The TLS predecessor is the **Secure Sockets Layer** (**SSL**).

Although SSL is now deprecated, you will find references to both the terms TLS and SSL in multiple libraries and online documentation. The Django development server is not able to serve your site through HTTPS since that is not its intended use. To test the social authentication functionality serving the site through HTTPS, we are going to use the RunServerPlus extension of the package Django Extensions. This package contains a collection of useful Django tools. Please note that you should never use the development server to run your site in a production environment.

Use the following command to install Django Extensions:

```
python -m pip install django-extensions==3.2.3
```

You will need to install Werkzeug, which contains a debugger layer required by the RunServerPlus extension of Django Extensions. Use the following command to install Werkzeug:

```
python -m pip install werkzeug==3.0.2
```

Finally, use the following command to install pyOpenSSL, which is required to use the SSL/TLS functionality of RunServerPlus:

```
python -m pip install pyOpenSSL==24.1.0
```

Edit the `settings.py` file of your project and add Django Extensions to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'django_extensions',
]
```

Now, use the `runserver_plus` management command provided by Django Extensions to run the development server, as follows:

```
python manage.py runserver_plus --cert-file cert.crt
```

We have provided a file name to the `runserver_plus` command for the SSL/TLS certificate. Django Extensions will generate a key and certificate automatically.

Open `https://mysite.com:8000/account/login/` in your browser. Now, you are accessing your site through HTTPS. Note we are now using `https://` instead of `http://`.

Your browser will show a security warning because you are using a self-generated certificate instead of a certificate trusted by a **certification authority** (**CA**).

If you are using Google Chrome, you will see the following screen:

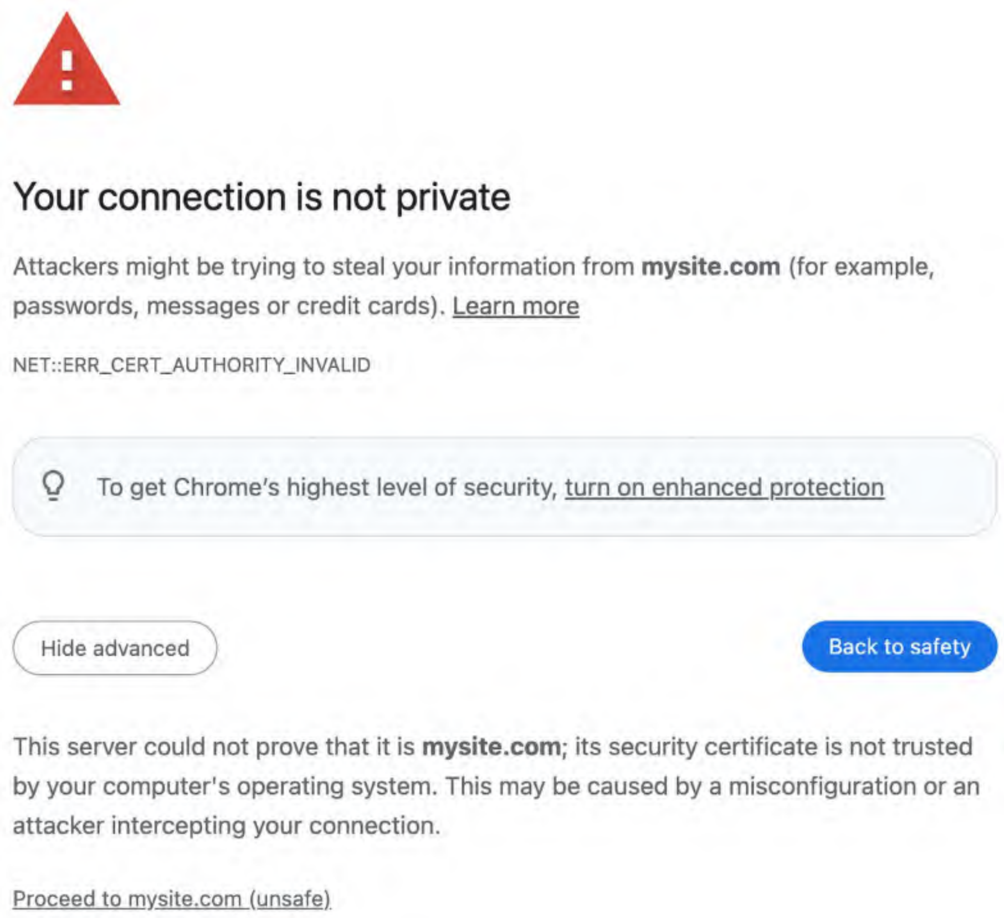

Figure 5.5: The safety error in Google Chrome

In this case, click on **Advanced** and then click on **Proceed to mysite.com (unsafe)**.

If you are using Safari, you will see the following screen:

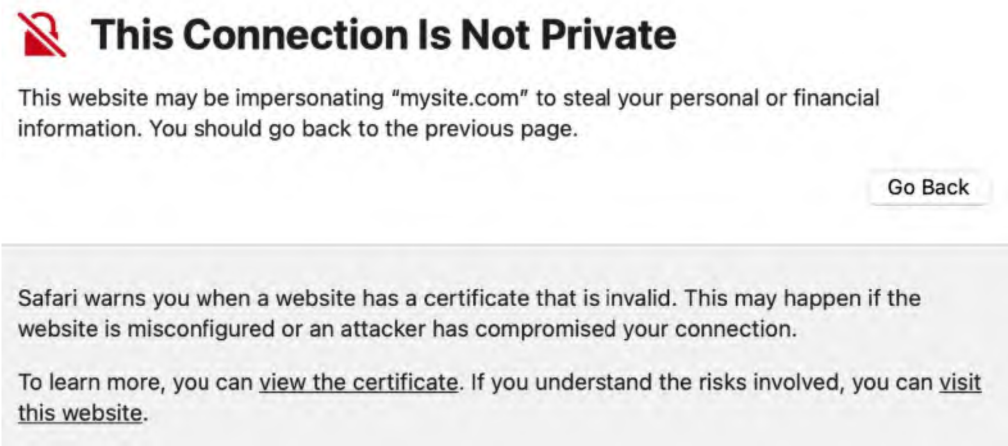

Figure 5.6: The safety error in Safari

In this case, click on **Show details** and then click on **visit this website.**

If you are using Microsoft Edge, you will see the following screen:

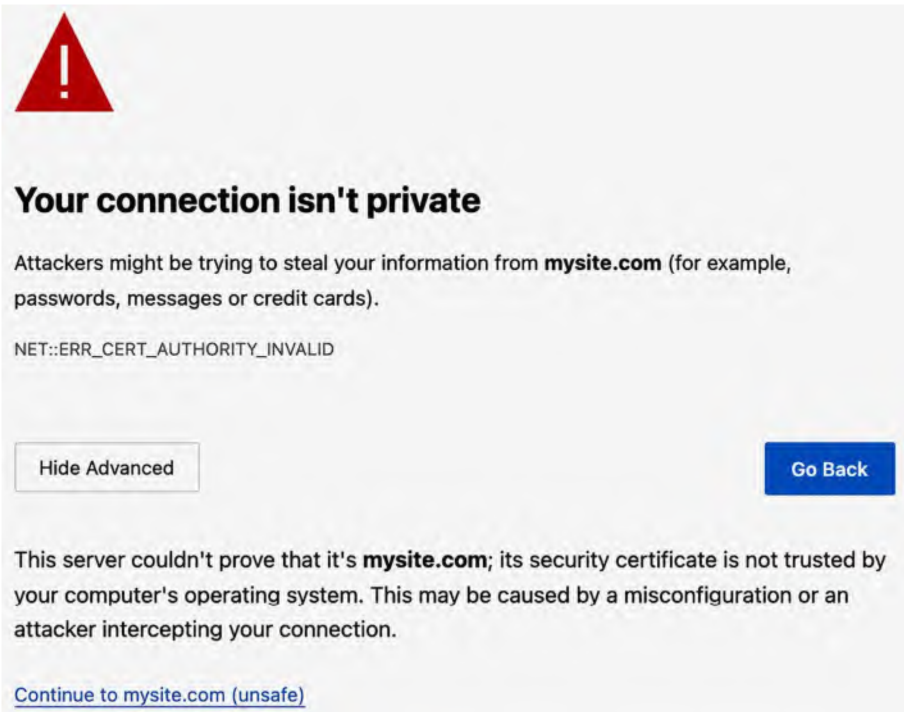

Figure 5.7: The safety error in Microsoft Edge

In this case, click on **Advanced** and then on **Continue to mysite.com (unsafe)**.

If you are using any other browser, access the advanced information displayed by your browser and accept the self-signed certificate so that your browser trusts the certificate.

You will see that the URL starts with `https://` and, in some cases, a lock icon that indicates that the connection is secure. Some browsers might display a broken lock icon because you are using a self-signed certificate instead of a trusted one. That won't be a problem for our tests:

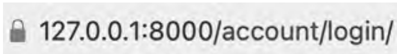

Figure 5.8: The URL with the secured connection icon

> Django Extensions includes many other interesting tools and features. You can find more information about this package at `https://django-extensions.readthedocs.io/en/latest/`.

You can now serve your site through HTTPS during development.

Authentication using Google

Google offers social authentication using OAuth 2.0, which allows users to sign in with Google accounts. You can read about Google's OAuth2 implementation at `https://developers.google.com/identity/protocols/OAuth2`.

To implement authentication using Google, add the following line highlighted in bold to the `AUTHENTICATION_BACKENDS` setting in the `settings.py` file of your project:

```
AUTHENTICATION_BACKENDS = [
    'django.contrib.auth.backends.ModelBackend',
    'account.authentication.EmailAuthBackend',
    'social_core.backends.google.GoogleOAuth2',
]
```

First, you will need to create an API key in your Google Developer Console. Open `https://console.cloud.google.com/projectcreate` in your browser. You will see the following screen:

Figure 5.9: The Google project creation form

Under **Project name**, enter `Bookmarks` and click the **CREATE** button.

When the new project is ready, make sure the project is selected in the top navigation bar as follows:

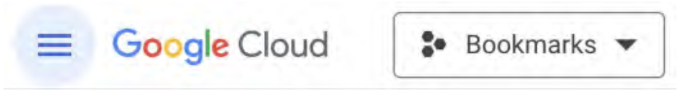

Figure 5.10: The Google Developer Console top navigation bar

After the project is created, under **APIs & Services**, click on **Credentials**:

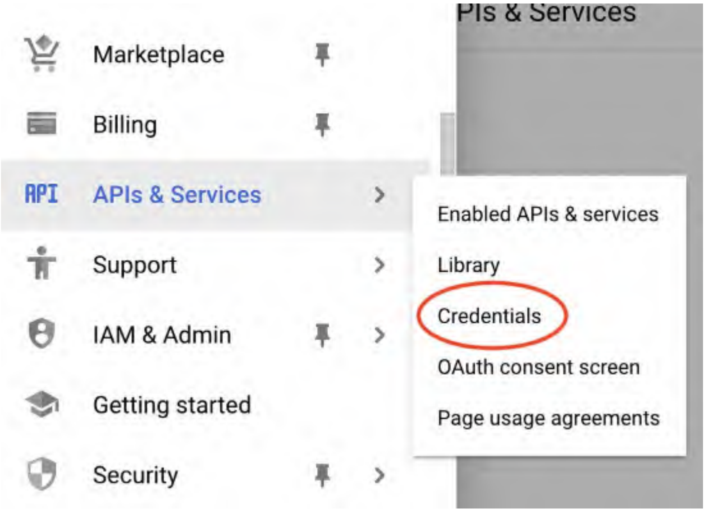

Figure 5.11: Google APIs and services menu

You will see the following screen:

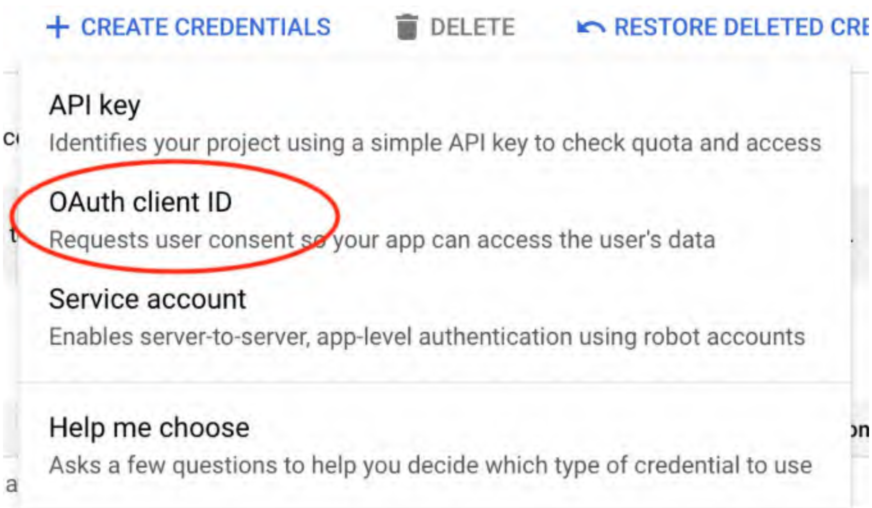

Figure 5.12: Google API creation of API credentials

Then, click on **CREATE CREDENTIALS** and click on **OAuth client ID**.

Google will ask you to configure the consent screen first, like this:

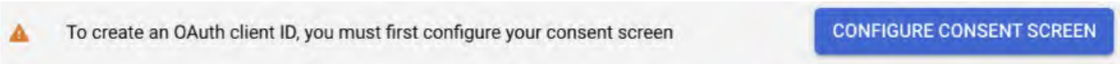

Figure 5.13: The alert to configure the OAuth consent screen

We will configure the page that will be shown to users to give their consent to access your site with their Google account. Click on the **CONFIGURE CONSENT SCREEN** button. You will be redirected to the following screen:

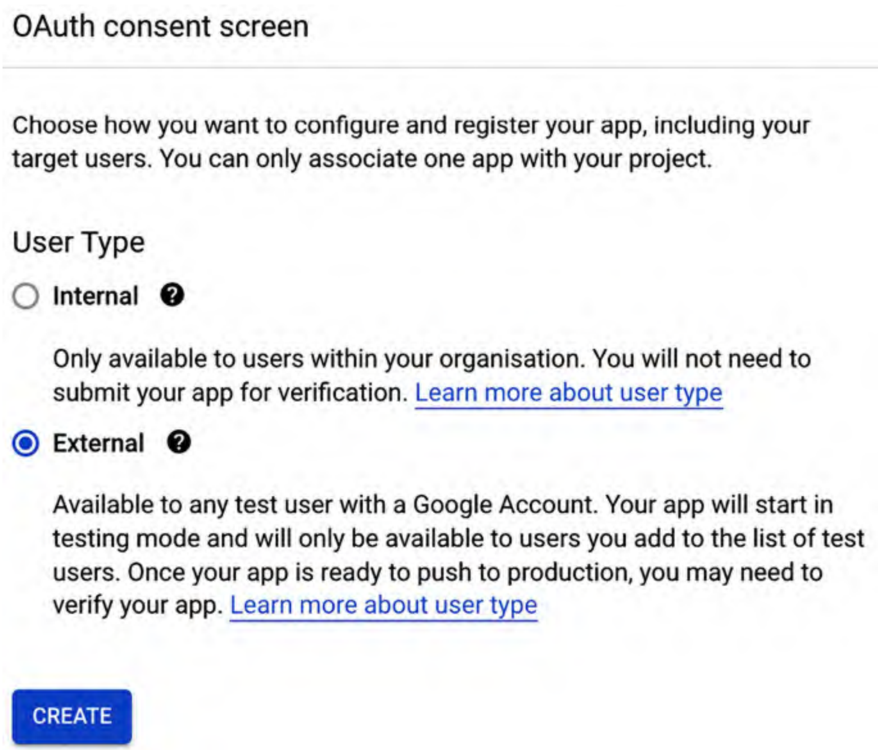

Figure 5.14: The User Type selection in the Google OAuth consent screen setup

Choose **External** for **User Type** and click the **CREATE** button. You will see the following screen:

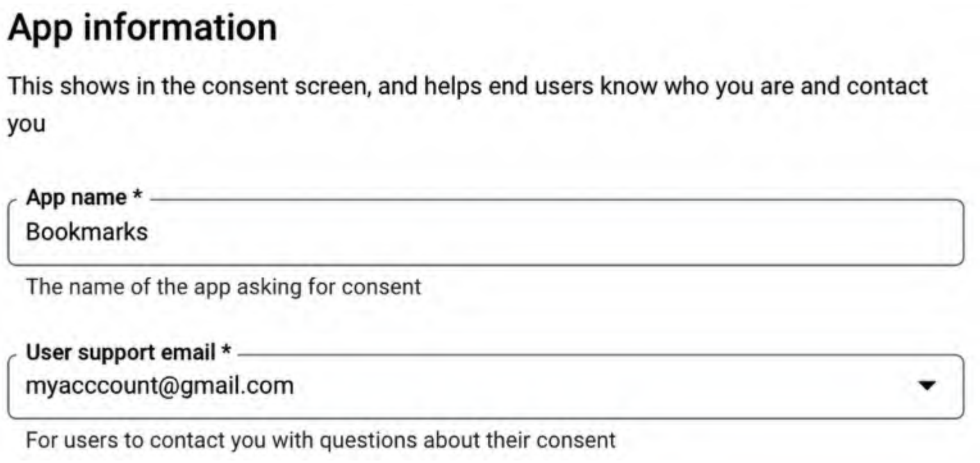

Figure 5.15: The Google OAuth consent screen setup

Under **App name**, enter `Bookmarks` and select your email for **User support email**.

Under **Authorised domains**, enter `mysite.com` as follows:

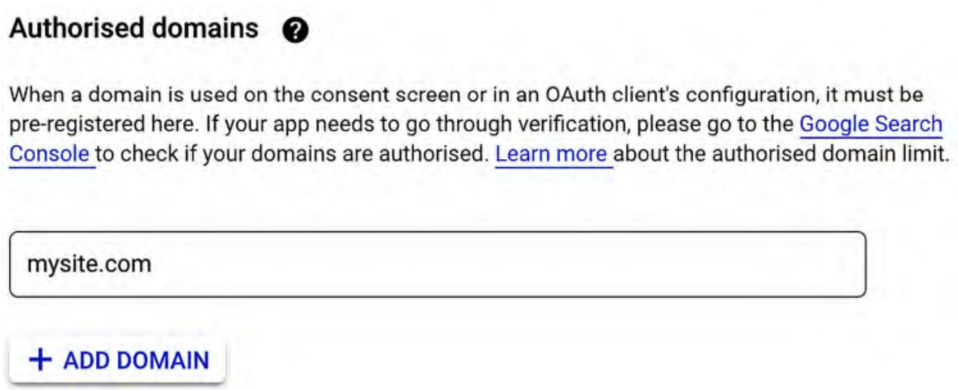

Figure 5.16: Google OAuth authorized domains

Enter your email under **Developer contact information** and click on **SAVE AND CONTINUE.**

In step 2, **Scopes**, don't change anything and click on **SAVE AND CONTINUE.**

In step 3, **Test users,** add your Google user to **Test users** and click on **SAVE AND CONTINUE** as follows:

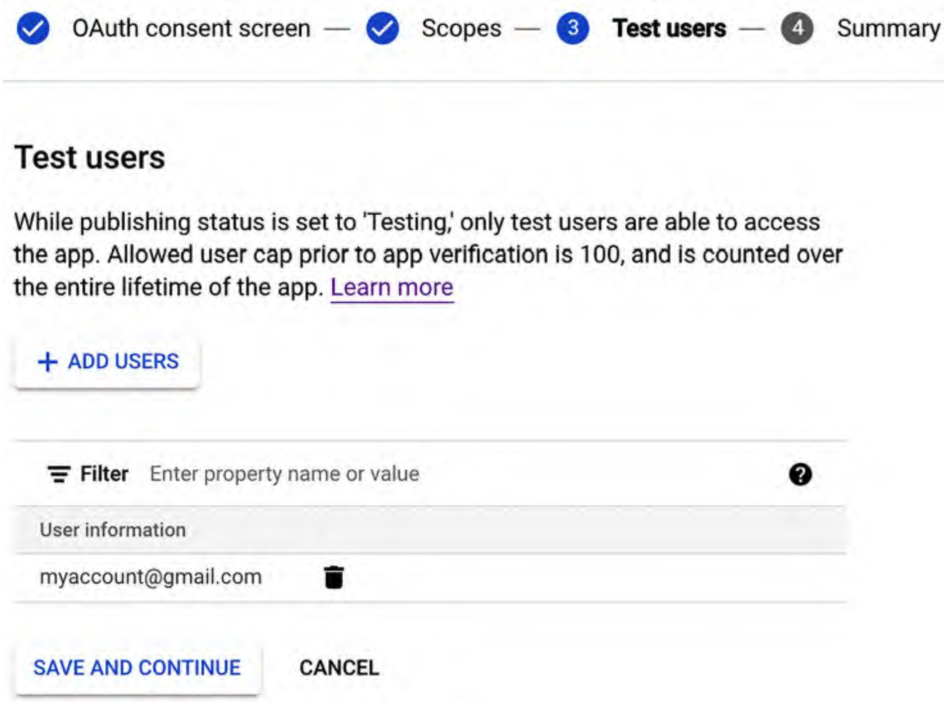

Figure 5.17: Google OAuth test users

You will see a summary of your consent screen configuration. Click on **BACK TO DASHBOARD.**

In the menu on the left sidebar, click on **Credentials**, click again on **Create credentials**, and then on **OAuth client ID.**

As the next step, enter the following information:

- **Application type:** Select **Web application**
- **Name:** Enter `Bookmarks`
- **Authorised JavaScript origins:** Add `https://mysite.com:8000`
- **Authorised redirect URIs:** Add `https://mysite.com:8000/social-auth/complete/google-oauth2/`

The form should look like this:

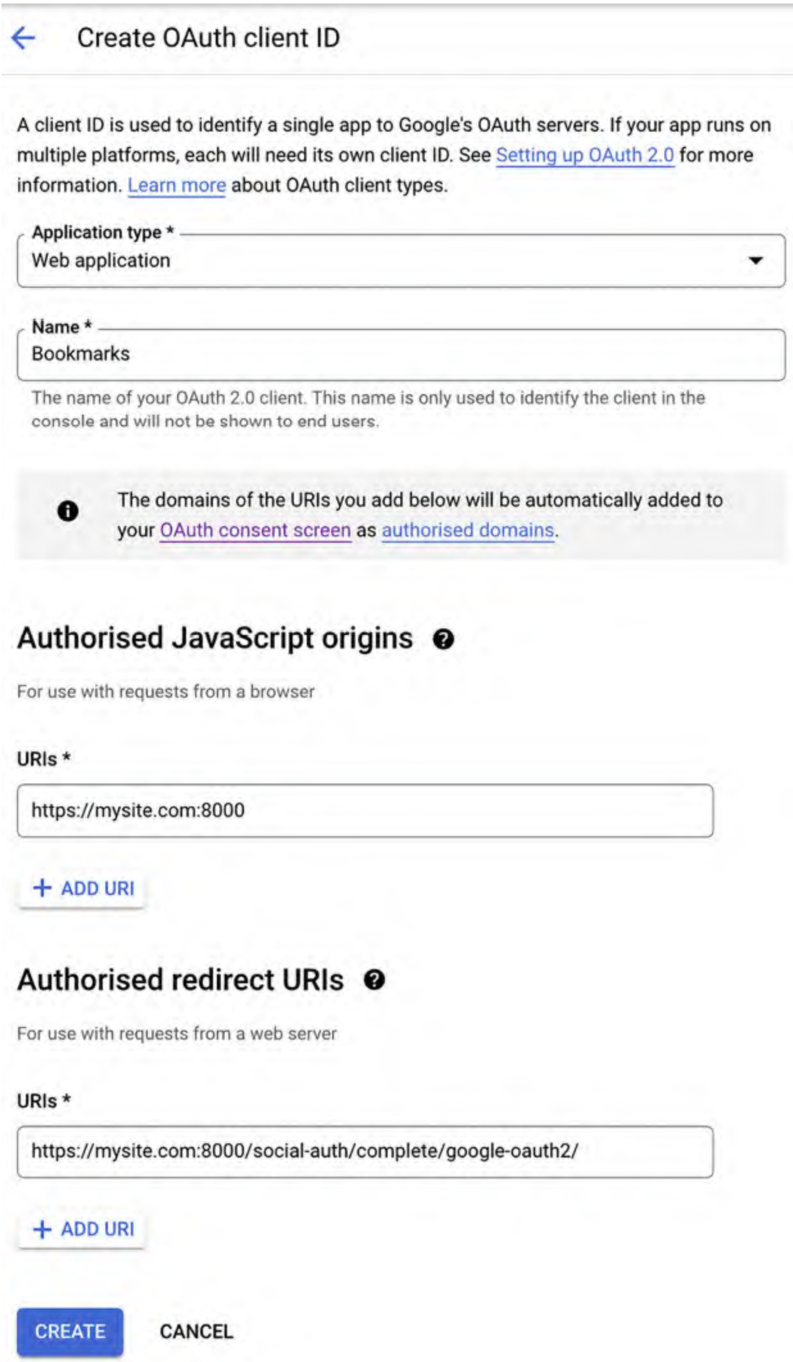

Figure 5.18: The Google OAuth client ID creation form

Click the **CREATE** button. You will get the **Client ID** and **Client secret** keys:

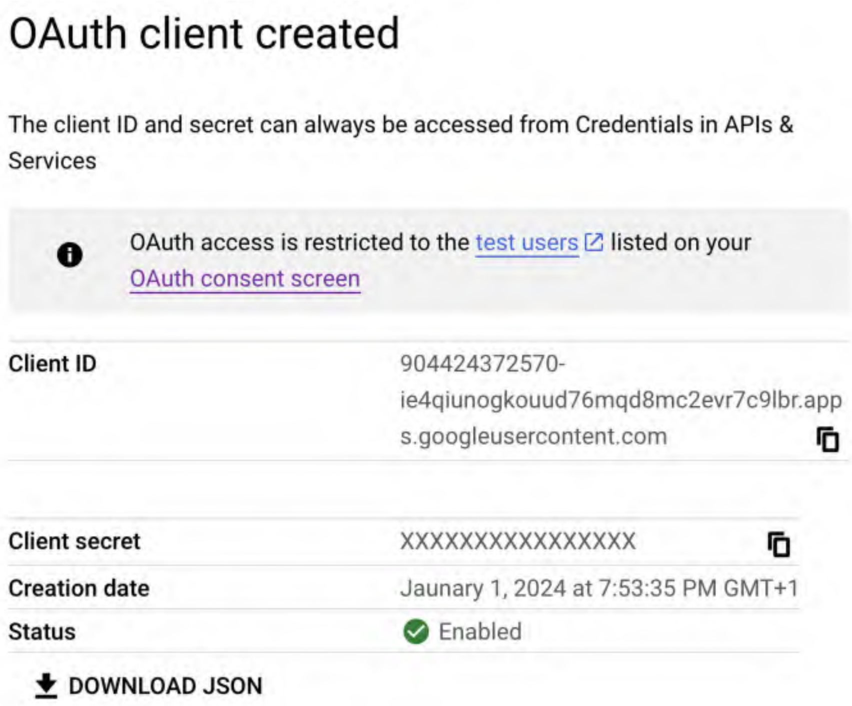

Figure 5.19: Google OAuth – Client ID and Client secret

Create a new file inside your project's root directory and name it `.env`. The `.env` file will contain key-value pairs of environment variables. Add the OAuth2 credentials to the new file, as follows:

```
GOOGLE_OAUTH2_KEY=xxxx
GOOGLE_OAUTH2_SECRET=xxxx
```

Replace xxxx with the OAuth2 key and secret respectively.

To facilitate the separation of configuration from code, we are going to use `python-decouple`. You already used this library in *Chapter 2*, *Enhancing Your Blog and Adding Social Features*.

Install `python-decouple` via `pip` by running the following command:

```
python -m pip install python-decouple==3.8
```

Edit the `settings.py` file of your project and add the following code to it:

```python
from decouple import config
# ...
SOCIAL_AUTH_GOOGLE_OAUTH2_KEY = config('GOOGLE_OAUTH2_KEY')
SOCIAL_AUTH_GOOGLE_OAUTH2_SECRET = config('GOOGLE_OAUTH2_SECRET')
```

The `SOCIAL_AUTH_GOOGLE_OAUTH2_KEY` and `SOCIAL_AUTH_GOOGLE_OAUTH2_SECRET` settings are loaded from the environment variables defined in the `.env` file.

Edit the `registration/login.html` template of the `account` application and append the following code highlighted in bold at the bottom of the `content` block:

```
{% block content %}
  ...
  <div class="social">
    <ul>
      <li class="google">
        <a href="{% url "social:begin" "google-oauth2" %}">
          Sign in with Google
        </a>
      </li>
    </ul>
  </div>
{% endblock %}
```

Use the `runserver_plus` management command provided by Django Extensions to run the development server, as follows:

```
python manage.py runserver_plus --cert-file cert.crt
```

Open `https://mysite.com:8000/account/login/` in your browser. The login page should now look as follows:

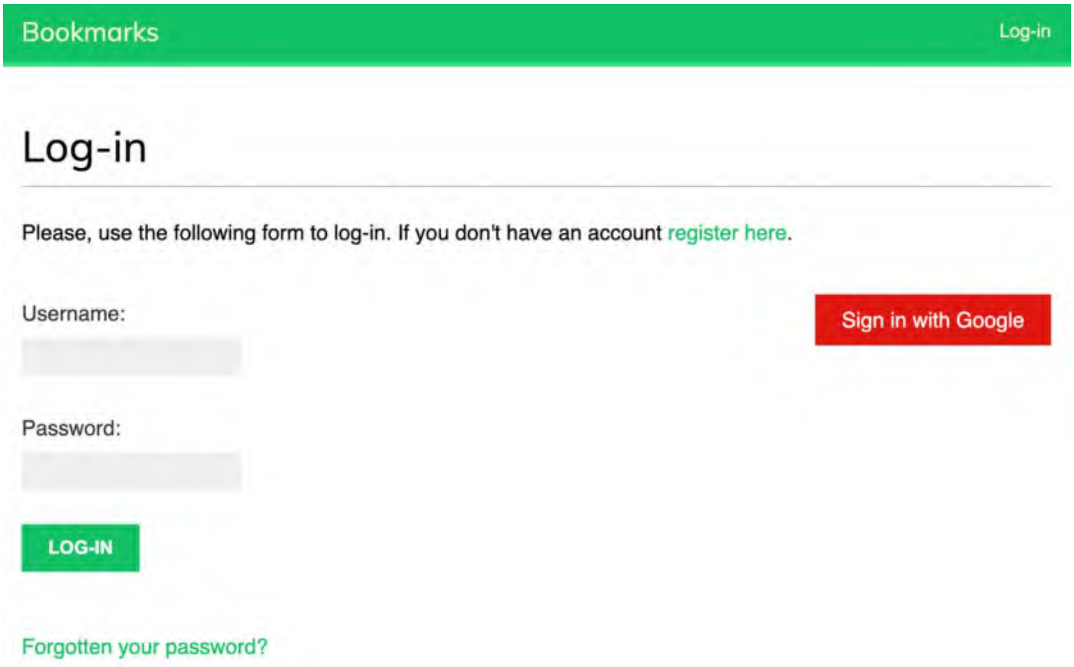

Figure 5.20: The login page including the button for Google authentication

Click on the **Sign in with Google** button. You will see the following screen:

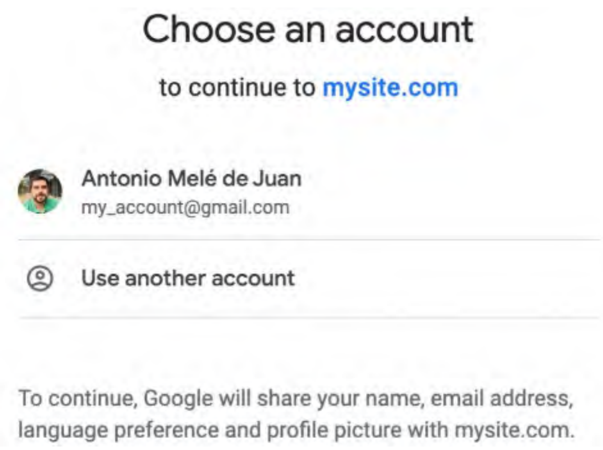

Figure 5.21: The Google application authorization screen

Click on your Google account to authorize the application. You will be logged in and redirected to the dashboard page of your site. Remember that you have set this URL in the `LOGIN_REDIRECT_URL` setting. As you can see, adding social authentication to your site is pretty straightforward.

You have now added social authentication to your project with Google. You can easily implement social authentication with other online services using Python Social Auth. In the next section, we will address creating user profiles when registering with social authentication.

Creating a profile for users that register with social authentication

When a user authenticates using social authentication, a new `User` object is created if there isn't an existing user associated with that social profile. Python Social Auth uses a pipeline consisting of a set of functions that are executed in a specific order during the authentication flow. These functions take care of retrieving any user details, creating a social profile in the database, and associating it with an existing user or creating a new one.

Currently, no `Profile` object is created when new users are created via social authentication. We will add a new step to the pipeline to automatically create a `Profile` object in the database when a new user is created.

Add the following `SOCIAL_AUTH_PIPELINE` setting to the `settings.py` file of your project:

```
SOCIAL_AUTH_PIPELINE = [
    'social_core.pipeline.social_auth.social_details',
    'social_core.pipeline.social_auth.social_uid',
    'social_core.pipeline.social_auth.auth_allowed',
    'social_core.pipeline.social_auth.social_user',
    'social_core.pipeline.user.get_username',
```

```
    'social_core.pipeline.user.create_user',
    'social_core.pipeline.social_auth.associate_user',
    'social_core.pipeline.social_auth.load_extra_data',
    'social_core.pipeline.user.user_details',
]
```

This is the default authentication pipeline used by Python Social Auth. It consists of several functions that perform different tasks when authenticating a user. You can find more details about the default authentication pipeline at `https://python-social-auth.readthedocs.io/en/latest/pipeline.html`.

Let's build a function that creates a `Profile` object in the database whenever a new user is created. We will then add this function to the social authentication pipeline.

Edit the `account/authentication.py` file and add the following code to it:

```
from account.models import Profile


def create_profile(backend, user, *args, **kwargs):
    """
    Create user profile for social authentication
    """
    Profile.objects.get_or_create(user=user)
```

The `create_profile` function takes two required arguments:

- `backend`: The social auth backend used for user authentication. Remember that you added the social authentication backends to the `AUTHENTICATION_BACKENDS` setting in your project.
- `user`: The `User` instance of the new or existing authenticated user.

You can check the different arguments that are passed to the pipeline functions at `https://python-social-auth.readthedocs.io/en/latest/pipeline.html#extending-the-pipeline`.

In the `create_profile` function, we check that a `user` object is present and we use the `get_or_create()` method to look up a `Profile` object for the given user, and we create one if necessary.

Now, we need to add the new function to the authentication pipeline. Add the following line highlighted in bold to the `SOCIAL_AUTH_PIPELINE` setting in your `settings.py` file:

```
SOCIAL_AUTH_PIPELINE = [
    'social_core.pipeline.social_auth.social_details',
    'social_core.pipeline.social_auth.social_uid',
    'social_core.pipeline.social_auth.auth_allowed',
    'social_core.pipeline.social_auth.social_user',
    'social_core.pipeline.user.get_username',
    'social_core.pipeline.user.create_user',
    'account.authentication.create_profile',
```

```
    'social_core.pipeline.social_auth.associate_user',
    'social_core.pipeline.social_auth.load_extra_data',
    'social_core.pipeline.user.user_details',
]
```

We have added the `create_profile` function after `social_core.pipeline.create_user`. At this point, a `User` instance is available. The user can be an existing user or a new one created in this step of the pipeline. The `create_profile` function uses the `User` instance to look up the related `Profile` object and create a new one if necessary.

Access the user list in the administration site at `https://mysite.com:8000/admin/auth/user/`. Remove any users created through social authentication.

Then, open `https://mysite.com:8000/account/login/` and perform social authentication for the user you deleted. A new user will be created and now a `Profile` object will be created as well. Access `https://mysite.com:8000/admin/account/profile/` to verify that a profile has been created for the new user.

We have successfully added the functionality to create the user profile automatically for social authentication.

Python Social Auth also offers a pipeline mechanism for the disconnection flow. You can find more details at `https://python-social-auth.readthedocs.io/en/latest/pipeline.html#disconnection-pipeline`.

Summary

In this chapter, you significantly improved your social site authentication capabilities by creating an email-based authentication backend and adding social authentication with Google. You also improved the user experience by providing feedback for their actions using the Django messages framework. Finally, you customized the authentication pipeline to create user profiles for new users automatically.

In the next chapter, you will create an image bookmarking system. You will learn about many-to-many relationships and customizing the behavior of forms. You will learn how to generate image thumbnails and how to build AJAX functionalities using JavaScript and Django.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter – `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter05`
- The Django messages framework – `https://docs.djangoproject.com/en/5.0/ref/contrib/messages/`
- Custom authentication sources – `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#other-authentication-sources`

- Automatic primary key fields – `https://docs.djangoproject.com/en/5.0/topics/db/models/#automatic-primary-key-fields`
- Python Social Auth – `https://github.com/python-social-auth`
- Python Social Auth's authentication backends – `https://python-social-auth.readthedocs.io/en/latest/backends/index.html#supported-backends`
- Django allowed hosts setting – `https://docs.djangoproject.com/en/5.0/ref/settings/#allowed-hosts`
- Django Extensions documentation – `https://django-extensions.readthedocs.io/en/latest/`
- Google's OAuth2 implementation – `https://developers.google.com/identity/protocols/OAuth2`
- Google API credentials – `https://console.developers.google.com/apis/credentials`
- Python Social Auth pipeline – `https://python-social-auth.readthedocs.io/en/latest/pipeline.html`
- Extending the Python Social Auth pipeline – `https://python-social-auth.readthedocs.io/en/latest/pipeline.html#extending-the-pipeline`
- Python Social Auth pipeline for disconnection – `https://python-social-auth.readthedocs.io/en/latest/pipeline.html#disconnection-pipeline`

6

Sharing Content on Your Website

In the previous chapter, you added success and error messages to your site using the Django messages framework. You also created an email authentication backend and added social authentication to your site using Google. You learned how to run your development server with HTTPS on your local machine using Django Extensions. You customized the social authentication pipeline to create a user profile for new users automatically.

In this chapter, you will learn how to create a JavaScript bookmarklet to share content from other sites on your website, and you will implement asynchronous browser requests in your project using JavaScript and Django.

This chapter will cover the following topics:

- Creating many-to-many relationships
- Customizing behavior for forms
- Using JavaScript with Django
- Building a JavaScript bookmarklet
- Generating image thumbnails using `easy-thumbnails`
- Implementing asynchronous HTTP requests with JavaScript and Django
- Building infinite scroll pagination

In this chapter, you will create an image bookmarking system. You will create models with many-to-many relationships and customize the behavior of forms. You will learn how to generate image thumbnails and how to build asynchronous browser functionalities using JavaScript and Django.

Functional overview

Figure 6.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

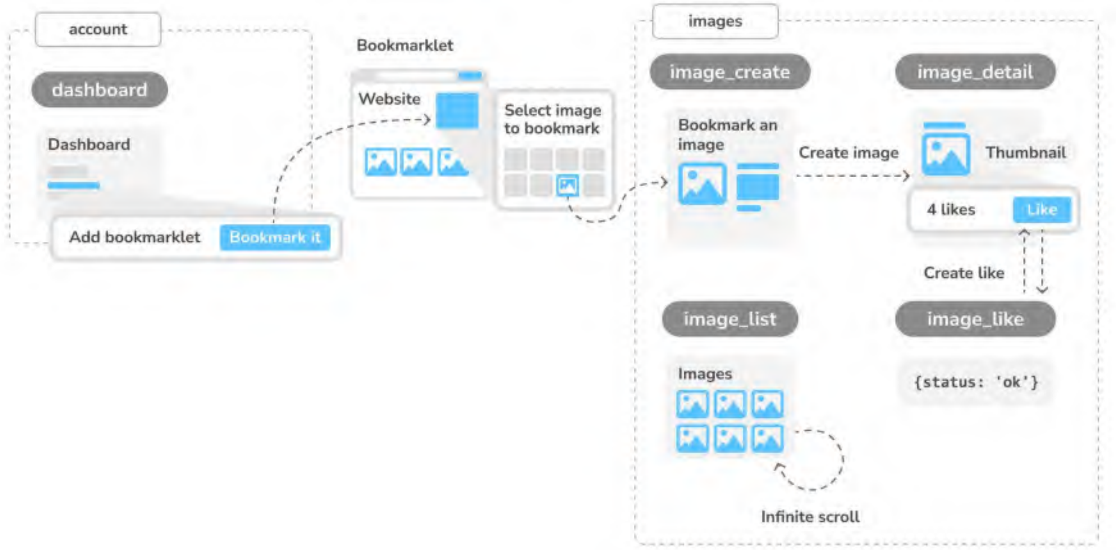

Figure 6.1: Diagram of functionalities built in Chapter 6

In the chapter, you will implement a **Bookmark it** button that will allow users to bookmark images from any website. You will use JavaScript to display an image selector on top of any website for users to select an image to bookmark. You will implement the `image_create` view and a form to retrieve the image from its original source and store it on your website. You will build the `image_detail` view to display single images and you will generate image thumbnails automatically using the `easy-thumbnails` package. You will also implement the `image_like` view to allow users to *like/unlike* images. This view will handle asynchronous HTTP requests performed with JavaScript and return a response in JSON format. You will finally create the `image_list` view to display all bookmarked images and you will implement an infinite scroll using JavaScript and Django pagination.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter06`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all requirements at once with the `python -m pip install -r requirements.txt` command.

Creating an image bookmarking website

We will now learn how to allow users to bookmark images that they find on other websites and share them on our site. To build this functionality, we will need the following elements:

- A data model to store images and related information.

- A form and a view to handle image uploads.
- JavaScript bookmarklet code that can be executed on any website. This code will find images across the page and allow users to select the image they want to bookmark.

First, create a new application inside your `bookmarks` project directory by running the following command in the shell prompt:

```
django-admin startapp images
```

Add the new application to the `INSTALLED_APPS` setting in the `settings.py` file of the project, as follows:

```
INSTALLED_APPS = [
    # ...
    'images.apps.ImagesConfig',
]
```

We have activated the `images` application in the project.

Building the image model

Edit the `models.py` file of the `images` application and add the following code to it:

```
from django.conf import settings
from django.db import models


class Image(models.Model):
    user = models.ForeignKey(
        settings.AUTH_USER_MODEL,
        related_name='images_created',
        on_delete=models.CASCADE
    )
    title = models.CharField(max_length=200)
    slug = models.SlugField(max_length=200, blank=True)
    url = models.URLField(max_length=2000)
    image = models.ImageField(upload_to='images/%Y/%m/%d/')
    description = models.TextField(blank=True)
    created = models.DateTimeField(auto_now_add=True)

    class Meta:
        indexes = [
            models.Index(fields=['-created']),
        ]
        ordering = ['-created']
```

```
    def __str__(self):
        return self.title
```

This is the model that we will use to store images in the platform. Let's take a look at the fields of this model:

- `user`: This indicates the `User` object that bookmarked this image. This is a foreign key field because it specifies a many-to-one relationship: a user can post multiple images, but each image is posted by a single user. We have used `CASCADE` for the `on_delete` parameter so that related images are deleted when a user is deleted.
- `title`: A title for the image.
- `slug`: A short label that contains only letters, numbers, underscores, or hyphens to be used for building beautiful SEO-friendly URLs.
- `url`: The original URL for this image. We use `max_length` to define a maximum length of `2000` characters.
- `image`: The image file.
- `description`: An optional description for the image.
- `created`: The date and time that indicate when the object was created in the database. We have added `auto_now_add` to automatically set the current datetime when the object is created.

In the `Meta` class of the model, we have defined a database index in descending order for the `created` field. We have also added the `ordering` attribute to tell Django that it should sort results by the `created` field by default. We indicate descending order by using a hyphen before the field name, such as `-created`, so that new images will be displayed first.

Database indexes improve query performance. Consider creating indexes for fields that you frequently query using `filter()`, `exclude()`, or `order_by()`. `ForeignKey` fields or fields with `unique=True` imply the creation of an index. You can learn more about database indexes at `https://docs.djangoproject.com/en/5.0/ref/models/options/#django.db.models.Options.indexes`.

We will override the `save()` method of the `Image` model to automatically generate the `slug` field based on the value of the `title` field. Import the `slugify()` function and add a `save()` method to the `Image` model, as follows. New lines are highlighted in bold:

```
from django.utils.text import slugify


class Image(models.Model):
    # ...

    def save(self, *args, **kwargs):
        if not self.slug:
            self.slug = slugify(self.title)
        super().save(*args, **kwargs)
```

When an `Image` object is saved, if the `slug` field doesn't have a value, the `slugify()` function is used to automatically generate a slug from the `title` field of the image. The object is then saved. By generating slugs automatically from the title, users won't have to provide a slug when they share images on our website.

Creating many-to-many relationships

Next, we will add another field to the `Image` model to store the users who like an image. We will need a many-to-many relationship in this case because a user might like multiple images and each image can be liked by multiple users.

Add the following field to the `Image` model:

```
users_like = models.ManyToManyField(
    settings.AUTH_USER_MODEL,
    related_name='images_liked',
    blank=True
)
```

When we define a `ManyToManyField` field, Django creates an intermediary join table using the primary keys of both models. *Figure 6.2* shows the database table that will be created for this relationship:

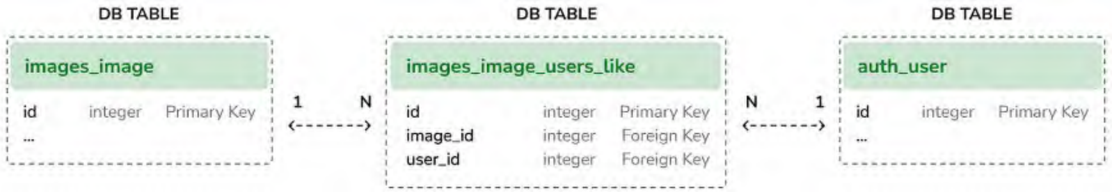

Figure 6.2: Intermediary database table for the many-to-many relationship

The `images_image_users_like` table is created by Django as an intermediary table that has references to the `images_image` table (`Image` model) and `auth_user` table (`User` model). The `ManyToManyField` field can be defined in either of the two related models.

As with `ForeignKey` fields, the `related_name` attribute of `ManyToManyField` allows you to name the relationship from the related object back to this one. `ManyToManyField` fields provide a many-to-many manager that allows you to retrieve related objects, such as `image.users_like.all()`, or get them from a `user` object, such as `user.images_liked.all()`.

You can learn more about many-to-many relationships at `https://docs.djangoproject.com/en/5.0/topics/db/examples/many_to_many/`.

Open the shell prompt and run the following command to create an initial migration:

```
python manage.py makemigrations images
```

The output should be similar to the following one:

```
Migrations for 'images':
```

```
  images/migrations/0001_initial.py
    - Create model Image
    - Create index images_imag_created_d57897_idx on field(s) -created of model
image
```

Now run the following command to apply your migration:

```
python manage.py migrate images
```

You will get an output that includes the following line:

```
Applying images.0001_initial... OK
```

The `Image` model is now synced to the database.

Registering the image model in the administration site

Edit the `admin.py` file of the `images` application and register the `Image` model into the administration site, as follows:

```python
from django.contrib import admin
from .models import Image


@admin.register(Image)
class ImageAdmin(admin.ModelAdmin):
    list_display = ['title', 'slug', 'image', 'created']
    list_filter = ['created']
```

Start the development server with the following command:

```
python manage.py runserver_plus --cert-file cert.crt
```

Open `https://127.0.0.1:8000/admin/` in your browser, and you will see the `Image` model in the administration site, like this:

Figure 6.3: The Images block on the Django administration site index page

You have completed the model to store images. Now you will learn how to implement a form to retrieve images by their URL and store them using the `Image` model.

Posting content from other websites

We will allow users to bookmark images from external websites and share them on our site. Users will provide the URL of the image, a title, and an optional description. We will create a form and a view to download the image and create a new `Image` object in the database.

Let's start by building a form to submit new images.

Create a new `forms.py` file inside the `images` application directory and add the following code to it:

```
from django import forms
from .models import Image


class ImageCreateForm(forms.ModelForm):
    class Meta:
        model = Image
        fields = ['title', 'url', 'description']
        widgets = {
            'url': forms.HiddenInput,
        }
```

We have defined a `ModelForm` form from the `Image` model, including only the `title`, `url`, and `description` fields. Users will not enter the image URL directly in the form. Instead, we will provide them with a JavaScript tool to choose an image from an external site, and the form will receive the image's URL as a parameter. We have overridden the default widget of the `url` field to use a `HiddenInput` widget. This widget is rendered as an HTML `input` element with a `type="hidden"` attribute. We use this widget because we don't want this field to be visible to users.

Cleaning form fields

In order to verify that the provided image URL is valid, we will check that the filename ends with a `.jpg`, `.jpeg`, or `.png` extension to allow sharing JPEG and PNG files only. In the previous chapter, we used the `clean_<fieldname>()` convention to implement field validation. This method is executed for each field, if the field is present, when we call `is_valid()` on a form instance. In the `clean` method, you can alter the field's value or raise any validation errors for the field.

In the `forms.py` file of the `images` application, add the following method to the `ImageCreateForm` class:

```
def clean_url(self):
    url = self.cleaned_data['url']
    valid_extensions = ['jpg', 'jpeg', 'png']
    extension = url.rsplit('.', 1)[1].lower()
    if extension not in valid_extensions:
        raise forms.ValidationError(
            'The given URL does not match valid image extensions.'
```

```
        )
    return url
```

In the preceding code, we have defined a `clean_url()` method to clean the `url` field. The code works as follows:

1. The value of the `url` field is retrieved by accessing the `cleaned_data` dictionary of the form instance.
2. The URL is split to check whether the file has a valid extension. If the extension is invalid, a `ValidationError` is raised and the form instance is not validated.

In addition to validating the given URL, we also need to download the image file and save it. We could, for example, use the view that handles the form to download the image file. Instead, let's take a more general approach by overriding the `save()` method of the model form to perform this task when the form is saved.

Installing the Requests library

When a user bookmarks an image, we will need to download the image file by its URL. We will use the Requests Python library for this purpose. Requests is the most popular HTTP library for Python. It abstracts the complexity of dealing with HTTP requests and provides a very simple interface to consume HTTP services. You can find the documentation for the Requests library at `https://requests.readthedocs.io/en/master/`.

Open the shell and install the Requests library with the following command:

```
python -m pip install requests==2.31.0
```

We will now override the `save()` method of `ImageCreateForm` and use the Requests library to retrieve the image by its URL.

Overriding the save() method of a ModelForm

As you know, `ModelForm` provides a `save()` method to save the current model instance to the database and return the object. This method receives a Boolean `commit` parameter, which allows you to specify whether the object has to be persisted to the database. If `commit` is `False`, the `save()` method will return a model instance but will not save it to the database. We will override the form's `save()` method in order to retrieve the image file by the given URL and save it to the file system.

Add the following imports at the top of the `forms.py` file:

```
import requests
from django.core.files.base import ContentFile
from django.utils.text import slugify
```

Then, add the following `save()` method to the `ImageCreateForm` form:

```
def save(self, force_insert=False, force_update=False, commit=True):
    image = super().save(commit=False)
```

```
        image_url = self.cleaned_data['url']
        name = slugify(image.title)
        extension = image_url.rsplit('.', 1)[1].lower()
        image_name = f'{name}.{extension}'
        # download image from the given URL
        response = requests.get(image_url)
        image.image.save(
            image_name,
            ContentFile(response.content),
            save=False
        )
        if commit:
            image.save()
        return image
```

We have overridden the `save()` method, keeping the parameters required by `ModelForm`. The preceding code can be explained as follows:

1. A new `image` instance is created by calling the `save()` method of the form with `commit=False`.
2. The URL of the image is retrieved from the `cleaned_data` dictionary of the form.
3. An image name is generated by combining the `image` title slug with the original file extension of the image.
4. The Requests Python library is used to download the image by sending an HTTP `GET` request using the image URL. The response is stored in the `response` object.
5. The `save()` method of the `image` field is called, passing it a `ContentFile` object that is instantiated with the downloaded file content. In this way, the file is saved to the media directory of the project. The `save=False` parameter is passed to prevent the object from being saved to the database.
6. To maintain the same behavior as the original `save()` method of the model form, the form is only saved to the database if the `commit` parameter is `True`.

We will need a view to create an instance of the form and handle its submission.

Edit the `views.py` file of the `images` application and add the following code to it. New code is highlighted in bold:

```
from django.contrib import messages
from django.contrib.auth.decorators import login_required
from django.shortcuts import redirect, render
from .forms import ImageCreateForm


@login_required
def image_create(request):
```

```
    if request.method == 'POST':
        # form is sent
        form = ImageCreateForm(data=request.POST)
        if form.is_valid():
            # form data is valid
            cd = form.cleaned_data
            new_image = form.save(commit=False)
            # assign current user to the item
            new_image.user = request.user
            new_image.save()
            messages.success(request, 'Image added successfully')
            # redirect to new created item detail view
            return redirect(new_image.get_absolute_url())
    else:
        # build form with data provided by the bookmarklet via GET
        form = ImageCreateForm(data=request.GET)
    return render(
        request,
        'images/image/create.html',
        {'section': 'images', 'form': form}
    )
```

In the preceding code, we have created a view to store images on the site. We have added the `login_required` decorator to the `image_create` view to prevent access to unauthenticated users. This is how this view works:

1. Initial data has to be provided through a `GET` HTTP request in order to create an instance of the form. This data will consist of the `url` and `title` attributes of an image from an external website. Both parameters will be set in the `GET` request by the JavaScript bookmarklet that we will create later. For now, we can assume that this data will be available in the request.
2. When the form is submitted with a `POST` HTTP request, it is validated with `form.is_valid()`. If the form data is valid, a new `image` instance is created by saving the form with `form.save(commit=False)`. The new instance is not saved to the database because of `commit=False`.
3. A relationship to the current user performing the request is added to the new `image` instance with `new_image.user = request.user`. This is how we will know who uploaded each image.
4. The `Image` object is saved to the database.
5. Finally, a success message is created using the Django messages framework and the user is redirected to the canonical URL of the new image. We haven't yet implemented the `get_absolute_url()` method of the `Image` model; we will do that later.

Create a new `urls.py` file inside the `images` application and add the following code to it:

```
from django.urls import path
```

```
from . import views


app_name = 'images'

urlpatterns = [
    path('create/', views.image_create, name='create'),
]
```

Edit the main `urls.py` file of the `bookmarks` project to include the patterns for the `images` application, as follows. The new code is highlighted in bold:

```
urlpatterns = [
    path('admin/', admin.site.urls),
    path('account/', include('account.urls')),
    path(
        'social-auth/',
        include('social_django.urls', namespace='social')
    ),
    path('images/', include('images.urls', namespace='images')),
]
```

Finally, we need to create a template to render the form. Create the following directory structure inside the `images` application directory:

```
templates/
  images/
    image/
      create.html
```

Edit the new `create.html` template and add the following code to it:

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

{% block title %}Bookmark an image{% endblock %}

{% block content %}
  <h1>Bookmark an image</h1>
  <img src="{{ request.GET.url }}" class="image-preview">
  <form method="post">
    {{ form.as_p }}
    {% csrf_token %}
    <input type="submit" value="Bookmark it!">
  </form>
{% endblock %}
```

Run the development server with the following command in the shell prompt:

```
python manage.py runserver_plus --cert-file cert.crt
```

Open `https://127.0.0.1:8000/images/create/?title=...&url=...` in your browser, including the `title` and `url` GET parameters, providing an existing JPEG image URL in the latter. For example, you can use the following URL: `https://127.0.0.1:8000/images/create/?title=%20Django%20and%20Duke&url=https://upload.wikimedia.org/wikipedia/commons/8/85/Django_Reinhardt_and_Duke_Ellington_%28Gottlieb%29.jpg`.

You will see the form with an image preview, like the following:

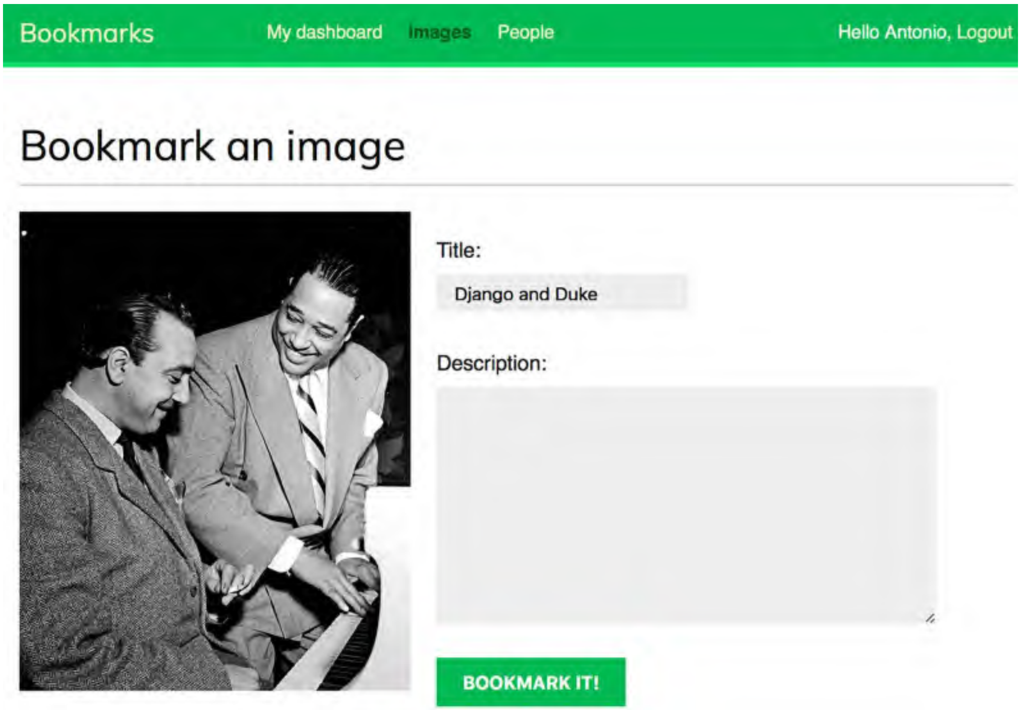

Figure 6.4: The Bookmark an image bookmark page

Add a description and click on the **BOOKMARK IT!** button. A new `Image` object will be saved in your database. However, you will get an error that indicates that the `Image` model has no `get_absolute_url()` method, as follows:

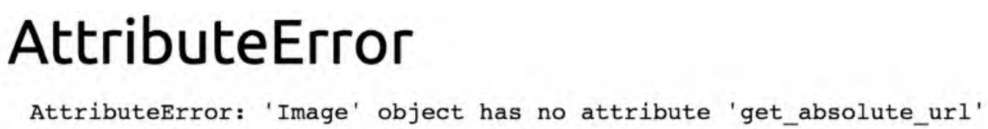

Figure 6.5: An error showing that the Image object has no get_absolute_url attribute

Don't worry about this error for now; we are going to implement the `get_absolute_url` method in the `Image` model later.

Open `https://127.0.0.1:8000/admin/images/image/` in your browser and verify that the new `Image` object has been saved, like this:

Figure 6.6: The administration site image list page showing the created Image object

Building a bookmarklet with JavaScript

A bookmarklet is a bookmark stored in a web browser that contains JavaScript code to extend the browser's functionality. When you click on the bookmark in the bookmarks or favorites bar of your browser, the JavaScript code is executed on the website being displayed in the browser. This is very useful for building tools that interact with other websites.

Some online services, such as Pinterest, implement their own bookmarklet to let users share content from other sites on their platforms. The Pinterest bookmarklet is implemented as a browser extension and is available at `https://help.pinterest.com/en/article/save-pins-with-the-pinterest-browser-button`. The **Pinterest Save** extension allows users to save images or websites to their Pinterest account with just one click on the browser.

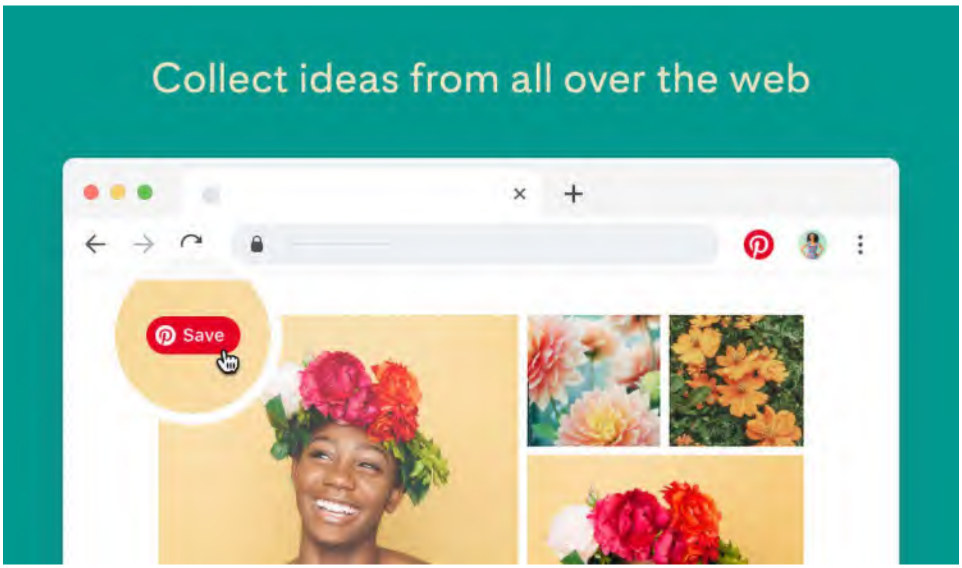

Figure 6.7: The Pinterest Save extension

Let's create a bookmarklet in a similar way for your website. For that, we will be using JavaScript.

This is how your users will add the bookmarklet to their browser and use it:

1. The user drags a link from your site to their browser's bookmarks bar. The link contains JavaScript code in its `href` attribute. This code will be stored in the bookmark.
2. The user navigates to any website and clicks on the bookmark in the bookmarks or favorites bar. The JavaScript code of the bookmark is executed.

Since the JavaScript code will be stored as a bookmark, we will not be able to update it after the user has added it to their bookmarks bar. This is an important drawback that you can solve by implementing a launcher script. Users will save the launcher script as a bookmark, and the launcher script will load the actual JavaScript bookmarklet from a URL. By doing this, you will be able to update the code of the bookmarklet at any time. This is the approach that we will take to build the bookmarklet. Let's start!

Create a new template under `images/templates/` and name it `bookmarklet_launcher.js`. This will be the launcher script. Add the following JavaScript code to the new file:

```
(function(){
  if(!window.bookmarklet) {
    bookmarklet_js = document.body.appendChild(document.
createElement('script'));
    bookmarklet_js.src = '//127.0.0.1:8000/static/js/bookmarklet.js?r='+Math.
floor(Math.random()*9999999999999999);
    window.bookmarklet = true;
  }
  else {
    bookmarkletLaunch();
  }
})();
```

The preceding script checks whether the bookmarklet has already been loaded by checking the value of the `bookmarklet` window variable with `if(!window.bookmarklet)`:

- If `window.bookmarklet` is not defined or doesn't have a truthy value (considered `true` in a Boolean context), a JavaScript file is loaded by appending a `<script>` element to the body of the HTML document loaded in the browser. The `src` attribute is used to load the URL of the `bookmarklet.js` script with a random 16-digit integer parameter generated with `Math.random()*9999999999999999`. Using a random number, we prevent the browser from loading the file from the browser's cache. If the bookmarklet JavaScript has been previously loaded, the different parameter value will force the browser to load the script from the source URL again. This way, we make sure the bookmarklet always runs the most up-to-date JavaScript code.

- If `window.bookmarklet` is defined and has a truthy value, the `bookmarkletLaunch()` function is executed. We will define `bookmarkletLaunch()` as a global function in the `bookmarklet.js` script.

By checking the `bookmarklet` window variable, we prevent the bookmarklet JavaScript code from being loaded more than once if users click on the bookmarklet repeatedly.

You created the bookmarklet launcher code. The actual bookmarklet code will reside in the `bookmarklet.js` static file. Using launcher code allows you to update the bookmarklet code at any time without requiring users to change the bookmark they previously added to their browser.

Let's add the bookmarklet launcher to the dashboard pages so that users can add it to the bookmarks bar of their browser.

Edit the `account/dashboard.html` template of the `account` application and make it look like the following. New lines are highlighted in bold:

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

{% block title %}Dashboard{% endblock %}

{% block content %}
  <h1>Dashboard</h1>
  {% with total_images_created=request.user.images_created.count %}
    <p>Welcome to your dashboard. You have bookmarked {{ total_images_created
}} image{{ total_images_created|pluralize }}.</p>
  {% endwith %}
  <p>Drag the following button to your bookmarks toolbar to bookmark images
from other websites → <a href="javascript:{% include "bookmarklet_launcher.js"
%}" class="button">Bookmark it</a></p>
  <p>You can also <a href="{% url "edit" %}">edit your profile</a> or <a
href="{% url "password_change" %}">change your password</a>.</p>
{% endblock %}
```

Make sure that no template tag is split over multiple lines; Django doesn't support multiple-line tags.

The dashboard now displays the total number of images bookmarked by the user. We have added a `{% with %}` template tag to create a variable with the total number of images bookmarked by the current user. We have included a link with an `href` attribute that contains the bookmarklet launcher script. This JavaScript code is loaded from the `bookmarklet_launcher.js` template.

Open `https://127.0.0.1:8000/account/` in your browser. You should see the following page:

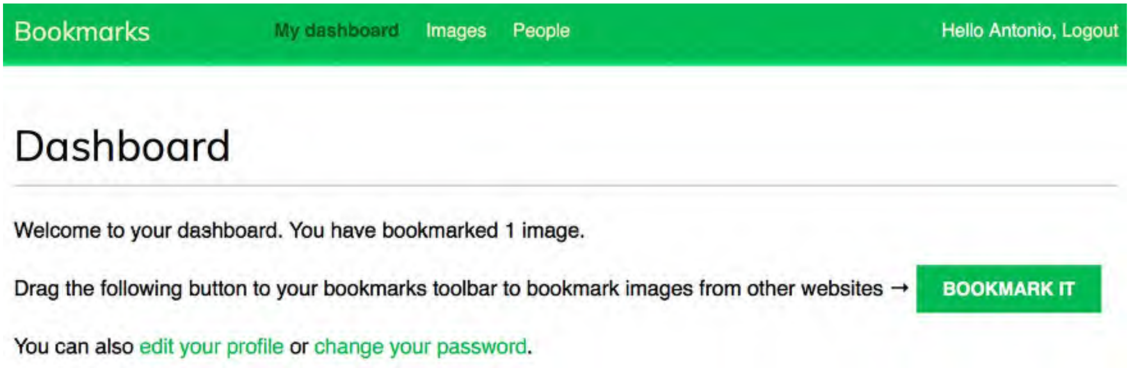

Figure 6.8: The dashboard page, including the total images bookmarked and the button for the bookmarklet

Now create the following directories and files inside the `images` application directory:

```
static/
  js/
    bookmarklet.js
```

You will find a `static/css/` directory in the `images` application directory in the code that comes along with this chapter. Copy the `css/` directory into the `static/` directory of your code. You can find the contents of the directory at `https://github.com/PacktPublishing/Django-5-by-Example/tree/main/Chapter06/bookmarks/images/static`.

The `css/bookmarklet.css` file provides the styles for the JavaScript bookmarklet. The `static/` directory should contain the following file structure now:

```
  css/
    bookmarklet.css
  js/
    bookmarklet.js
```

Edit the `bookmarklet.js` static file and add the following JavaScript code to it:

```
const siteUrl = '//127.0.0.1:8000/';
const styleUrl = siteUrl + 'static/css/bookmarklet.css';
const minWidth = 250;
const minHeight = 250;
```

You have declared four different constants that will be used by the bookmarklet. These constants are:

- `siteUrl` and `staticUrl`: The base URL for the website and the base URL for static files.

- `minWidth` and `minHeight`: The minimum width and height in pixels for the images that the bookmarklet will collect from the site. The bookmarklet will identify images that have at least `250px` width and `250px` height.

Edit the `bookmarklet.js` static file and add the following code highlighted in bold:

```
const siteUrl = '//127.0.0.1:8000/';
const styleUrl = siteUrl + 'static/css/bookmarklet.css';
const minWidth = 250;
const minHeight = 250;

// load CSS
var head = document.getElementsByTagName('head')[0];
var link = document.createElement('link');
link.rel = 'stylesheet';
link.type = 'text/css';
link.href = styleUrl + '?r=' + Math.floor(Math.random()*9999999999999999);
head.appendChild(link);
```

This section loads the CSS stylesheet for the bookmarklet. We use JavaScript to manipulate the **Document Object Model** (**DOM**). The DOM represents an HTML document in memory and it is created by the browser when a web page is loaded. The DOM is constructed as a tree of objects that comprise the structure and content of the HTML document.

The previous code generates an object equivalent to the following JavaScript code and appends it to the `<head>` element of the HTML page:

```
<link rel="stylesheet" type="text/css" href= "//127.0.0.1:8000/static/css/bookmarklet.css?r=1234567890123456">
```

Let's review how this is done:

1. The `<head>` element of the site is retrieved with `document.getElementsByTagName()`. This function retrieves all HTML elements of the page with the given tag. By using `[0]`, we access the first instance found. We access the first element because all HTML documents should have a single `<head>` element.
2. A `<link>` element is created with `document.createElement('link')`.
3. The `rel` and `type` attributes of the `<link>` element are set. This is equivalent to the HTML `<link rel="stylesheet" type="text/css">`.
4. The `href` attribute of the `<link>` element is set with the URL of the `bookmarklet.css` stylesheet. A 16-digit random number is used as a URL parameter to prevent the browser from loading the file from the cache.
5. The new `<link>` element is added to the `<head>` element of the HTML page using `head.appendChild(link)`.

Now we will create the HTML element to display a `<div>` container on the website where the bookmarklet is executed. The HTML container will be used to display all images found on the site and let users choose the image they want to share. It will use the CSS styles defined in the `bookmarklet.css` stylesheet.

Edit the `bookmarklet.js` static file and add the following code highlighted in bold:

```
const siteUrl = '//127.0.0.1:8000/';
const styleUrl = siteUrl + 'static/css/bookmarklet.css';
const minWidth = 250;
const minHeight = 250;

// load CSS
var head = document.getElementsByTagName('head')[0];
var link = document.createElement('link');
link.rel = 'stylesheet';
link.type = 'text/css';
link.href = styleUrl + '?r=' + Math.floor(Math.random()*9999999999999999);
head.appendChild(link);

// load HTML
var body = document.getElementsByTagName('body')[0];
boxHtml = `
  <div id="bookmarklet">
    <a href="#" id="close">&times;</a>
    <h1>Select an image to bookmark:</h1>
    <div class="images"></div>
  </div>`;
body.innerHTML += boxHtml;
```

With this code, the `<body>` element of the DOM is retrieved and new HTML is added to it by modifying its property `innerHTML`. A new `<div>` element is added to the body of the page. The `<div>` container consists of the following elements:

- A link to close the container defined with `<a href="#" id="close">×</a>`.
- A title defined with `<h1>Select an image to bookmark:</h1>`.
- A `<div>` element to list the images found on the site defined with `<div class="images"></div>`. This container is initially empty and will be filled with the images found on the site.

The HTML container, including the previously loaded CSS styles, will look like *Figure 6.9*:

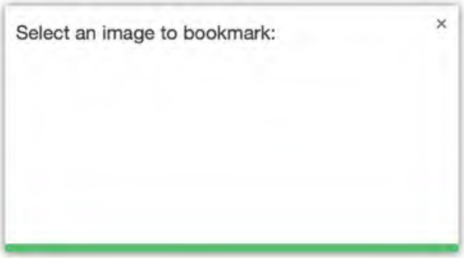

Figure 6.9: The image selection container

Now let's implement a function to launch the bookmarklet. Edit the `bookmarklet.js` static file and add the following code at the bottom:

```
function bookmarkletLaunch() {
  bookmarklet = document.getElementById('bookmarklet');
  var imagesFound = bookmarklet.querySelector('.images');

  // clear images found
  imagesFound.innerHTML = '';
  // display bookmarklet
  bookmarklet.style.display = 'block';

  // close event
  bookmarklet.querySelector('#close')
             .addEventListener('click', function(){
               bookmarklet.style.display = 'none'
             });
}
// launch the bookmkarklet
bookmarkletLaunch();
```

This is the `bookmarkletLaunch()` function. Before the definition of this function, the CSS for the bookmarklet is loaded and the HTML container is added to the DOM of the page. The `bookmarkletLaunch()` function works as follows:

1. The bookmarklet's main container is retrieved by getting the DOM element with the ID `bookmarklet` with `document.getElementById()`.
2. The `bookmarklet` element is used to retrieve the child element with the class `images`. The `querySelector()` method allows you to retrieve DOM elements using CSS selectors. Selectors allow you to find DOM elements to which a set of CSS rules applies. You can find a list of CSS selectors at `https://developer.mozilla.org/en-US/docs/Web/CSS/CSS_Selectors` and you can read more information about how to locate DOM elements using selectors at `https://developer.mozilla.org/en-US/docs/Web/API/Document_object_model/Locating_DOM_elements_using_selectors`.

3. The `images` container is cleared by setting its `innerHTML` attribute to an empty string and the bookmarklet is displayed by setting the `display` CSS property to `block`.
4. The `#close` selector is used to find the DOM element with the ID `close`. A `click` event is attached to the element with the `addEventListener()` method. When users click the element, the bookmarklet's main container is hidden by setting its `display` property to `none`.
5. The `bookmarkletLaunch()` function is executed after its definition.

After loading the CSS styles and the HTML container of the bookmarklet, you have to find image elements in the DOM of the current website. Images that have the minimum required dimension have to be added to the HTML container of the bookmarklet. Edit the `bookmarklet.js` static file and add the following code highlighted in bold to the bottom of the `bookmarklet()` function:

```
function bookmarkletLaunch() {
  bookmarklet = document.getElementById('bookmarklet');
  var imagesFound = bookmarklet.querySelector('.images');

  // clear images found
  imagesFound.innerHTML = '';
  // display bookmarklet
  bookmarklet.style.display = 'block';

  // close event
  bookmarklet.querySelector('#close')
             .addEventListener('click', function(){
               bookmarklet.style.display = 'none'
             });

  // find images in the DOM with the minimum dimensions
  images = document.querySelectorAll('img[src$=".jpg"], img[src$=".jpeg"],
img[src$=".png"]');
  images.forEach(image => {
    if(image.naturalWidth >= minWidth
       && image.naturalHeight >= minHeight)
    {
      var imageFound = document.createElement('img');
      imageFound.src = image.src;
      imagesFound.append(imageFound);
    }
  })
}

// launch the bookmkarklet
bookmarkletLaunch();
```

The preceding code uses the `img[src$=".jpg"]`, `img[src$=".jpeg"]`, and `img[src$=".png"]` selectors to find all `<img>` DOM elements whose `src` attribute finishes with `.jpg`, `.jpeg`, or, `.png`, respectively. Using these selectors with `document.querySelectorAll()` allows you to find all images in JPEG and PNG format displayed on the website. Iteration over the results is performed with the `forEach()` method. Small images are filtered out because we don't consider them to be relevant. Only images with a size larger than the one specified with the `minWidth` and `minHeight` variables are used for the results. A new `<img>` element is created for each image found, where the `src` source URL attribute is copied from the original image and added to the `imagesFound` container.

For security reasons, your browser will prevent you from running the bookmarklet over HTTP on a site served through HTTPS. That's the reason we keep using `RunServerPlus` to run the development server using an auto-generated TLS/SSL certificate. Remember that you learned how to run the development server through HTTPS in *Chapter 5, Implementing Social Authentication*.

In a production environment, a valid TLS/SSL certificate will be required. When you own a domain name, you can apply for a trusted **Certification Authority** (CA) to issue a TLS/SSL certificate for it so that browsers can verify its identity. If you want to obtain a trusted certificate for a real domain, you can use the *Let's Encrypt* service. *Let's Encrypt* is a non-profit CA that simplifies obtaining and renewing trusted TLS/SSL certificates for free. You can find more information at `https://letsencrypt.org`.

Run the development server with the following command from the shell prompt:

```
python manage.py runserver_plus --cert-file cert.crt
```

Open `https://127.0.0.1:8000/account/` in your browser. Log in with an existing user, then click and drag the **BOOKMARK IT** button to the bookmarks bar of your browser, as follows:

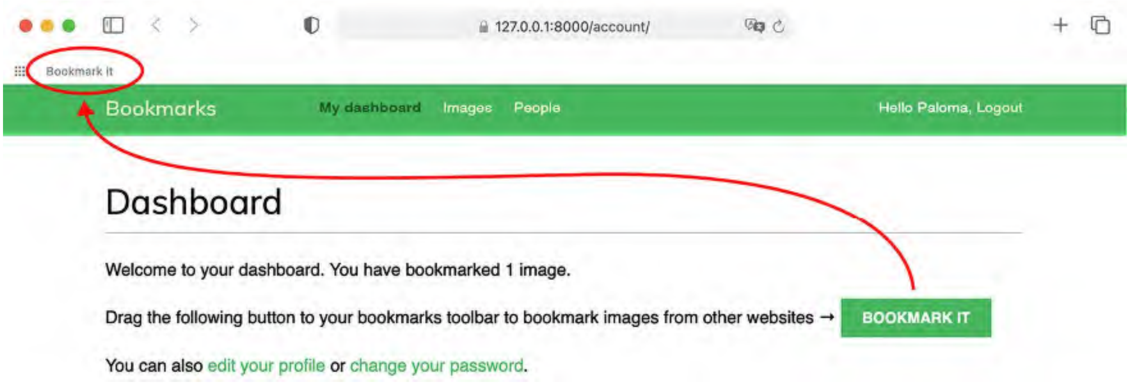

Figure 6.10: Adding the BOOKMARK IT button to the bookmarks bar

Open a website of your choice in your browser and click on the **Bookmark it** bookmarklet in the bookmarks bar. You will see that a new white overlay appears on the website, displaying all JPEG and PNG images found with dimensions higher than 250×250 pixels.

Figure 6.11 shows the bookmarklet running on `https://amazon.com/`:

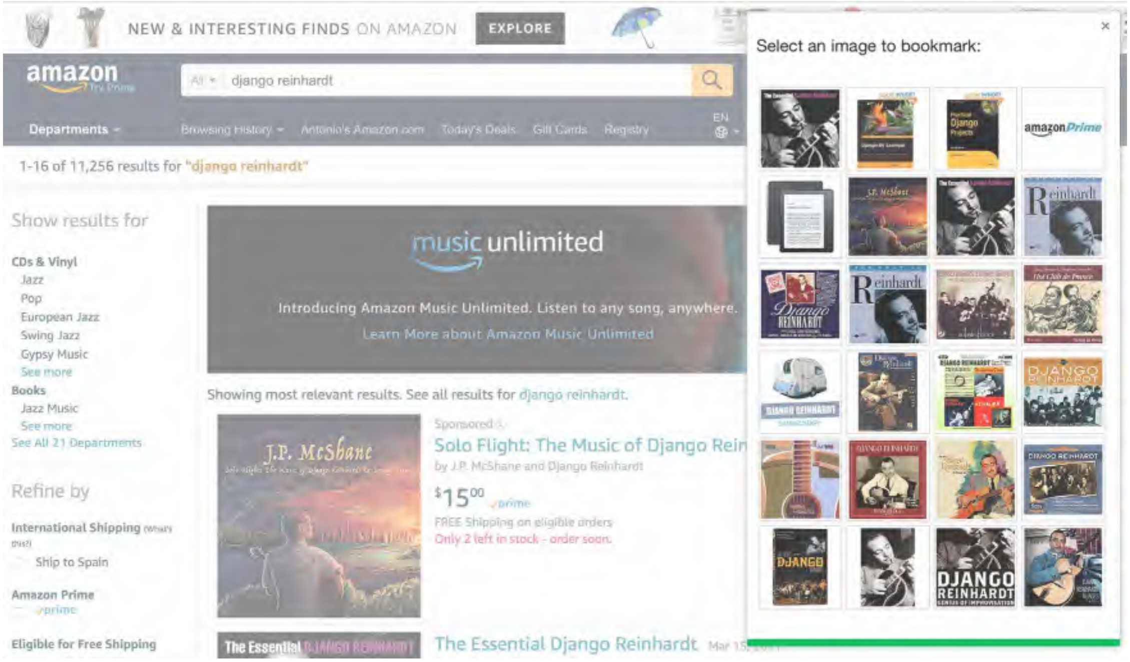

Figure 6.11: The bookmarklet loaded on amazon.com

If the HTML container doesn't appear, check the `RunServer` shell console log. If you see a MIME type error, it is most likely that your MIME map files are incorrect or need to be updated. You can apply the correct mapping for JavaScript and CSS files by adding the following lines to the `settings.py` file:

```
if DEBUG:
    import mimetypes
    mimetypes.add_type('application/javascript', '.js', True)
    mimetypes.add_type('text/css', '.css', True)
```

The HTML container includes the images that can be bookmarked. We will now implement the functionality for users to click on the desired image to bookmark it.

Edit the `js/bookmarklet.js` static file and add the following code at the bottom of the `bookmarklet()` function:

```
function bookmarkletLaunch() {
  bookmarklet = document.getElementById('bookmarklet');
  var imagesFound = bookmarklet.querySelector('.images');

  // clear images found
  imagesFound.innerHTML = '';
  // display bookmarklet
  bookmarklet.style.display = 'block';
```

```
    // close event
    bookmarklet.querySelector('#close')
               .addEventListener('click', function(){
                 bookmarklet.style.display = 'none'
               });

    // find images in the DOM with the minimum dimensions
    images = document.querySelectorAll('img[src$=".jpg"], img[src$=".jpeg"],
  img[src$=".png"]');
    images.forEach(image => {
      if(image.naturalWidth >= minWidth
         && image.naturalHeight >= minHeight)
      {
        var imageFound = document.createElement('img');
        imageFound.src = image.src;
        imagesFound.append(imageFound);
      }
    })

    // select image event
    imagesFound.querySelectorAll('img').forEach(image => {
      image.addEventListener('click', function(event){
        imageSelected = event.target;
        bookmarklet.style.display = 'none';
        window.open(siteUrl + 'images/create/?url='
                    + encodeURIComponent(imageSelected.src)
                    + '&title='
                    + encodeURIComponent(document.title),
                    '_blank');
      })
    })
  }

  // launch the bookmkarklet
  bookmarkletLaunch();
```

The preceding code works as follows:

1. A `click()` event is attached to each image element within the `imagesFound` container.
2. When the user clicks on any of the images, the image element clicked is stored in the variable `imageSelected`.
3. The bookmarklet is then hidden by setting its `display` property to none.

4. A new browser window is opened with the URL to bookmark a new image on the site. The content of the `<title>` element of the website is passed to the URL in the `title` `GET` parameter and the selected image URL is passed in the `url` parameter.

Open a new URL with your browser, for example, `https://commons.wikimedia.org/`, as follows:

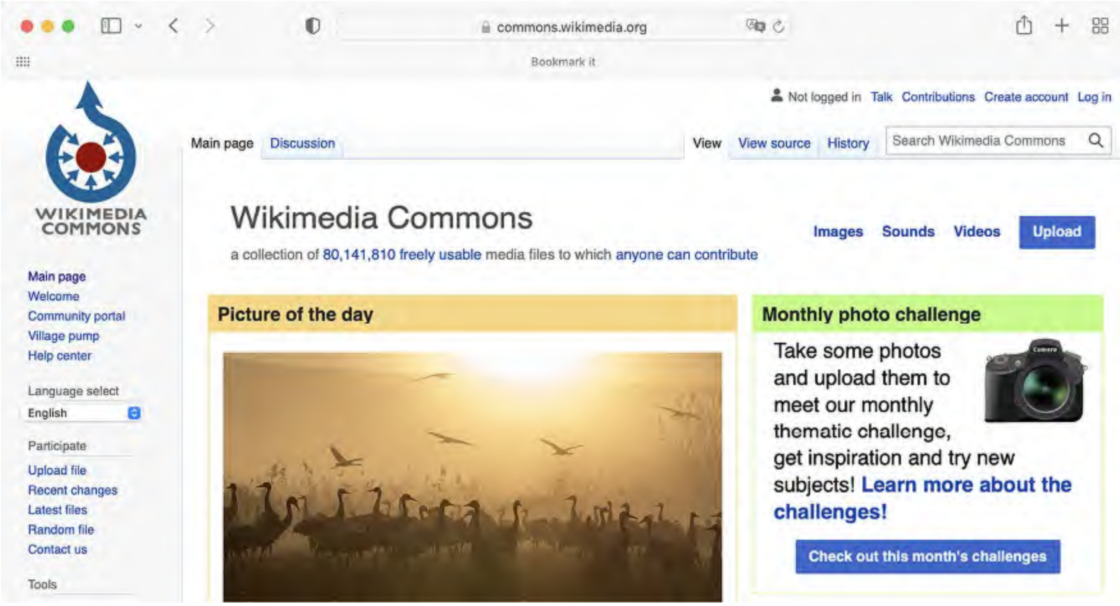

Figure 6.12: The Wikimedia Commons website

Figures 6.12 to *6.15* image: *A flock of cranes (Grus grus) in Hula Valley, Northern Israel* by Tomere (Licence: Creative Commons Attribution-Share Alike 4.0 International: `https://creativecommons.org/licenses/by-sa/4.0/deed.en`)

Click on the **Bookmark it** bookmarklet to display the image selection overlay. You will see the image selection overlay like this:

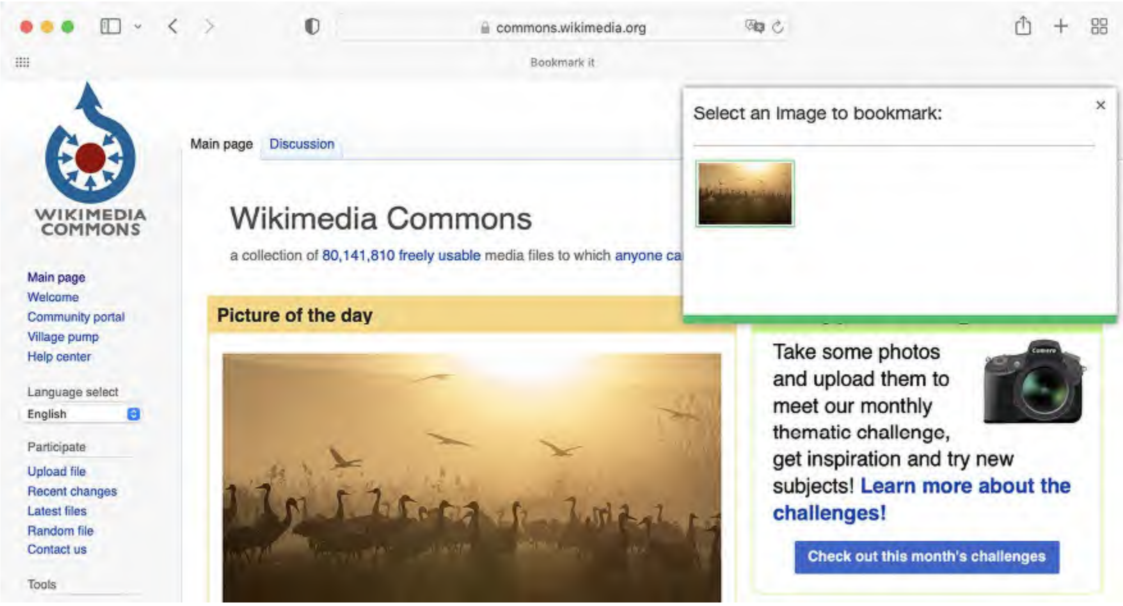

Figure 6.13: The bookmarklet loaded on an external website

If you click on an image, you will be redirected to the image creation page, passing the title of the website and the URL of the selected image as `GET` parameters. The page will look as follows:

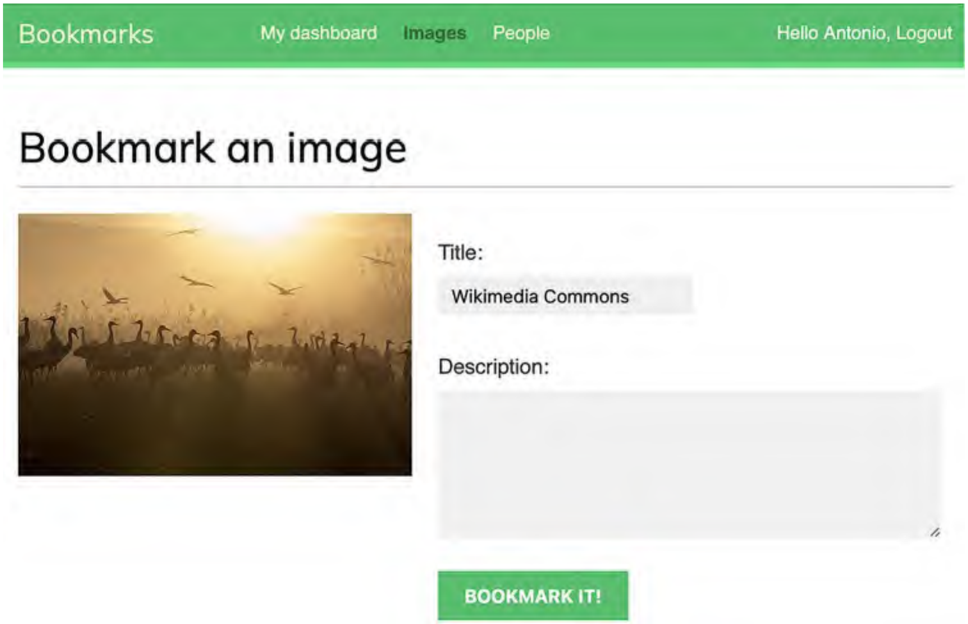

Figure 6.14: The form to bookmark an image

Congratulations! This is your first JavaScript bookmarklet, and it is fully integrated into your Django project. Next, we will create the detail view for images and implement the canonical URL for images.

Creating a detail view for images

Let's now create a simple detail view to display images that have been bookmarked on the site. Open the `views.py` file of the `images` application and add the following code to it:

```
from django.shortcuts import get_object_or_404
from .models import Image


def image_detail(request, id, slug):
    image = get_object_or_404(Image, id=id, slug=slug)
    return render(
        request,
        'images/image/detail.html',
        {'section': 'images', 'image': image}
    )
```

This is a simple view to display an image. Edit the `urls.py` file of the `images` application and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    path('create/', views.image_create, name='create'),
    path(
        'detail/<int:id>/<slug:slug>/',
        views.image_detail,
        name='detail'
    ),
]
```

Edit the `models.py` file of the `images` application and add the `get_absolute_url()` method to the `Image` model, as follows:

```
from django.urls import reverse


class Image(models.Model):
    # ...
    def get_absolute_url(self):
        return reverse('images:detail', args=[self.id, self.slug])
```

Remember that the common pattern for providing canonical URLs for objects is to define a `get_absolute_url()` method in the model.

Finally, create a template inside the `/templates/images/image/` template directory for the `images` application and name it `detail.html`. Add the following code to it:

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

{% block title %}{{ image.title }}{% endblock %}

{% block content %}
  <h1>{{ image.title }}</h1>
  <img src="{{ image.image.url }}" class="image-detail">
  {% with total_likes=image.users_like.count %}
    <div class="image-info">
      <div>
        <span class="count">
          {{ total_likes }} like{{ total_likes|pluralize }}
        </span>
      </div>
      {{ image.description|linebreaks }}
    </div>
    <div class="image-likes">
      {% for user in image.users_like.all %}
        <div>
          {% if user.profile.photo %}
            <img src="{{ user.profile.photo.url }}">
          {% endif %}
          <p>{{ user.first_name }}</p>
        </div>
      {% empty %}
        Nobody likes this image yet.
      {% endfor %}
    </div>
  {% endwith %}
{% endblock %}
```

This is the template for displaying the detail view of a bookmarked image. We have used the `{% with %}` tag to create the `total_likes` variable with the result of a QuerySet that counts all user likes. By doing so, we avoid evaluating the same QuerySet twice (first to display the total number of likes, then to use the `pluralize` template filter). We have also included the image description and we have added a `{% for %}` loop to iterate over `image.users_like.all` to display all the users who like this image.

Whenever you need to repeat a query in your template, use the `{% with %}` template tag to prevent additional database queries.

Now, open an external URL in your browser and use the bookmarklet to bookmark a new image. You will be redirected to the image detail page after you post the image. The page will include a success message, as follows:

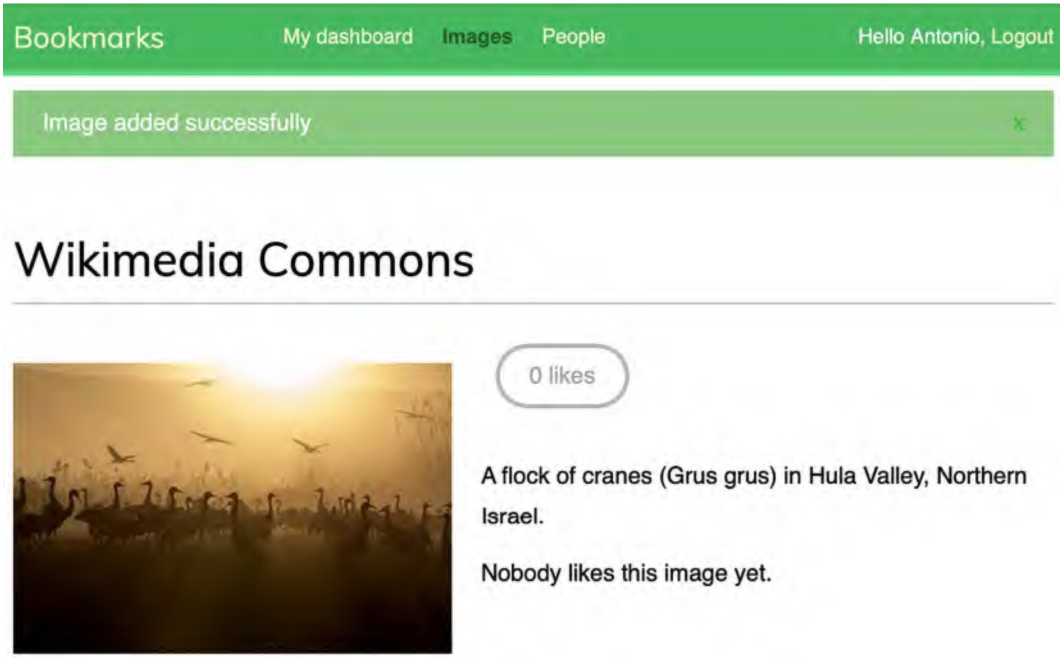

Figure 6.15: The image detail page for the image bookmark

Great! You completed the bookmarklet functionality. Next, you will learn how to create thumbnails for images.

Creating image thumbnails using easy-thumbnails

We are displaying the original image on the detail page, but the dimensions of different images may vary considerably. The file size of some images may be very large, and loading them might take too long. The best way to display optimized images in a uniform manner is to generate thumbnails. A thumbnail is a small image representation of a larger image. Thumbnails will load faster in the browser and are a great way to homogenize images of very different sizes. We will use a Django application called `easy-thumbnails` to generate thumbnails for the images bookmarked by users.

Open the terminal and install `easy-thumbnails` using the following command:

```
python -m pip install easy-thumbnails==2.8.5
```

Edit the `settings.py` file of the `bookmarks` project and add `easy_thumbnails` to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'easy_thumbnails',
]
```

Then, run the following command to sync the application with your database:

```
python manage.py migrate
```

You will see an output that includes the following lines:

```
Applying easy_thumbnails.0001_initial... OK
Applying easy_thumbnails.0002_thumbnaildimensions... OK
```

The `easy-thumbnails` application offers you different ways to define image thumbnails. The application provides a `{% thumbnail %}` template tag to generate thumbnails in templates and a custom `ImageField` if you want to define thumbnails in your models. Let's use the template tag approach.

Edit the `images/image/detail.html` template and consider the following line:

```
<img src="{{ image.image.url }}" class="image-detail">
```

The following lines should replace the preceding one:

```
{% load thumbnail %}
<a href="{{ image.image.url }}">
  <img src="{% thumbnail image.image 300x0 %}" class="image-detail">
</a>
```

We have defined a thumbnail with a fixed width of `300` pixels and a flexible height to maintain the aspect ratio by using the value `0`. The first time a user loads this page, a thumbnail image will be created. The thumbnail is stored in the same directory as the original file. The location is defined by the `MEDIA_ROOT` setting and the `upload_to` attribute of the `image` field of the `Image` model. The generated thumbnail will then be served in the following requests.

Run the development server with the following command from the shell prompt:

```
python manage.py runserver_plus --cert-file cert.crt
```

Access the image detail page for an existing image. The thumbnail will be generated and displayed on the site. Right-click on the image and open it in a new browser tab, as follows:

Figure 6.16: Opening the image in a new browser tab

Check the URL of the generated image in your browser. It should look as follows:

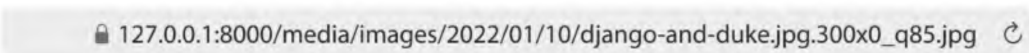

Figure 6.17: The URL of the generated image

The original filename is followed by additional details of the settings used to create the thumbnail. For a JPEG image, you will see a filename like `filename.jpg.300x0_q85.jpg`, where `300x0` indicates the size parameters used to generate the thumbnail, and `85` is the value for the default JPEG quality used by the library to generate the thumbnail.

You can use a different quality value using the `quality` parameter. To set the highest JPEG quality, you can use the value `100`, like this: `{% thumbnail image.image 300x0 quality=100 %}`. A higher quality will imply a larger file size.

The `easy-thumbnails` application offers several options to customize your thumbnails, including cropping algorithms and different effects that can be applied. If you run into any issues generating thumbnails, you can add `THUMBNAIL_DEBUG = True` to the `settings.py` file to obtain the debug information. You can read the full documentation of `easy-thumbnails` at `https://easy-thumbnails.readthedocs.io/`.

Adding asynchronous actions with JavaScript

We are going to add a **like** button to the image detail page to let users click on it to like an image. When users click the *like* button, we will send an HTTP request to the web server using JavaScript. This will perform the *like* action without reloading the whole page. For this functionality, we will implement a view that allows users to like/unlike images.

The JavaScript **Fetch API** is the built-in way to make asynchronous HTTP requests to web servers from web browsers. By using the Fetch API, you can send and retrieve data from the web server without the need for a whole page refresh. The Fetch API was launched as a modern successor to the `XMLHttpRequest` (XHR) object that is built into the browser, used to make HTTP requests without reloading the page. The set of web development techniques to send and retrieve data from a web server asynchronously without reloading the page is also known as **AJAX**, which stands for **Asynchronous JavaScript and XML**. AJAX is a misleading name because AJAX requests can exchange data not only in XML format but also in formats such as JSON, HTML, and plain text. You might find references to the Fetch API and AJAX indistinctively on the internet.

You can find information about the Fetch API at `https://developer.mozilla.org/en-US/docs/Web/API/Fetch_API/Using_Fetch`.

We will start by implementing the view to perform the *like* and *unlike* actions, and then we will add the JavaScript code to the related template to perform asynchronous HTTP requests.

Edit the `views.py` file of the `images` application and add the following code to it:

```
from django.http import JsonResponse
from django.views.decorators.http import require_POST


@login_required
@require_POST
def image_like(request):
    image_id = request.POST.get('id')
    action = request.POST.get('action')
    if image_id and action:
        try:
```

```
            image = Image.objects.get(id=image_id)
            if action == 'like':
                image.users_like.add(request.user)
            else:
                image.users_like.remove(request.user)
            return JsonResponse({'status': 'ok'})
        except Image.DoesNotExist:
            pass
    return JsonResponse({'status': 'error'})
```

We have used two decorators for the new view. The `login_required` decorator prevents users who are not logged in from accessing this view. The `require_POST` decorator returns an `HttpResponseNotAllowed` object (status code `405`) if the HTTP request is not done via `POST`. This way, you only allow `POST` requests for this view.

Django also provides a `require_GET` decorator to only allow `GET` requests and a `require_http_methods` decorator to which you can pass a list of allowed methods as an argument.

This view expects the following `POST` parameters:

- `image_id`: The ID of the `Image` object on which the user is performing the action
- `action`: The action that the user wants to perform, which should be a string with the value `like` or `unlike`

We have used the manager provided by Django for the `users_like` many-to-many field of the `Image` model in order to add or remove objects from the relationship using the `add()` or `remove()` methods. If the `add()` method is called passing an object that is already present in the related object set, it will not be duplicated. If the `remove()` method is called with an object that is not in the related object set, nothing will happen. Another useful method of many-to-many managers is `clear()`, which removes all objects from the related object set.

To generate the view response, we have used the `JsonResponse` class provided by Django, which returns an HTTP response with an `application/json` content type, converting the given object into a JSON output.

Edit the `urls.py` file of the `images` application and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    path('create/', views.image_create, name='create'),
    path(
        'detail/<int:id>/<slug:slug>/',
        views.image_detail,
        name='detail'
    ),
    path('like/', views.image_like, name='like'),
]
```

Loading JavaScript on the DOM

We need to add JavaScript code to the image detail template. To use JavaScript in our templates, we will add a base wrapper in the `base.html` template of the project first.

Edit the `base.html` template of the `account` application and include the following code highlighted in bold before the closing `</body>` HTML tag:

```
<!DOCTYPE html>
<html>
<head>
 ...
</head>
<body>
  ...
  <script>
    document.addEventListener('DOMContentLoaded', (event) => {
      // DOM loaded
      {% block domready %}
      {% endblock %}
    })
  </script>
</body>
</html>
```

We have added a `<script>` tag to include JavaScript code. The `document.addEventListener()` method is used to define a function that will be called when the given event is triggered. We pass the event name `DOMContentLoaded`, which fires when the initial HTML document has been completely loaded and the DOM hierarchy has been fully constructed. By using this event, we make sure the DOM is fully constructed before we interact with any HTML elements and we manipulate the DOM. The code within the function will only be executed once the DOM is ready.

Inside the document-ready handler, we have included a Django template block called `domready`. Any template that extends the `base.html` template can use this block to include specific JavaScript code to execute when the DOM is ready.

Don't get confused by the JavaScript code and Django template tags. The Django template language is rendered on the server side to generate the HTML document, and JavaScript is executed in the browser on the client side. In some cases, it is useful to generate JavaScript code dynamically using Django in order to use the results of QuerySets or server-side calculations to define variables in JavaScript.

The examples in this chapter include JavaScript code in Django templates. The preferred method to add JavaScript code to your templates is by loading `.js` files, which are served as static files, especially if you are using large scripts.

Cross-site request forgery for HTTP requests in JavaScript

You learned about **cross-site request forgery** (**CSRF**) in *Chapter 2*, *Enhancing Your Blog with Advanced Features*. With CSRF protection active, Django looks for a CSRF token in all `POST` requests. When you submit forms, you can use the `{% csrf_token %}` template tag to send the token along with the form. HTTP requests made in JavaScript have to pass the CSRF token as well in every `POST` request.

Django allows you to set a custom `X-CSRFToken` header in your HTTP requests with the value of the CSRF token.

To include the token in HTTP requests that originate from JavaScript, we will need to retrieve the CSRF token from the `csrftoken` cookie, which is set by Django if the CSRF protection is active. To handle cookies, we will use JavaScript Cookie. JavaScript Cookie is a lightweight JavaScript API for handling cookies. You can learn more about it at `https://github.com/js-cookie/js-cookie`.

Edit the `base.html` template of the `account` application and add the following code highlighted in bold at the bottom of the `<body>` element like this:

```
<!DOCTYPE html>
<html>
<head>
 ...
</head>
<body>
  ...
  <script src="//cdn.jsdelivr.net/npm/js-cookie@3.0.5/dist/js.cookie.min.js"></
script>
  <script>
    const csrftoken = Cookies.get('csrftoken');
    document.addEventListener('DOMContentLoaded', (event) => {
      // DOM loaded
      {% block domready %}
      {% endblock %}
    })
  </script>
</body>
</html>
```

We have implemented the following functionality:

1. The JavaScript Cookie plugin is loaded from a public **Content Delivery Network** (**CDN**).
2. The value of the `csrftoken` cookie is retrieved with `Cookies.get()` and stored in the JavaScript constant `csrftoken`.

We have to include the CSRF token in all JavaScript fetch requests that use unsafe HTTP methods, such as `POST` or `PUT`. We will later include the `csrftoken` constant in a custom HTTP header named `X-CSRFToken` when sending HTTP `POST` requests.

You can find more information about Django's CSRF protection and AJAX at `https://docs.djangoproject.com/en/5.0/ref/csrf/#ajax`.

Next, we will implement the HTML and JavaScript code for users to like/unlike images.

Performing HTTP requests with JavaScript

Edit the `images/image/detail.html` template and add the following code highlighted in bold:

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

{% block title %}{{ image.title }}{% endblock %}

{% block content %}
  <h1>{{ image.title }}</h1>
  {% load thumbnail %}
  <a href="{{ image.image.url }}">
    <img src="{% thumbnail image.image 300x0 %}" class="image-detail">
  </a>
  {% with total_likes=image.users_like.count users_like=image.users_like.all %}
    <div class="image-info">
      <div>
        <span class="count">
        <span class="total">{{ total_likes }}</span>
        like{{ total_likes|pluralize }}
        </span>
        <a href="#" data-id="{{ image.id }}" data-action="{% if request.user in
users_like %}un{% endif %}like"
    class="like button">
          {% if request.user not in users_like %}
            Like
          {% else %}
            Unlike
          {% endif %}
        </a>
      </div>
      {{ image.description|linebreaks }}
    </div>
    <div class="image-likes">
```

```
      {% for user in users_like %}
        <div>
          {% if user.profile.photo %}
            <img src="{{ user.profile.photo.url }}">
          {% endif %}
          <p>{{ user.first_name }}</p>
        </div>
      {% empty %}
        Nobody likes this image yet.
      {% endfor %}
    </div>
  {% endwith %}
{% endblock %}
```

In the preceding code, we have added another variable to the `{% with %}` template tag to store the results of the `image.users_like.all` query and prevent the query from being executed against the database multiple times. This variable is used to check whether the current user is in this list with `{% if request.user in users_like %}` and then with `{% if request.user not in users_like %}`. The same variable is then used to iterate over the users that like this image with `{% for user in users_like %}`.

We have added to this page the total number of users who like the image and have included a link for the user to like/unlike the image. The related object set, `users_like`, is used to check whether `request.user` is contained in the related object set, to display the text **Like** or **Unlike** based on the current relationship between the user and this image. We have added the following attributes to the `<a>` HTML link element:

- `data-id`: The ID of the image displayed.
- `data-action`: The action to perform when the user clicks on the link. This can be either `like` or `unlike`.

Any attribute on any HTML element with a name that starts with `data-` is a data attribute. Data attributes are used to store custom data for your application.

We will send the value of the `data-id` and `data-action` attributes in the HTTP request to the `image_like` view. When a user clicks on the **like/unlike** link, we will need to perform the following actions in the browser:

1. Send an HTTP `POST` request to the `image_like` view, passing the image `id` and the `action` parameters to it.
2. If the HTTP request is successful, update the `data-action` attribute of the `<a>` HTML element with the opposite action (`like` / `unlike`), and modify its display text accordingly.
3. Update the total number of likes displayed on the page.

Add the following `domready` block at the bottom of the `images/image/detail.html` template:

```
{% block domready %}
```

```
  const url = '{% url "images:like" %}';
  var options = {
    method: 'POST',
    headers: {'X-CSRFToken': csrftoken},
    mode: 'same-origin'
  }
  document.querySelector('a.like')
          .addEventListener('click', function(e){
    e.preventDefault();
    var likeButton = this;
  });
{% endblock %}
```

The preceding code works as follows:

1. The `{% url %}` template tag is used to build the `images:like` URL. The generated URL is stored in the `url` JavaScript constant.
2. An `options` object is created with the options that will be passed to the HTTP request with the Fetch API. These are:
   - `method`: The HTTP method to use. In this case, it's `POST`.
   - `headers`: Additional HTTP headers to include in the request. We include the `X-CSRFToken` header with the value of the `csrftoken` constant that we defined in the `base.html` template.
   - `mode`: The mode of the HTTP request. We use `same-origin` to indicate the request is made to the same origin. You can find more information about modes at `https://developer.mozilla.org/en-US/docs/Web/API/Request/mode`.
3. The `a.like` selector is used to find all `<a>` elements of the HTML document with the `like` class using `document.querySelector()`.
4. An event listener is defined for the `click` event on the elements targeted with the selector. This function is executed every time the user clicks on the **like/unlike** link.
5. Inside the handler function, `e.preventDefault()` is used to avoid the default behavior of the `<a>` element. This will prevent the default behavior of the link element, stopping the event propagation, and preventing the link from following the URL.
6. A `likeButton` variable is used to store the reference to `this`, the element on which the event was triggered.

Now we need to send the HTTP request using the Fetch API. Edit the `domready` block of the `images/image/detail.html` template and add the following code highlighted in bold:

```
{% block domready %}
  const url = '{% url "images:like" %}';
  var options = {
    method: 'POST',
```

```
    headers: {'X-CSRFToken': csrftoken},
    mode: 'same-origin'
  }

  document.querySelector('a.like')
          .addEventListener('click', function(e){
    e.preventDefault();
    var likeButton = this;

    // add request body
    var formData = new FormData();
    formData.append('id', likeButton.dataset.id);
    formData.append('action', likeButton.dataset.action);
    options['body'] = formData;

    // send HTTP request
    fetch(url, options)
    .then(response => response.json())
    .then(data => {
      if (data['status'] === 'ok')
      {
      }
    })
  });
{% endblock %}
```

The new code works as follows:

1. A `FormData` object is created to construct a set of key/value pairs representing form fields and their values. The object is stored in the `formData` variable.
2. The `id` and `action` parameters expected by the `image_like` Django view are added to the `formData` object. The values for these parameters are retrieved from the `likeButton` element clicked. The `data-id` and `data-action` attributes are accessed with `dataset.id` and `dataset.action`.
3. A new `body` key is added to the `options` object that will be used for the HTTP request. The value for this key is the `formData` object.
4. The Fetch API is used by calling the `fetch()` function. The `url` variable defined previously is passed as the URL for the request, and the `options` object is passed as the options for the request.
5. The `fetch()` function returns a promise that resolves with a `Response` object, which is a representation of the HTTP response. The `.then()` method is used to define a handler for the promise. To extract the JSON body content, we use `response.json()`. You can learn more about the `Response` object at `https://developer.mozilla.org/en-US/docs/Web/API/Response`.

6. The `.then()` method is used again to define a handler for the data extracted to JSON. In this handler, the `status` attribute of the data received is used to check whether its value is `ok`.

You added the functionality to send the HTTP request and handle the response. After a successful request, you need to change the button and its related action to the opposite: from *like* to *unlike*, or from *unlike* to *like*. By doing so, users are able to undo their action.

Edit the `domready` block of the `images/image/detail.html` template and add the following code highlighted in bold:

```
{% block domready %}
  var url = '{% url "images:like" %}';
  var options = {
    method: 'POST',
    headers: {'X-CSRFToken': csrftoken},
    mode: 'same-origin'
  }

  document.querySelector('a.like')
          .addEventListener('click', function(e){
    e.preventDefault();
    var likeButton = this;

    // add request body
    var formData = new FormData();
    formData.append('id', likeButton.dataset.id);
    formData.append('action', likeButton.dataset.action);
    options['body'] = formData;

    // send HTTP request
    fetch(url, options)
    .then(response => response.json())
    .then(data => {
      if (data['status'] === 'ok')
      {
        var previousAction = likeButton.dataset.action;

        // toggle button text and data-action
        var action = previousAction === 'like' ? 'unlike' : 'like';
        likeButton.dataset.action = action;
        likeButton.innerHTML = action;

        // update like count
```

```
        var likeCount = document.querySelector('span.count .total');
        var totalLikes = parseInt(likeCount.innerHTML);
        likeCount.innerHTML = previousAction === 'like' ? totalLikes + 1 :
totalLikes - 1;
      }
    })
  });
{% endblock %}
```

The preceding code works as follows:

1. The previous action of the button is retrieved from the `data-action` attribute of the link and it is stored in the `previousAction` variable.
2. The `data-action` attribute of the link and the link text are toggled. This allows users to undo their actions.
3. The total like count is retrieved from the DOM by using the selector `span.count.total` and the value is parsed to an integer with `parseInt()`. The total like count is increased or decreased according to the action performed (*like* or *unlike*).

Open the image detail page in your browser for an image that you have uploaded. You should be able to see the following initial likes count and the **LIKE** button, as follows:

Figure 6.18: The likes count and LIKE button in the image detail template

Click on the **LIKE** button. You will note that the total likes count increases by one and the button text changes to **UNLIKE**, as follows:

Figure 6.19: The likes count and button after clicking the LIKE button

If you click on the **UNLIKE** button, the action is performed, and then the button's text changes back to **LIKE** and the total count changes accordingly.

When programming JavaScript, especially when performing AJAX requests, it is recommended to use a tool for debugging JavaScript and HTTP requests. Most modern browsers include developer tools to debug JavaScript. Usually, you can right-click anywhere on the website to open the contextual menu and click on **Inspect** or **Inspect Element** to access the web developer tools of your browser.

In the next section, you will learn how to use asynchronous HTTP requests with JavaScript and Django to implement infinite scroll pagination.

Adding infinite scroll pagination to the image list

Next, we need to list all bookmarked images on the website. We will use JavaScript requests to build an infinite scroll functionality. Infinite scroll is achieved by loading the next results automatically when the user scrolls to the bottom of the page.

Let's implement an image list view that will handle both standard browser requests and requests originating from JavaScript. When the user initially loads the image list page, we will display the first page of images. When they scroll to the bottom of the page, we will retrieve the following page of items with JavaScript and append it to the bottom of the main page.

The same view will handle both standard and AJAX infinite scroll pagination. Edit the `views.py` file of the `images` application and add the following code highlighted in bold:

```
from django.core.paginator import EmptyPage, PageNotAnInteger, Paginator
from django.http import HttpResponse

# ...

@login_required
def image_list(request):
    images = Image.objects.all()
    paginator = Paginator(images, 8)
    page = request.GET.get('page')
    images_only = request.GET.get('images_only')
    try:
        images = paginator.page(page)
    except PageNotAnInteger:
        # If page is not an integer deliver the first page
        images = paginator.page(1)
    except EmptyPage:
        if images_only:
            # If AJAX request and page out of range
            # return an empty page
            return HttpResponse('')
        # If page out of range return last page of results
        images = paginator.page(paginator.num_pages)
    if images_only:
        return render(
            request,
            'images/image/list_images.html',
            {'section': 'images', 'images': images}
        )
```

```
    return render(
            request,
            'images/image/list.html',
            {'section': 'images', 'images': images}
    )
```

In this view, a QuerySet is created to retrieve all images from the database. Then, a `Paginator` object is created to paginate over the results, retrieving eight images per page. The `page` HTTP `GET` parameter is retrieved to get the requested page number. The `images_only` HTTP `GET` parameter is retrieved to know if the whole page has to be rendered or only the new images.

We will render the whole page when it is requested by the browser. However, we will only render the HTML with new images for Fetch API requests, since we will be appending them to the existing HTML page.

An `EmptyPage` exception will be triggered if the requested page is out of range. If this is the case and only images have to be rendered, an empty `HttpResponse` will be returned. This will allow you to stop the AJAX pagination on the client side when reaching the last page. The results are rendered using two different templates:

- For JavaScript HTTP requests, which will include the `images_only` parameter, the `list_images.html` template will be rendered. This template will only contain the images of the requested page.
- For browser requests, the `list.html` template will be rendered. This template will extend the `base.html` template to display the whole page and will include the `list_images.html` template to include the list of images.

Edit the `urls.py` file of the `images` application and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    path('create/', views.image_create, name='create'),
    path(
        'detail/<int:id>/<slug:slug>/',
        views.image_detail,
        name='detail'
    ),
    path('like/', views.image_like, name='like'),
    path('', views.image_list, name='list'),
]
```

Finally, you need to create the templates mentioned here. Inside the `images/image/` template directory, create a new template and name it `list_images.html`. Add the following code to it:

```
{% load thumbnail %}
{% for image in images %}
  <div class="image">
    <a href="{{ image.get_absolute_url }}">
```

```
      {% thumbnail image.image 300x300 crop="smart" as im %}
      <a href="{{ image.get_absolute_url }}">
        <img src="{{ im.url }}">
      </a>
    </a>
    <div class="info">
      <a href="{{ image.get_absolute_url }}" class="title">
        {{ image.title }}
      </a>
    </div>
  </div>
{% endfor %}
```

The preceding template displays the list of images. You will use it to return results for AJAX requests. In this code, you iterate over images and generate a square thumbnail for each image. You normalize the size of the thumbnails to `300x300` pixels. You also use the `smart` cropping option. This option indicates that the image has to be incrementally cropped down to the requested size by removing slices from the edges with the least entropy.

Create another template in the same directory and name it `images/image/list.html`. Add the following code to it:

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

{% block title %}Images bookmarked{% endblock %}

{% block content %}
  <h1>Images bookmarked</h1>
  <div id="image-list">
    {% include "images/image/list_images.html" %}
  </div>
{% endblock %}
```

The list template extends the `base.html` template. To avoid repeating code, you include the `images/image/list_images.html` template for displaying images. The `images/image/list.html` template will hold the JavaScript code for loading additional pages when scrolling to the bottom of the page.

Edit the `images/image/list.html` template and add the following code highlighted in bold:

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

{% block title %}Images bookmarked{% endblock %}

{% block content %}
  <h1>Images bookmarked</h1>
```

```
  <div id="image-list">
    {% include "images/image/list_images.html" %}
  </div>
{% endblock %}

{% block domready %}
  var page = 1;
  var emptyPage = false;
  var blockRequest = false;

window.addEventListener('scroll', function(e) {
    var margin = document.body.clientHeight - window.innerHeight - 200;
    if(window.pageYOffset > margin && !emptyPage && !blockRequest) {
      blockRequest = true;
      page += 1;
      fetch('?images_only=1&page=' + page)
      .then(response => response.text())
      .then(html => {
        if (html === '') {
          emptyPage = true;
        }
        else {
          var imageList = document.getElementById('image-list');
          imageList.insertAdjacentHTML('beforeEnd', html);
          blockRequest = false;
        }
      })
    }
  });

  // Launch scroll event
  const scrollEvent = new Event('scroll');
  window.dispatchEvent(scrollEvent);
{% endblock %}
```

The preceding code provides the infinite scroll functionality. You include the JavaScript code in the `domready` block that you defined in the `base.html` template. The code is as follows:

1. You define the following variables:

- `page`: Stores the current page number.
- `empty_page`: Allows you to know whether the user is on the last page and retrieves an empty page. As soon as you get an empty page, you will stop sending additional HTTP requests because you will assume that there are no more results.
- `block_request`: Prevents you from sending additional requests while an HTTP request is in progress.

2. You use `window.addEventListener()` to capture the `scroll` event and to define a handler function for it.
3. You calculate the `margin` variable to get the difference between the total document height and the window inner height, because that's the height of the remaining content for the user to scroll. You subtract a value of `200` from the result so that you load the next page when the user is closer than 200 pixels to the bottom of the page.
4. Before sending an HTTP request, you check that:
    - The `window.pageYOffset` is higher than the calculated margin.
    - The user didn't get to the last page of results (`emptyPage` has to be `false`).
    - There is no other ongoing HTTP request (`blockRequest` has to be `false`).
5. If the previous conditions are met, you set `blockRequest` to `true` to prevent the `scroll` event from triggering additional HTTP requests, and you increase the `page` counter by `1` to retrieve the next page.
6. You use `fetch()` to send an HTTP `GET` request, setting the URL parameters `image_only=1` to retrieve only the HTML for images instead of the whole HTML page, and `page` for the requested page number.
7. The body content is extracted from the HTTP response with `response.text()` and the HTML returned is treated accordingly:
    - **If the response has no content**: You get to the end of the results and there are no more pages to load. You set `emptyPage` to `true` to prevent additional HTTP requests.
    - **If the response contains data**: You append the data to the HTML element with the `image-list` ID. The page content expands vertically, appending results when the user approaches the bottom of the page. You remove the lock for additional HTTP requests by setting `blockRequest` to `false`.
8. Below the event listener, you simulate an initial `scroll` event when the page is loaded. You create the event by creating a new `Event` object, and then you launch it with `window.dispatchEvent()`. By doing this, you ensure that the event is triggered if the initial content fits the window and has no scroll.

Open `https://127.0.0.1:8000/images/` in your browser. You will see the list of images that you have bookmarked so far. It should look similar to this:

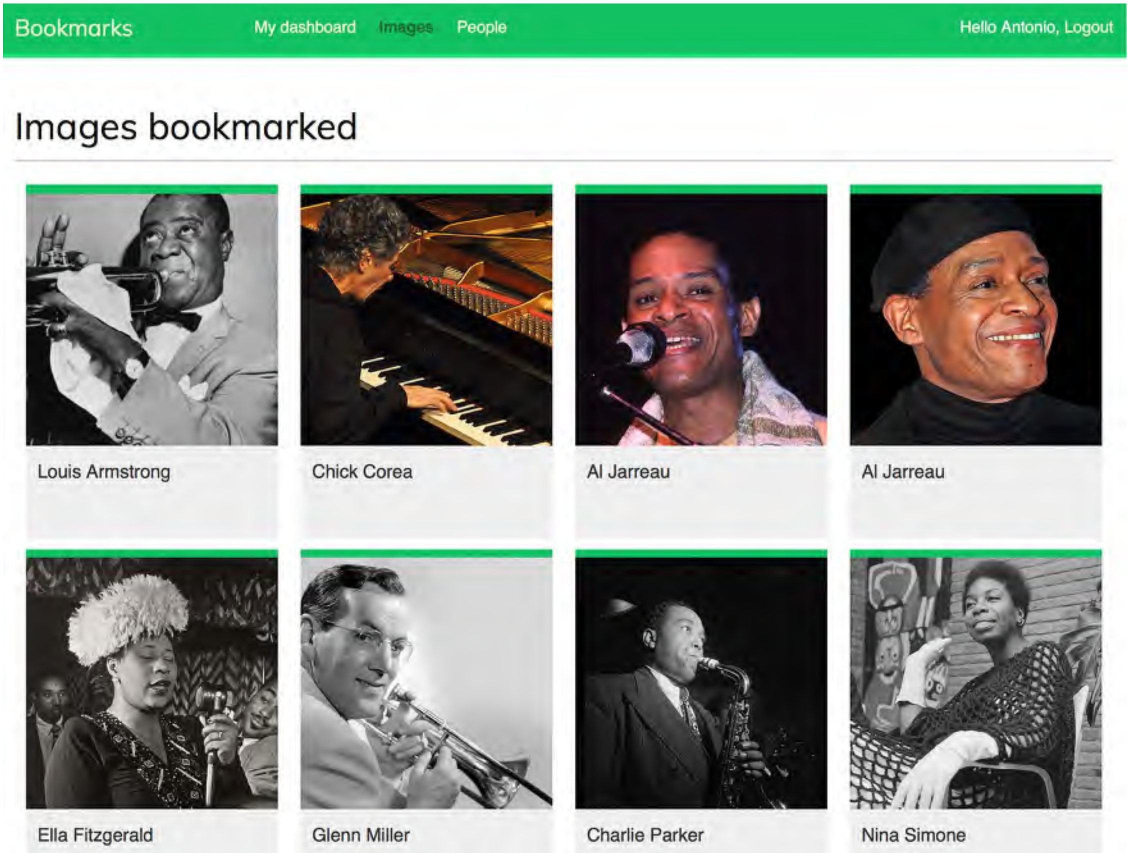

Figure 6.20: The image list page with infinite scroll pagination

Figure 6.19 image attributions:

- *Chick Corea* by ataelw (license: Creative Commons Attribution 2.0 Generic: `https://creativecommons.org/licenses/by/2.0/`)
- *Al Jarreau - Düsseldorf 1981* by Eddi Laumanns aka RX-Guru (license: Creative Commons Attribution 3.0 Unported: `https://creativecommons.org/licenses/by/3.0/`)
- *Al Jarreau* by Kingkongphoto and www.celebrity-photos.com (license: Creative Commons Attribution-ShareAlike 2.0 Generic: `https://creativecommons.org/licenses/by-sa/2.0/`)

Scroll to the bottom of the page to load additional pages. Ensure that you have bookmarked more than eight images using the bookmarklet, because that's the number of images you are displaying per page.

You can use your browser developer tools to track the AJAX requests. Usually, you can right-click anywhere on the website to open the contextual menu and click on **Inspect** or **Inspect Element** to access the web developer tools of your browser. Look for the panel for network requests.

Reload the page and scroll to the bottom of the page to load new pages. You will see the request for the first page and the AJAX requests for additional pages, like in *Figure 6.21*:

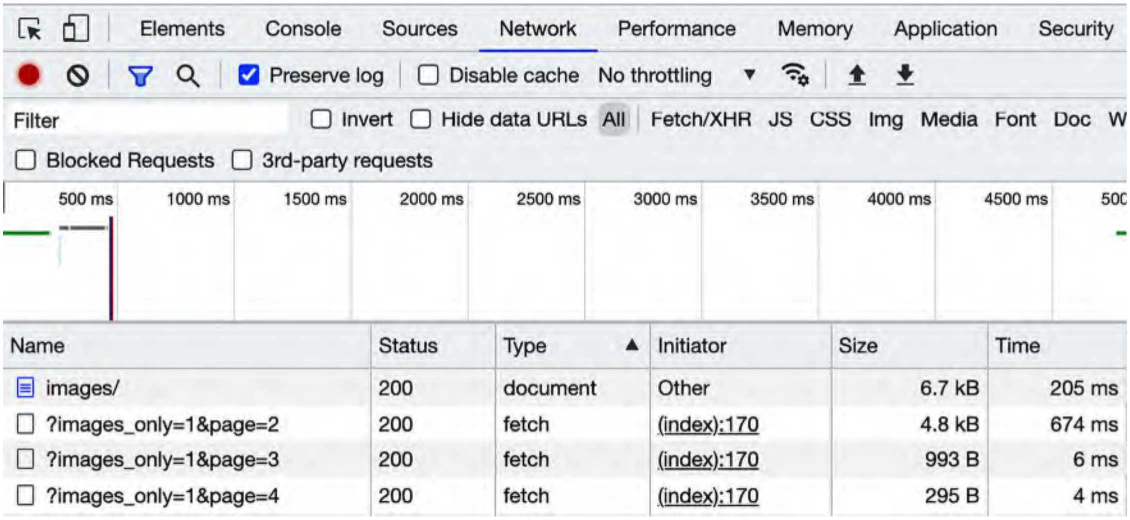

Figure 6.21: HTTP requests registered in the developer tools of the browser

In the shell where you are running Django, you will see the requests as well, like this:

```
[04/Jan/2024 08:14:20] "GET /images/ HTTP/1.1" 200
[04/Jan/2024 08:14:25] "GET /images/?images_only=1&page=2 HTTP/1.1" 200
[04/Jan/2024 08:14:26] "GET /images/?images_only=1&page=3 HTTP/1.1" 200
[04/Jan/2024 08:14:26] "GET /images/?images_only=1&page=4 HTTP/1.1" 200
```

Finally, edit the `base.html` template of the `account` application and add the URL for the `images` item highlighted in bold:

```
<ul class="menu">
  ...
  <li {% if section == "images" %}class="selected"{% endif %}>
    <a href="{% url "images:list" %}">Images</a>
  </li>
  ...
</ul>
```

Now you can access the image list from the main menu.

Summary

In this chapter, you created models with many-to-many relationships and learned how to customize the behavior of forms. You built a JavaScript bookmarklet to share images from other websites on your site. This chapter has also covered the creation of image thumbnails using the `easy-thumbnails` application.

Finally, you implemented AJAX views using the JavaScript Fetch API and added infinite scroll pagination to the image list view.

In the next chapter, you will learn how to build a follow system and an activity stream. You will work with generic relations, signals, and denormalization. You will also learn how to use Redis with Django to count image views and generate an image ranking.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter06`
- Database indexes: `https://docs.djangoproject.com/en/5.0/ref/models/options/#django.db.models.Options.indexes`
- Many-to-many relationships: `https://docs.djangoproject.com/en/5.0/topics/db/examples/many_to_many/`
- Requests HTTP library for Python: `https://docs.djangoproject.com/en/5.0/topics/db/examples/many_to_many/`
- Pinterest Save extension: `https://help.pinterest.com/en/article/save-pins-with-the-pinterest-browser-button`
- Static content for the account application: `https://github.com/PacktPublishing/Django-5-by-Example/tree/main/Chapter06/bookmarks/images/static`
- CSS selectors: `https://developer.mozilla.org/en-US/docs/Web/CSS/CSS_Selectors`
- Locating DOM elements using CSS selectors: `https://developer.mozilla.org/en-US/docs/Web/API/Document_object_model/Locating_DOM_elements_using_selectors`
- Let's Encrypt free automated certificate authority: `https://letsencrypt.org`
- Django `easy-thumbnails` app: `https://easy-thumbnails.readthedocs.io/`
- JavaScript Fetch API usage: `https://developer.mozilla.org/en-US/docs/Web/API/Fetch_API/Using_Fetch`
- JavaScript Cookie library: `https://github.com/js-cookie/js-cookie`
- Django's CSRF protection and AJAX: `https://docs.djangoproject.com/en/5.0/ref/csrf/#ajax`
- JavaScript Fetch API Request mode: `https://developer.mozilla.org/en-US/docs/Web/API/Request/mode`
- JavaScript Fetch API Response: `https://developer.mozilla.org/en-US/docs/Web/API/Response`

7

Tracking User Actions

In the previous chapter, you built a JavaScript bookmarklet to share content from other websites on your platform. You also implemented asynchronous actions with JavaScript in your project and created an infinite scroll.

In this chapter, you will learn how to build a follow system and create a user activity stream. You will also discover how Django signals work and you will integrate Redis's fast I/O storage into your project to store item views.

This chapter will cover the following points:

- Building a follow system
- Creating many-to-many relationships with an intermediate model
- Creating an activity stream application
- Adding generic relations to models
- Optimizing QuerySets for related objects
- Using signals for denormalizing counts
- Using Django Debug Toolbar to obtain relevant debug information
- Counting image views with Redis
- Creating a ranking of the most viewed images with Redis

Functional overview

Figure 7.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

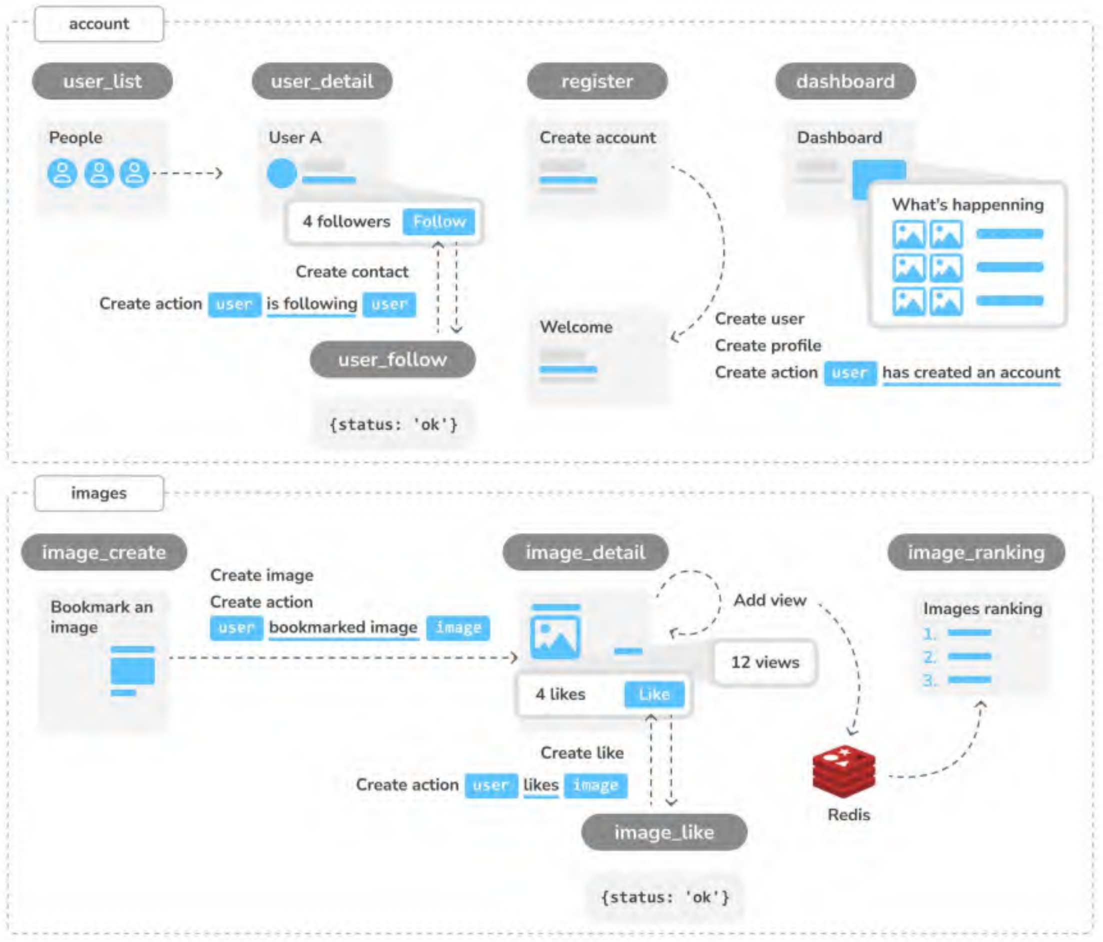

Figure 7.1: Diagram of functionalities built in Chapter 7

In this chapter, you will build the `user_list` view to list all users and the `user_detail` view to display a single user profile. You will implement a follow system with JavaScript, using the `user_follow` view to store user follows. You will create a system to store user actions, and you will implement the actions for creating an account, following a user, creating an image, and liking an image. You will use this system to display an activity stream in the `dashboard` view with the latest actions. You will also use Redis to store a *view* every time the `image_detail` view is loaded and create the view `image_ranking` to display a ranking of the most viewed images.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter07`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all requirements at once with the command `python -m pip install -r requirements.txt`.

Building a follow system

Let's build a follow system in your project. This means that your users will be able to follow each other and track what other users share on the platform. The relationship between users is a *many-to-many* relationship; this means that a user can follow multiple users and they, in turn, can be followed by multiple users.

Creating many-to-many relationships with an intermediate model

In previous chapters, you created many-to-many relationships by adding the `ManyToManyField` to one of the related models and letting Django create the database table for the relationship. This is suitable for most cases, but sometimes you may need to create an intermediate model for the relationship. Creating an intermediate model is necessary when you want to store additional information on the relationship, for example, the date when the relationship was created, or a field that describes the nature of the relationship.

Let's create an intermediate model to build relationships between users. There are two reasons for using an intermediate model:

- You are using the `User` model provided by Django and you want to avoid altering it
- You want to store the time when the relationship was created

Edit the `models.py` file of the `account` application and add the following code to it:

```
class Contact(models.Model):
    user_from = models.ForeignKey(
        settings.AUTH_USER_MODEL,
        related_name='rel_from_set',
        on_delete=models.CASCADE
    )
    user_to = models.ForeignKey(
        settings.AUTH_USER_MODEL,
        related_name='rel_to_set',
        on_delete=models.CASCADE
    )
    created = models.DateTimeField(auto_now_add=True)

    class Meta:
        indexes = [
            models.Index(fields=['-created']),
        ]
```

```
        ordering = ['-created']

    def __str__(self):
        return f'{self.user_from} follows {self.user_to}'
```

The preceding code shows the Contact model that you will use for user relationships. It contains the following fields:

- user_from: A ForeignKey for the user who creates the relationship
- user_to: A ForeignKey for the user being followed
- created: A DateTimeField field with auto_now_add=True to store the time when the relationship was created

A database index is automatically created on the ForeignKey fields. In the Meta class of the model, we have defined a database index in descending order for the created field. We have also added the ordering attribute to tell Django that it should sort results by the created field by default. We indicate descending order by using a hyphen before the field name, like -created.

Figure 7.2 shows the intermediate Contact model and its corresponding database table:

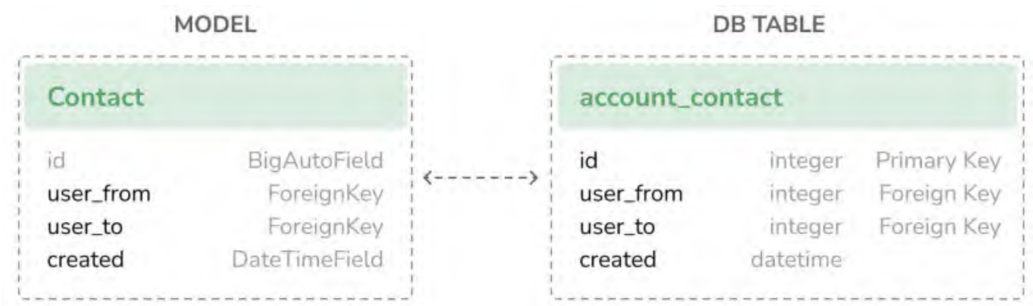

Figure 7.2: The intermediate Contact model and its database table

Using the ORM, you could create a relationship for a user, user1, following another user, user2, like this:

```
user1 = User.objects.get(id=1)
user2 = User.objects.get(id=2)
Contact.objects.create(user_from=user1, user_to=user2)
```

The related managers, rel_from_set and rel_to_set, will return a QuerySet for the Contact model. In order to access the end side of the relationship from the User model, it would be desirable for User to contain a ManyToManyField, as follows:

```
following = models.ManyToManyField(
    'self',
    through=Contact,
    related_name='followers',
    symmetrical=False
)
```

In the preceding example, you tell Django to use your custom intermediate model for the relationship by adding `through=Contact` to `ManyToManyField`. This is a many-to-many relationship from the `User` model to itself; you refer to `'self'` in `ManyToManyField` to create a relationship to the same model.

> When you need additional fields in a many-to-many relationship, create a custom model with a `ForeignKey` for each side of the relationship. You can manage the relationship using the intermediate model, or you can add a `ManyToManyField` field in one of the related models and indicate to Django that your intermediate model should be used by including it in the `through` parameter.

If the `User` model was part of your application, you could add the previous field to the model. However, you can't alter the `User` class directly because it belongs to the `django.contrib.auth` application. Let's take a slightly different approach by adding this field dynamically to the `User` model.

Edit the `models.py` file of the `account` application and add the following lines highlighted in bold:

```
from django.contrib.auth import get_user_model

# ...

# Add the following field to User dynamically
user_model = get_user_model()
user_model.add_to_class(
    'following',
    models.ManyToManyField(
        'self',
        through=Contact,
        related_name='followers',
        symmetrical=False
    )
)
```

In the preceding code, you retrieve the user model with the generic function `get_user_model()` provided by Django. You use the `add_to_class()` method of Django models to monkey patch the `User` model.

Be mindful that using `add_to_class()` is not the recommended way of adding fields to models. However, you can take advantage of using it in this case to avoid creating a custom user model, keeping all the advantages of Django's built-in `User` model.

You also simplify the way that you retrieve related objects using the Django ORM with `user.followers.all()` and `user.following.all()`. You use the intermediate `Contact` model and avoid complex queries that would involve additional database joins, as would have been the case had you defined the relationship in your custom `Profile` model. The table for this many-to-many relationship will be created using the `Contact` model. Thus, the `ManyToManyField`, added dynamically, will not imply any database changes for the Django `User` model.

Keep in mind that, in most cases, it is preferable to add fields to the `Profile` model you created before, instead of monkey patching the `User` model. Ideally, you shouldn't alter the existing Django `User` model. Django allows you to use custom user models. If you want to use a custom user model, take a look at the documentation at `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#specifying-a-custom-user-model`.

> When you start a new project, it is highly recommended that you create a custom user model, even if the default `User` model is sufficient for you. This is because you gain the option of customizing the model.

Note that the relationship includes `symmetrical=False`. When you define a `ManyToManyField` in the model creating a relationship with itself, Django forces the relationship to be symmetrical. In this case, you are setting `symmetrical=False` to define a non-symmetrical relationship (if I follow you, it doesn't mean that you automatically follow me).

> When you use an intermediate model for many-to-many relationships, some of the related manager's methods are disabled, such as `add()`, `create()`, or `remove()`. You need to create or delete instances of the intermediate model instead.

Run the following command to generate the initial migrations for the `account` application:

```
python manage.py makemigrations account
```

You will obtain an output like the following one:

```
Migrations for 'account':
  account/migrations/0002_contact.py
    - Create model Contact
```

Now, run the following command to sync the application with the database:

```
python manage.py migrate account
```

You should see an output that includes the following line:

```
Applying account.0002_contact... OK
```

The `Contact` model is now synced to the database, and you are able to create relationships between users. However, your site doesn't offer a way to browse users or see a particular user's profile yet. Let's build the list and detail views for the `User` model.

Creating list and detail views for user profiles

Open the `views.py` file of the `account` application and add the following code highlighted in bold:

```
from django.contrib.auth import authenticate, get_user_model, login
```

```
from django.shortcuts import get_object_or_404, render

# ...

User = get_user_model()

@login_required
def user_list(request):
    users = User.objects.filter(is_active=True)
    return render(
        request,
        'account/user/list.html',
        {'section': 'people', 'users': users}
    )


@login_required
def user_detail(request, username):
    user = get_object_or_404(User, username=username, is_active=True)
    return render(
        request,
        'account/user/detail.html',
        {'section': 'people', 'user': user}
    )
```

These are simple list and detail views for `User` objects. We retrieve the `User` model dynamically using the `get_user_model()` function. The `user_list` view gets all active users. The Django `User` model contains an `is_active` flag to designate whether the user account is considered active. You filter the query by `is_active=True` to return only active users. This view returns all results, but you can improve it by adding pagination in the same way as you did for the `image_list` view.

The `user_detail` view uses the `get_object_or_404()` shortcut to retrieve the active user with the given username. The view returns an HTTP `404` response if no active user with the given username is found.

Edit the `urls.py` file of the `account` application and add a URL pattern for each view, as follows. The new code is highlighted in bold:

```
urlpatterns = [
    # ...
    path('', include('django.contrib.auth.urls')),
    path('', views.dashboard, name='dashboard'),
    path('register/', views.register, name='register'),
    path('edit/', views.edit, name='edit'),
    path('users/', views.user_list, name='user_list'),
```

```
    path('users/<username>/', views.user_detail, name='user_detail'),
]
```

You will use the `user_detail` URL pattern to generate the canonical URL for users. You have already defined a `get_absolute_url()` method in a model to return the canonical URL for each object. Another way to specify the URL for a model is by adding the `ABSOLUTE_URL_OVERRIDES` setting to your project.

> By using the username instead of the user ID in the `user_detail` URL pattern, you enhance both usability and security. Usernames, unlike sequential IDs, thwart enumeration attacks by obscuring your data structure. This makes it harder for attackers to predict URLs and formulate attack vectors.

Edit the `settings.py` file of your project and add the following code highlighted in bold:

```
from django.urls import reverse_lazy

# ...

ABSOLUTE_URL_OVERRIDES = {
    'auth.user': lambda u: reverse_lazy('user_detail', args=[u.username])
}
```

Django adds a `get_absolute_url()` method dynamically to any models that appear in the `ABSOLUTE_URL_OVERRIDES` setting. This method returns the corresponding URL for the given model specified in the setting. In the previous code section, you generate the `user_detail` URL for the given user for the `auth.user` object. Now, you can use `get_absolute_url()` on a `User` instance to retrieve its corresponding URL.

Open the Python shell with the following command:

```
python manage.py shell
```

Then run the following code to test it:

```
>>> from django.contrib.auth.models import User
>>> user = User.objects.latest('id')
>>> str(user.get_absolute_url())
'/account/users/ellington/'
```

The returned URL follows the expected format, `/account/users/<username>/`.

You will need to create templates for the views that you just built. Add the following directory and files to the `templates/account/` directory of the `account` application:

```
/user/
    detail.html
```

```
list.html
```

Edit the `account/user/list.html` template and add the following code to it:

```
{% extends "base.html" %}
{% load thumbnail %}

{% block title %}People{% endblock %}

{% block content %}
  <h1>People</h1>
  <div id="people-list">
    {% for user in users %}
      <div class="user">
        <a href="{{ user.get_absolute_url }}">
          <img src="{% thumbnail user.profile.photo 180x180 %}">
        </a>
        <div class="info">
          <a href="{{ user.get_absolute_url }}" class="title">
            {{ user.get_full_name }}
          </a>
        </div>
      </div>
    {% endfor %}
  </div>
{% endblock %}
```

The preceding template allows you to list all the active users on the site. You iterate over the given users and use the `{% thumbnail %}` template tag from `easy-thumbnails` to generate profile image thumbnails.

Note that the users need to have a profile image. To use a default image for users that don't have a profile image, you can add an `if/else` statement to check whether the user has a profile photo, like `{% if user.profile.photo %} {# photo thumbnail #} {% else %} {# default image #} {% endif %}`.

Open the `base.html` template of your project and include the `user_list` URL in the `href` attribute of the following menu item. The new code is highlighted in bold:

```
<ul class="menu">
  ...
  <li {% if section == "people" %}class="selected"{% endif %}>
    <a href="{% url "user_list" %}">People</a>
  </li>
</ul>
```

Start the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/account/users/` in your browser. You should see a list of users like the following one:

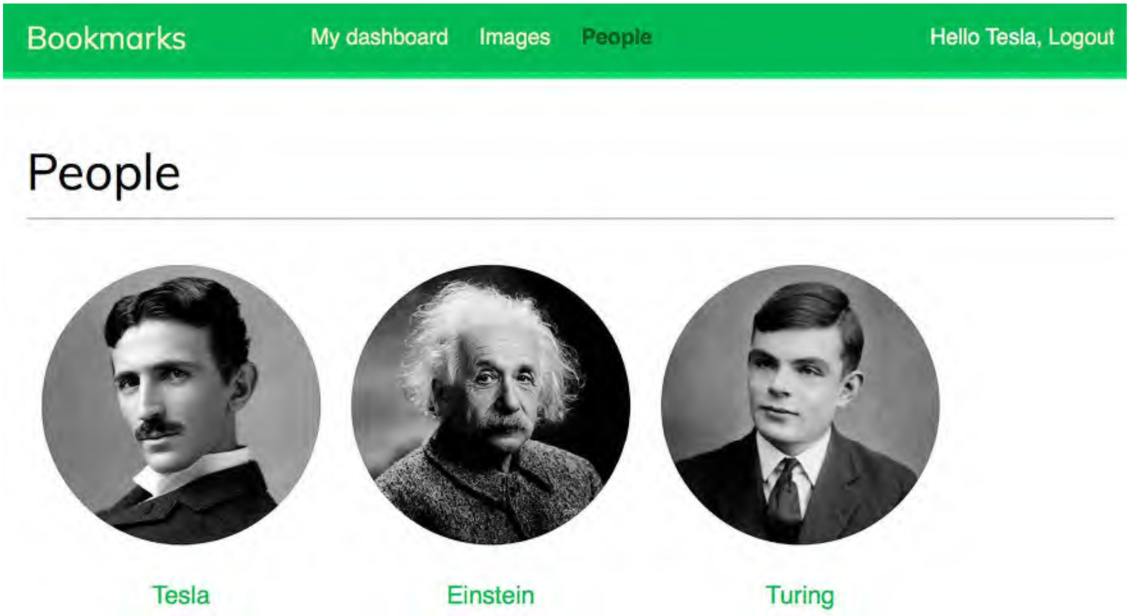

Figure 7.3: The user list page with profile image thumbnails

Remember that if you have any difficulty generating thumbnails, you can add `THUMBNAIL_DEBUG = True` to your `settings.py` file in order to obtain debug information in the shell.

Edit the `account/user/detail.html` template of the `account` application and add the following code to it:

```
{% extends "base.html" %}
{% load thumbnail %}

{% block title %}{{ user.get_full_name }}{% endblock %}
```

```
{% block content %}
  <h1>{{ user.get_full_name }}</h1>
  <div class="profile-info">
    <img src="{% thumbnail user.profile.photo 180x180 %}" class="user-detail">
  </div>
  {% with total_followers=user.followers.count %}
    <span class="count">
      <span class="total">{{ total_followers }}</span>
      follower{{ total_followers|pluralize }}
    </span>
    <a href="#" data-id="{{ user.id }}" data-action="{% if request.user in
user.followers.all %}un{% endif %}follow" class="follow button">
      {% if request.user not in user.followers.all %}
        Follow
      {% else %}
        Unfollow
      {% endif %}
    </a>
    <div id="image-list" class="image-container">
      {% include "images/image/list_images.html" with images=user.images_
created.all %}
    </div>
  {% endwith %}
{% endblock %}
```

Make sure that no template tag is split into multiple lines; Django doesn't support multiple-line tags.

In the `detail` template, the user profile is displayed, and the `{% thumbnail %}` template tag is used to show the profile image. The total number of followers is presented along with a link to follow or unfollow the user. This link will be used to follow/unfollow a particular user. The `data-id` and `data-action` attributes of the `<a>` HTML element contain the user ID and the initial action to perform when the link element is clicked – `follow` or `unfollow`. The initial action (*follow* or *unfollow*) depends on whether the user requesting the page is already a follower of the user. The images bookmarked by the user are displayed by including the `images/image/list_images.html` template.

Open your browser again and click on a user who has bookmarked some images. The user page will look as follows:

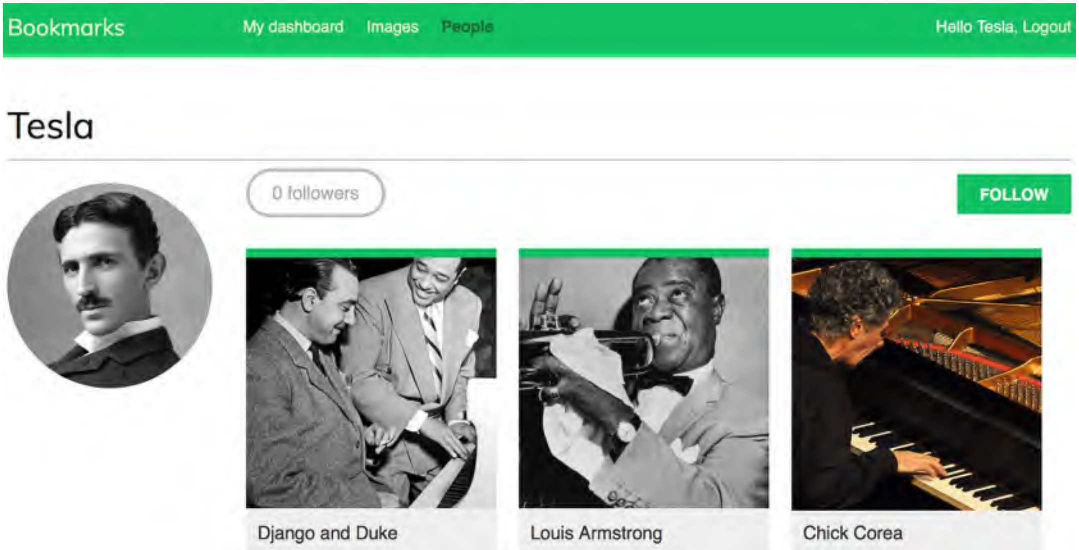

Figure 7.4: The user detail page

The preceding image is of *Chick Corea* by ataelw (Creative Commons Attribution 2.0 Generic license: `https://creativecommons.org/licenses/by/2.0/`).

Adding user follow/unfollow actions with JavaScript

Let's add functionality to follow/unfollow users. We will create a new view to follow/unfollow users and implement an asynchronous HTTP request with JavaScript for the follow/unfollow action.

Edit the `views.py` file of the `account` application and add the following code highlighted in bold:

```
from django.http import HttpResponse, JsonResponse
from django.views.decorators.http import require_POST
from .models import Contact, Profile

# ...

@require_POST
@login_required
def user_follow(request):
    user_id = request.POST.get('id')
    action = request.POST.get('action')
```

```
    if user_id and action:
        try:
            user = User.objects.get(id=user_id)
            if action == 'follow':
                Contact.objects.get_or_create(
                    user_from=request.user,
                    user_to=user
                )
            else:
                Contact.objects.filter(
                    user_from=request.user,
                    user_to=user
                ).delete()
            return JsonResponse({'status':'ok'})
        except User.DoesNotExist:
            return JsonResponse({'status':'error'})
    return JsonResponse({'status':'error'})
```

The `user_follow` view is quite similar to the `image_like` view that you created in *Chapter 6*, *Sharing Content on Your Website*. Since you are using a custom intermediate model for the user's many-to-many relationship, the default `add()` and `remove()` methods of the automatic manager of `ManyToManyField` are not available. Instead, the intermediate `Contact` model is used to create or delete user relationships.

Edit the `urls.py` file of the `account` application and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    path('', include('django.contrib.auth.urls')),
    path('', views.dashboard, name='dashboard'),
    path('register/', views.register, name='register'),
    path('edit/', views.edit, name='edit'),
    path('users/', views.user_list, name='user_list'),
    path('users/follow/', views.user_follow, name='user_follow'),
    path('users/<username>/', views.user_detail, name='user_detail'),
]
```

Ensure that you place the preceding pattern before the `user_detail` URL pattern. Otherwise, any requests to `/users/follow/` will match the regular expression of the `user_detail` pattern and that view will be executed instead. Remember that in every HTTP request, Django checks the requested URL against each pattern in order of appearance and stops at the first match.

Edit the `user/detail.html` template of the `account` application and append the following code to it:

```
{% block domready %}
  const url = '{% url "user_follow" %}';
  var options = {
```

```
      method: 'POST',
      headers: {'X-CSRFToken': csrftoken},
      mode: 'same-origin'
    }

    document.querySelector('a.follow')
            .addEventListener('click', function(e){
      e.preventDefault();
      var followButton = this;

      // add request body
      var formData = new FormData();
      formData.append('id', followButton.dataset.id);
      formData.append('action', followButton.dataset.action);
      options['body'] = formData;

      // send HTTP request
      fetch(url, options)
      .then(response => response.json())
      .then(data => {
        if (data['status'] === 'ok')
        {
          var previousAction = followButton.dataset.action;

          // toggle button text and data-action
          var action = previousAction === 'follow' ? 'unfollow' : 'follow';
          followButton.dataset.action = action;
          followButton.innerHTML = action;

          // update follower count
          var followerCount = document.querySelector('span.count .total');
          var totalFollowers = parseInt(followerCount.innerHTML);
          followerCount.innerHTML = previousAction === 'follow' ? totalFollowers
  + 1 : totalFollowers - 1;
        }
      })
    });
  {% endblock %}
```

The preceding template block contains the JavaScript code to perform the asynchronous HTTP request to follow or unfollow a particular user and also to toggle the follow/unfollow link.

The Fetch API is used to perform the AJAX request and set both the `data-action` attribute and the text of the HTML `<a>` element based on its previous value. When the action is completed, the total number of followers displayed on the page is updated as well.

Open the user detail page of an existing user and click on the **FOLLOW** link to test the functionality you just built. You will see, on the left-hand side of the following image, that the followers count has increased:

Figure 7.5: The followers count and follow/unfollow button

The follow system is now complete and users can follow each other. Next, we will build an activity stream creating relevant content for each user that is based on the people they follow.

Creating an activity stream application

Many social websites display an activity stream to their users so that they can track what other users do on the platform. An activity stream is a list of recent activities performed by a user or a group of users. For example, Facebook's News Feed is an activity stream. Sample actions can be *user X bookmarked image Y* or *user X is now following user Y*.

You are going to build an activity stream application so that every user can see the recent interactions of the users they follow. To do so, you will need a model to save the actions performed by users on the website and a simple way to add actions to the feed.

Create a new application named `actions` inside your project with the following command:

```
python manage.py startapp actions
```

Add the new application to `INSTALLED_APPS` in the `settings.py` file of your project to activate the application in your project. The new line is highlighted in bold:

```
INSTALLED_APPS = [
    # ...
    'actions.apps.ActionsConfig',
]
```

Edit the `models.py` file of the `actions` application and add the following code to it:

```
from django.conf import settings
from django.db import models


class Action(models.Model):
    user = models.ForeignKey(
        settings.AUTH_USER_MODEL,
```

```
        related_name='actions',
        on_delete=models.CASCADE
    )
    verb = models.CharField(max_length=255)
    created = models.DateTimeField(auto_now_add=True)

    class Meta:
        indexes = [
            models.Index(fields=['-created']),
        ]
        ordering = ['-created']
```

The preceding code shows the `Action` model that will be used to store user activities. The fields of this model are as follows:

- `user`: The user who performed the action; this is a `ForeignKey` to the `AUTH_USER_MODEL`, by default, the Django `User` model.
- `verb`: The verb describing the action that the user has performed.
- `created`: The date and time when this action was created. We use `auto_now_add=True` to automatically set this to the current datetime when the object is saved for the first time in the database.

In the `Meta` class of the model, we have defined a database index in descending order for the `created` field. We have also added the `ordering` attribute to tell Django that it should sort results by the `created` field in descending order by default.

With this basic model, you can only store actions such as *user X did something*. You need an extra `ForeignKey` field to save actions that involve a `target` object, such as *user X bookmarked image Y* or *user X is now following user Y*. As you already know, a normal `ForeignKey` can point to only one model. Instead, you will need a way for the action's `target` object to be an instance of an existing model. This is what the Django `contenttypes` framework will help you to do.

Using the contenttypes framework

Django includes a `contenttypes` framework located at `django.contrib.contenttypes`. This application can track all models installed in your project and provides a generic interface to interact with your models.

The `django.contrib.contenttypes` application is included in the `INSTALLED_APPS` setting by default when you create a new project using the `startproject` command. It is used by other `contrib` packages, such as the authentication framework and the administration application.

The `contenttypes` application contains a `ContentType` model. Instances of this model represent the actual models of your application, and new instances of `ContentType` are automatically created when new models are installed in your project. The `ContentType` model has the following fields:

- `app_label`: This indicates the name of the application that the model belongs to. This is automatically taken from the `app_label` attribute of the model `Meta` options. For example, your `Image` model belongs to the `images` application.
- `model`: The name of the model class.
- `name`: This is a property that indicates the human-readable name of the model, automatically generated from the `verbose_name` attribute of the model `Meta` options.

Let's take a look at how you can interact with `ContentType` objects. Open the shell using the following command:

```
python manage.py shell
```

You can obtain the `ContentType` object corresponding to a specific model by performing a query with the `app_label` and `model` attributes, as follows:

```
>>> from django.contrib.contenttypes.models import ContentType
>>> image_type = ContentType.objects.get(app_label='images', model='image')
>>> image_type
<ContentType: images | image>
```

You can also retrieve the model class from a `ContentType` object by calling its `model_class()` method:

```
>>> image_type.model_class()
<class 'images.models.Image'>
```

It's also common to obtain the `ContentType` object for a particular model class, as follows:

```
>>> from images.models import Image
>>> ContentType.objects.get_for_model(Image)
<ContentType: images | image>
```

These are just some examples of using `contenttypes`. Django offers more ways to work with them. You can find the official documentation for the `contenttypes` framework at `https://docs.djangoproject.com/en/5.0/ref/contrib/contenttypes/`.

Adding generic relations to your models

In generic relations, `ContentType` objects play the role of pointing to the model used for the relationship. You will need three fields to set up a generic relation in a model:

- A `ForeignKey` field to `ContentType`: This will tell you what the model for the relationship is
- A field to store the primary key of the related object: This will usually be a `PositiveIntegerField` to match Django's automatic primary key fields
- A field to define and manage the generic relation using the two previous fields: The `contenttypes` framework offers a `GenericForeignKey` field for this purpose

Edit the `models.py` file of the `actions` application and add the following code highlighted in bold:

```
from django.conf import settings
```

```
from django.contrib.contenttypes.fields import GenericForeignKey
from django.contrib.contenttypes.models import ContentType
from django.db import models


class Action(models.Model):
    user = models.ForeignKey(
        settings.AUTH_USER_MODEL,
        related_name='actions',
        on_delete=models.CASCADE
    )
    verb = models.CharField(max_length=255)
    created = models.DateTimeField(auto_now_add=True)
    target_ct = models.ForeignKey(
        ContentType,
        blank=True,
        null=True,
        related_name='target_obj',
        on_delete=models.CASCADE
    )
    target_id = models.PositiveIntegerField(null=True, blank=True)
    target = GenericForeignKey('target_ct', 'target_id')

    class Meta:
        indexes = [
            models.Index(fields=['-created']),
            models.Index(fields=['target_ct', 'target_id']),
        ]
        ordering = ['-created']
```

We have added the following fields to the `Action` model:

- `target_ct`: A `ForeignKey` field that points to the `ContentType` model
- `target_id`: A `PositiveIntegerField` for storing the primary key of the related object
- `target`: A `GenericForeignKey` field to the related object based on the combination of the two previous fields

We have also added a multiple-field index including the `target_ct` and `target_id` fields.

Django does not create `GenericForeignKey` fields in the database. The only fields that are mapped to database fields are `target_ct` and `target_id`. Both fields have `blank=True` and `null=True` attributes so that a `target` object is not required when saving `Action` objects.

You can make your applications more flexible by using generic relations instead of foreign keys. Generic relations allow you to associate models in a non-exclusive manner, enabling a single model to relate to multiple other models.

Figure 7.6 shows the `Action` model, including the relationship with the `ContentType` model of the `contenttypes` Django contrib package:

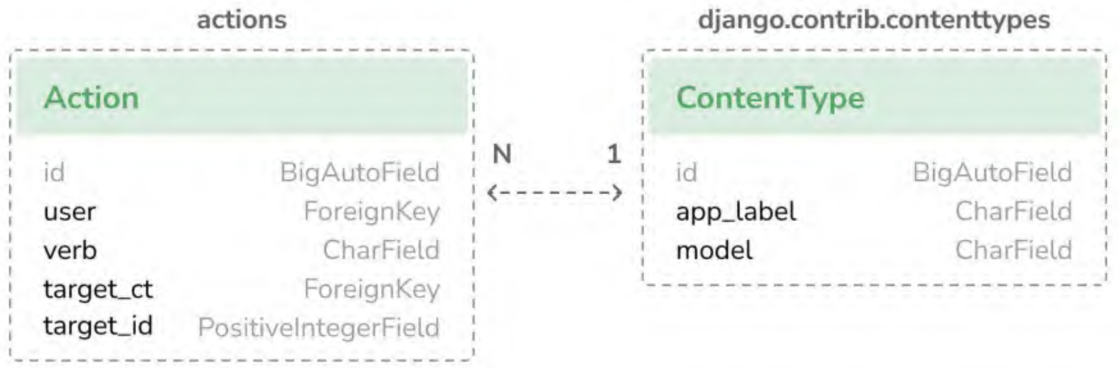

Figure 7.6: The Action model and the ContentType model

Run the following command to create initial migrations for this application:

```
python manage.py makemigrations actions
```

You should see the following output:

```
Migrations for 'actions':
  actions/migrations/0001_initial.py
    - Create model Action
    - Create index actions_act_created_64f10d_idx on field(s) -created of model
action
    - Create index actions_act_target__f20513_idx on field(s) target_ct,
target_id of model action
```

Then, run the next command to sync the application with the database:

```
python manage.py migrate
```

The output of the command should indicate that the new migrations have been applied, as follows:

```
Applying actions.0001_initial... OK
```

Let's add the `Action` model to the administration site. Edit the `admin.py` file of the `actions` application and add the following code to it:

```
from django.contrib import admin
```

```
from .models import Action


@admin.register(Action)
class ActionAdmin(admin.ModelAdmin):
    list_display = ['user', 'verb', 'target', 'created']
    list_filter = ['created']
    search_fields = ['verb']
```

You just registered the `Action` model on the administration site.

Start the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/actions/action/add/` in your browser. You should see the page for creating a new `Action` object, as follows:

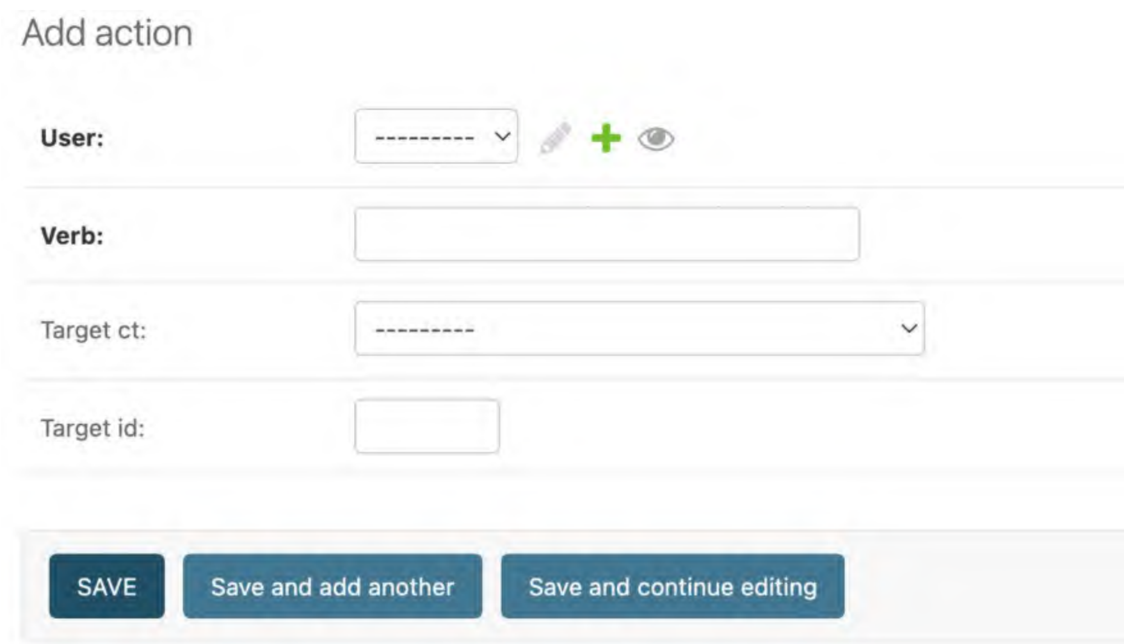

Figure 7.7: The Add action page on the Django administration site

As you will notice in the preceding screenshot, only the `target_ct` and `target_id` fields that are mapped to actual database fields are shown. The `GenericForeignKey` field does not appear in the form. The `target_ct` field allows you to select any of the registered models of your Django project. You can restrict the content types to choose from a limited set of models using the `limit_choices_to` attribute in the `target_ct` field; the `limit_choices_to` attribute allows you to restrict the content of `ForeignKey` fields to a specific set of values.

Create a new file inside the actions application directory and name it utils.py. You need to define a shortcut function that will allow you to create new Action objects in a simple way. Edit the new utils.py file and add the following code to it:

```
from django.contrib.contenttypes.models import ContentType
from .models import Action


def create_action(user, verb, target=None):
    action = Action(user=user, verb=verb, target=target)
    action.save()
```

The create_action() function allows you to create actions that optionally include a target object. You can use this function anywhere in your code as a shortcut to add new actions to the activity stream.

Avoiding duplicate actions in the activity stream

Sometimes, your users might click several times on the **Like** or **Unlike** button or perform the same action multiple times in a short period of time. This will easily lead to storing and displaying duplicate actions. To avoid this, let's improve the create_action() function to skip obvious duplicated actions.

Edit the utils.py file of the actions application, as follows:

```
import datetime
from django.contrib.contenttypes.models import ContentType
from django.utils import timezone
from .models import Action


def create_action(user, verb, target=None):
    # check for any similar action made in the last minute
    now = timezone.now()
    last_minute = now - datetime.timedelta(seconds=60)
    similar_actions = Action.objects.filter(
        user_id=user.id,
        verb= verb,
        created__gte=last_minute
    )
    if target:
        target_ct = ContentType.objects.get_for_model(target)
        similar_actions = similar_actions.filter(
            target_ct=target_ct,
            target_id=target.id
        )
```

```
    if not similar_actions:
        # no existing actions found
        action = Action(user=user, verb=verb, target=target)
        action.save()
        return True
    return False
```

You have changed the `create_action()` function to avoid saving duplicate actions and return a Boolean to tell you whether the action was saved. This is how you avoid duplicates:

1. First, you get the current time using the `timezone.now()` method provided by Django. This method does the same as `datetime.datetime.now()` but returns a timezone-aware object. Django provides a setting called `USE_TZ` to enable or disable timezone support. The default `settings.py` file created using the `startproject` command includes `USE_TZ=True`.
2. You use the `last_minute` variable to store the datetime from one minute ago and retrieve any identical actions performed by the user since then.
3. You create an `Action` object if no identical action already exists in the last minute. You return `True` if an `Action` object was created or `False` otherwise.

Adding user actions to the activity stream

It's time to add some actions to your views to build the activity stream for your users. You will store an action for each of the following interactions:

- A user bookmarks an image
- A user likes an image
- A user creates an account
- A user starts following another user

Edit the `views.py` file of the `images` application and add the following import:

```
from actions.utils import create_action
```

In the `image_create` view, add `create_action()` after saving the image, as follows. The new line is highlighted in bold:

```
@login_required
def image_create(request):
    if request.method == 'POST':
        # form is sent
        form = ImageCreateForm(data=request.POST)
        if form.is_valid():
            # form data is valid
            cd = form.cleaned_data
            new_image = form.save(commit=False)
            # assign current user to the item
```

```
            new_image.user = request.user
            new_image.save()
            create_action(request.user, 'bookmarked image', new_image)
            messages.success(request, 'Image added successfully')
            # redirect to new created image detail view
            return redirect(new_image.get_absolute_url())
    else:
        # build form with data provided by the bookmarklet via GET
        form = ImageCreateForm(data=request.GET)
    return render(
        request,
        'images/image/create.html',
        {'section': 'images', 'form': form}
    )
```

In the `image_like` view, add `create_action()` after adding the user to the `users_like` relationship, as follows. The new line is highlighted in bold:

```
@login_required
@require_POST
def image_like(request):
    image_id = request.POST.get('id')
    action = request.POST.get('action')
    if image_id and action:
        try:
            image = Image.objects.get(id=image_id)
            if action == 'like':
                image.users_like.add(request.user)
                create_action(request.user, 'likes', image)
            else:
                image.users_like.remove(request.user)
            return JsonResponse({'status':'ok'})
        except Image.DoesNotExist:
            pass
    return JsonResponse({'status':'error'})
```

Now, edit the `views.py` file of the `account` application and add the following import:

```
from actions.utils import create_action
```

In the `register` view, add `create_action()` after creating the `Profile` object, as follows. The new line is highlighted in bold:

```
def register(request):
```

```
    if request.method == 'POST':
        user_form = UserRegistrationForm(request.POST)
        if user_form.is_valid():
            # Create a new user object but avoid saving it yet
            new_user = user_form.save(commit=False)
            # Set the chosen password
            new_user.set_password(
                user_form.cleaned_data['password']
            )
            # Save the User object
            new_user.save()
            # Create the user profile
            Profile.objects.create(user=new_user)
            create_action(new_user, 'has created an account')
            return render(
                request,
                'account/register_done.html',
                {'new_user': new_user}
            )
    else:
        user_form = UserRegistrationForm()
    return render(
        request,
        'account/register.html',
        {'user_form': user_form}
    )
```

In the `user_follow` view, add `create_action()`, as follows. The new line is highlighted in bold:

```
@require_POST
@login_required
def user_follow(request):
    user_id = request.POST.get('id')
    action = request.POST.get('action')
    if user_id and action:
        try:
            user = User.objects.get(id=user_id)
            if action == 'follow':
                Contact.objects.get_or_create(
                    user_from=request.user,
                    user_to=user
                )
```

```
                create_action(request.user, 'is following', user)
            else:
                Contact.objects.filter(
                    user_from=request.user,
                    user_to=user
                ).delete()
            return JsonResponse({'status':'ok'})
        except User.DoesNotExist:
            return JsonResponse({'status':'error'})
    return JsonResponse({'status':'error'})
```

As you can see in the preceding code, thanks to the `Action` model and the helper function, it's very easy to save new actions to the activity stream.

Displaying the activity stream

Finally, you need a way to display the activity stream for each user. You will include the activity stream on the user's dashboard. Edit the `views.py` file of the `account` application. Import the `Action` model and modify the `dashboard` view, as follows. The new code is highlighted in bold:

```
from actions.models import Action

# ...

@login_required
def dashboard(request):
    # Display all actions by default
    actions = Action.objects.exclude(user=request.user)
    following_ids = request.user.following.values_list(
        'id', flat=True
    )
    if following_ids:
        # If user is following others, retrieve only their actions
        actions = actions.filter(user_id__in=following_ids)
    actions = actions[:10]
    return render(
        request,
        'account/dashboard.html',
        {'section': 'dashboard', 'actions': actions}
    )
```

In the preceding view, you retrieve all actions from the database, excluding the ones performed by the current user. By default, you retrieve the latest actions performed by all users on the platform.

If the user is following other users, you restrict the query to retrieve only the actions performed by the users they follow. Finally, you limit the result to the first 10 actions returned. You don't use `order_by()` in the QuerySet because you rely on the default ordering that you provided in the `Meta` options of the `Action` model. Recent actions will come first since you set `ordering = ['-created']` in the `Action` model.

Optimizing QuerySets that involve related objects

Every time you retrieve an `Action` object, you will usually access its related `User` object and the user's related `Profile` object. The Django ORM offers a simple way to retrieve related objects at the same time, thereby avoiding additional queries to the database.

Using select_related()

Django offers a QuerySet method called `select_related()` that allows you to retrieve related objects for one-to-many relationships. This translates to a single, more complex QuerySet, but you avoid additional queries when accessing the related objects.

The `select_related` method is for `ForeignKey` and `OneToOne` fields. It works by performing a SQL `JOIN` and including the fields of the related object in the `SELECT` statement.

To take advantage of `select_related()`, edit the following line of the preceding code in the `views.py` file of the account application to add `select_related`, including the fields that you will use, as follows. Edit the `views.py` file of the account application. The new code is highlighted in bold:

```
@login_required
def dashboard(request):
    # Display all actions by default
    actions = Action.objects.exclude(user=request.user)
    following_ids = request.user.following.values_list(
        'id', flat=True
    )
    if following_ids:
        # If user is following others, retrieve only their actions
        actions = actions.filter(user_id__in=following_ids)
    actions = actions.select_related(
        'user', 'user__profile'
    )[:10]
    return render(
        request,
        'account/dashboard.html',
        {'section': 'dashboard', 'actions': actions}
    )
```

You use `user__profile` to join the `Profile` table in a single SQL query. If you call `select_related()` without passing any arguments to it, it will retrieve objects from all `ForeignKey` relationships. Always limit `select_related()` to the relationships that will be accessed afterward.

Using `select_related()` carefully can vastly improve execution time.

Using prefetch_related()

`select_related()` will help you boost the performance for retrieving related objects in one-to-many relationships. However, `select_related()` doesn't work for many-to-many or many-to-one relationships (`ManyToMany` or reverse `ForeignKey` fields). Django offers a different QuerySet method called `prefetch_related` that works for many-to-many and many-to-one relationships in addition to the relationships supported by `select_related()`. The `prefetch_related()` method performs a separate lookup for each relationship and joins the results using Python. This method also supports the prefetching of `GenericRelation` and `GenericForeignKey`.

Edit the `views.py` file of the `account` application and complete your query by adding `prefetch_related()` to it for the target `GenericForeignKey` field, as follows. The new code is highlighted in bold:

```
@login_required
def dashboard(request):
    # Display all actions by default
    actions = Action.objects.exclude(user=request.user)
    following_ids = request.user.following.values_list(
        'id', flat=True
    )
    if following_ids:
        # If user is following others, retrieve only their actions
        actions = actions.filter(user_id__in=following_ids)
    actions = actions.select_related(
        'user', 'user__profile'
    ).prefetch_related('target')[:10]
    return render(
        request,
        'account/dashboard.html',
        {'section': 'dashboard', 'actions': actions}
    )
```

This query is now optimized for retrieving the user actions, including related objects.

Creating templates for actions

Let's now create the template to display a particular `Action` object. Create a new directory inside the `actions` application directory and name it `templates`. Add the following file structure to it:

```
actions/
    action/
        detail.html
```

Edit the `actions/action/detail.html` template file and add the following lines to it:

```
{% load thumbnail %}

{% with user=action.user profile=action.user.profile %}
<div class="action">
  <div class="images">
    {% if profile.photo %}
      {% thumbnail user.profile.photo "80x80" crop="100%" as im %}
      <a href="{{ user.get_absolute_url }}">
        <img src="{{ im.url }}" alt="{{ user.get_full_name }}"
         class="item-img">
      </a>
    {% endif %}
    {% if action.target %}
      {% with target=action.target %}
        {% if target.image %}
          {% thumbnail target.image "80x80" crop="100%" as im %}
          <a href="{{ target.get_absolute_url }}">
            <img src="{{ im.url }}" class="item-img">
          </a>
        {% endif %}
      {% endwith %}
    {% endif %}
  </div>
  <div class="info">
    <p>
      <span class="date">{{ action.created|timesince }} ago</span>
      <br />
      <a href="{{ user.get_absolute_url }}">
        {{ user.first_name }}
```

```
        </a>
        {{ action.verb }}
        {% if action.target %}
          {% with target=action.target %}
            <a href="{{ target.get_absolute_url }}">{{ target }}</a>
          {% endwith %}
        {% endif %}
      </p>
    </div>
  </div>
{% endwith %}
```

This is the template used to display an `Action` object. First, you use the `{% with %}` template tag to retrieve the user performing the action and the related `Profile` object. Then, you display the image of the `target` object if the `Action` object has a related `target` object. Finally, you display the link to the user who performed the action, the verb, and the `target` object, if any.

Edit the `account/dashboard.html` template of the `account` application and append the following code highlighted in bold to the bottom of the `content` block:

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

{% block title %}Dashboard{% endblock %}

{% block content %}

  ...

  <h2>What's happening</h2>
  <div id="action-list">
    {% for action in actions %}
      {% include "actions/action/detail.html" %}
    {% endfor %}
  </div>
{% endblock %}
```

Open `http://127.0.0.1:8000/account/` in your browser. Log in as an existing user and perform several actions so that they get stored in the database. Then, log in using another user, follow the previous user, and take a look at the generated action stream on the dashboard page.

It should look like the following:

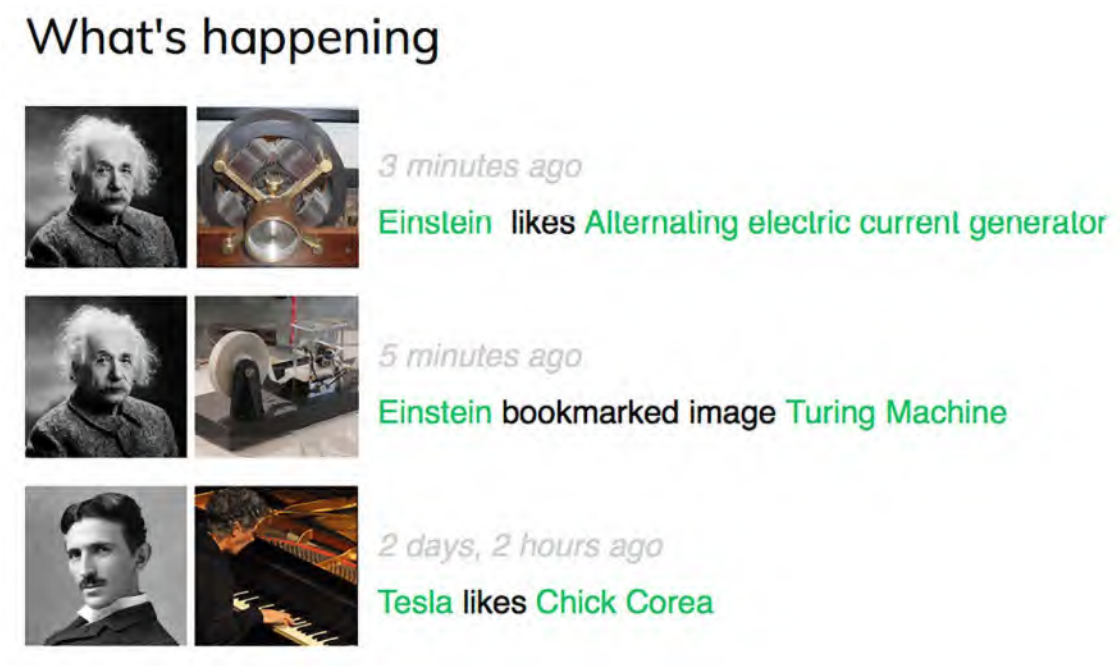

Figure 7.8: The activity stream for the current user

> *Figure 7.8* image attributions:
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You just created a complete activity stream for your users, and you can easily add new user actions to it. You can also add infinite scroll functionality to the activity stream by implementing the same AJAX paginator that you used for the `image_list` view. Next, you will learn how to use Django signals to denormalize action counts.

Using signals for denormalizing counts

There are some cases when you may want to denormalize your data. Denormalization is making data redundant in such a way that it optimizes read performance. For example, you might be copying related data to an object to avoid expensive read queries to the database when retrieving the related data. You have to be careful about denormalization and only start using it when you really need it. The biggest issue you will find with denormalization is that it's difficult to keep your denormalized data updated.

Let's take a look at an example of how to improve your queries by denormalizing counts. You will denormalize data from your `Image` model and use Django signals to keep the data updated.

Working with signals

Django comes with a signal dispatcher that allows receiver functions to get notified when certain actions occur. Signals are very useful when you need your code to do something every time something else happens. Signals allow you to decouple logic: you can capture a certain action, regardless of the application or code that triggered that action, and implement logic that gets executed whenever that action occurs. For example, you can build a signal receiver function that gets executed every time a `User` object is saved. You can also create your own signals so that others can get notified when an event happens.

Django provides several signals for models located at `django.db.models.signals`. Some of these signals are as follows:

- `pre_save` and `post_save` are sent before or after calling the `save()` method of a model
- `pre_delete` and `post_delete` are sent before or after calling the `delete()` method of a model or QuerySet
- `m2m_changed` is sent when a `ManyToManyField` on a model is changed

These are just a subset of the signals provided by Django. You can find a list of all built-in signals at `https://docs.djangoproject.com/en/5.0/ref/signals/`.

Let's say you want to retrieve images by popularity. You can use the Django aggregation functions to retrieve images ordered by the number of users who like them. Remember that you used Django aggregation functions in *Chapter 3*, *Extending Your Blog Application*. The following code example will retrieve images according to their number of likes:

```
from django.db.models import Count
from images.models import Image

images_by_popularity = Image.objects.annotate(
    total_likes=Count('users_like')
).order_by('-total_likes')
```

However, ordering images by counting their total likes is more expensive in terms of performance than ordering them by a field that stores total counts. You can add a field to the `Image` model to denormalize the total number of likes to boost performance in queries that involve this field. The issue is how to keep this field updated.

Edit the `models.py` file of the `images` application and add the following `total_likes` field to the `Image` model. The new code is highlighted in bold:

```
class Image(models.Model):
    # ...
    total_likes = models.PositiveIntegerField(default=0)

    class Meta:
        indexes = [
            models.Index(fields=['-created']),
            models.Index(fields=['-total_likes']),
        ]
        ordering = ['-created']
```

The `total_likes` field will allow you to store the total count of users who like each image. Denormalizing counts is useful when you want to filter or order QuerySets by them. We have added a database index for the `total_likes` field in descending order because we plan to retrieve images ordered by their total likes in descending order.

> There are several ways to improve performance that you have to take into account before denormalizing fields. Consider database indexes, query optimization, and caching before starting to denormalize your data.

Run the following command to create the migrations for adding the new field to the database table:

```
python manage.py makemigrations images
```

You should see the following output:

```
Migrations for 'images':
  images/migrations/0002_image_total_likes_and_more.py
    - Add field total_likes to image
    - Create index images_imag_total_l_0bcd7e_idx on field(s) -total_likes of
model image
```

Then, run the following command to apply the migration:

```
python manage.py migrate images
```

The output should include the following line:

```
Applying images.0002_image_total_likes_and_more... OK
```

You need to attach a receiver function to the `m2m_changed` signal.

Create a new file inside the `images` application directory and name it `signals.py`. Add the following code to it:

```python
from django.db.models.signals import m2m_changed
from django.dispatch import receiver
from .models import Image


@receiver(m2m_changed, sender=Image.users_like.through)
def users_like_changed(sender, instance, **kwargs):
    instance.total_likes = instance.users_like.count()
    instance.save()
```

First, you register the `users_like_changed` function as a receiver function using the `receiver()` decorator. You attach it to the `m2m_changed` signal. Then, you connect the function to `Image.users_like.through` so that the function is only called if the `m2m_changed` signal has been launched by this sender. There is an alternate method for registering a receiver function; it consists of using the `connect()` method of the `Signal` object.

> Django signals are synchronous and blocking. Don't confuse signals with asynchronous tasks. However, you can combine both to launch asynchronous tasks when your code gets notified by a signal. You will learn how to create asynchronous tasks with Celery in *Chapter 8*, *Building an Online Shop*.

You have to connect your receiver function to a signal so that it gets called every time the signal is sent. The recommended method for registering your signals is by importing them into the `ready()` method of your application configuration class. Django provides an application registry that allows you to configure and introspect your applications.

Application configuration classes

Django allows you to specify configuration classes for your applications. When you create an application using the `startapp` command, Django adds an `apps.py` file to the application directory, including a basic application configuration that inherits from the `AppConfig` class.

The application configuration class allows you to store metadata and the configuration for the application, and it provides introspection for the application. You can find more information about application configurations at `https://docs.djangoproject.com/en/5.0/ref/applications/`.

In order to register your signal receiver functions, when you use the `receiver()` decorator, you just need to import the `signals` module of your application inside the `ready()` method of the application configuration class. This method is called as soon as the application registry is fully populated. Any other initializations for your application should also be included in this method.

Edit the `apps.py` file of the `images` application and add the following code highlighted in bold:

```
from django.apps import AppConfig

class ImagesConfig(AppConfig):
    default_auto_field = 'django.db.models.BigAutoField'
    name = 'images'

    def ready(self):
        # import signal handlers
        import images.signals
```

You import the signals for this application in the `ready()` method so that they are imported when the `images` application is loaded.

Run the development server with the following command:

```
python manage.py runserver
```

Open your browser to view an image detail page and click on the **Like** button.

Go to the administration site, navigate to the edit image URL, such as `http://127.0.0.1:8000/admin/images/image/1/change/`, and take a look at the `total_likes` attribute. You should see that the `total_likes` attribute is updated with the total number of users who like the image, as follows:

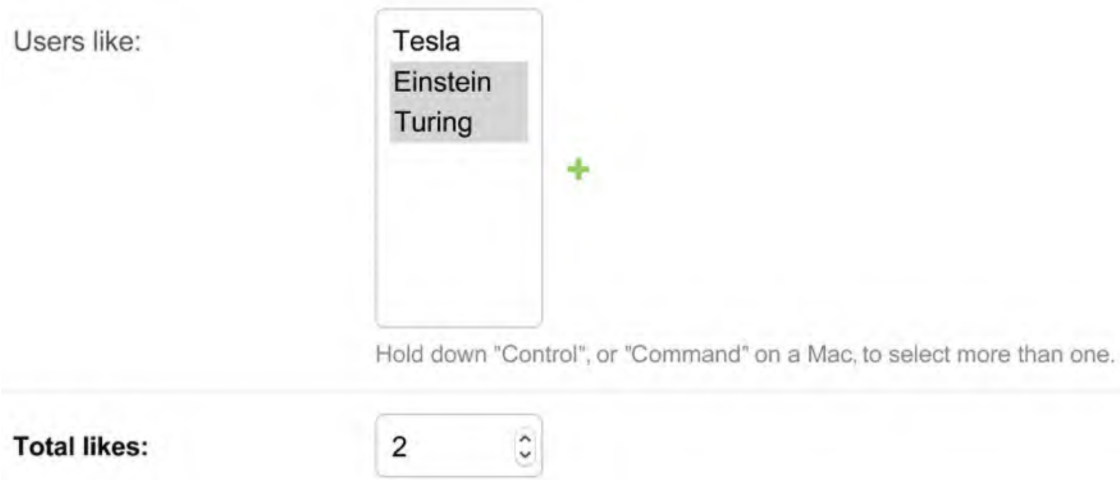

Figure 7.9: The image edit page on the administration site, including denormalization for total likes

Now, you can use the `total_likes` attribute to order images by popularity or display the value anywhere, avoiding using complex queries to calculate it.

Consider the following query to get images ordered by their likes count in descending order:

```
from django.db.models import Count

images_by_popularity = Image.objects.annotate(
    likes=Count('users_like')
).order_by('-likes')
```

The preceding query can now be written as follows:

```
images_by_popularity = Image.objects.order_by('-total_likes')
```

This results in a less expensive SQL query thanks to denormalizing the total likes for images. You have also learned how you can use Django signals.

> Use signals with caution since they make it difficult to know the control flow. In many cases, you can avoid using signals if you know which receivers need to be notified.

You will need to set initial counts for the rest of the `Image` objects to match the current status of the database.

Open the shell with the following command:

```
python manage.py shell
```

Execute the following code in the shell:

```
>>> from images.models import Image
>>> for image in Image.objects.all():
...     image.total_likes = image.users_like.count()
...     image.save()
```

You have manually updated the likes count for the existing images in the database. From now on, the `users_like_changed` signal receiver function will handle updating the `total_likes` field whenever the many-to-many related objects change.

Next, you will learn how to use Django Debug Toolbar to obtain relevant debug information for requests, including execution time, SQL queries executed, templates rendered, signals registered, and much more.

Using Django Debug Toolbar

By this point, you will already be familiar with Django's debug page. Throughout the previous chapters, you have seen the distinctive yellow and gray Django debug page several times.

For example, in *Chapter 2*, *Enhancing Your Blog with Advanced Features*, in the *Handling pagination errors* section, the debug page showed information related to unhandled exceptions when implementing object pagination.

The Django debug page provides useful debug information. However, there is a Django application that includes more detailed debug information and can be really helpful when developing.

Django Debug Toolbar is an external Django application that allows you to see relevant debug information about the current request/response cycle. The information is divided into multiple panels that show different information, including request/response data, Python package versions used, execution time, settings, headers, SQL queries, templates used, cache, signals, and logging.

You can find the documentation for Django Debug Toolbar at `https://django-debug-toolbar.readthedocs.io/`.

Installing Django Debug Toolbar

Install `django-debug-toolbar` via `pip` using the following command:

```
python -m pip install django-debug-toolbar==4.3.0
```

Edit the `settings.py` file of your project and add `debug_toolbar` to the `INSTALLED_APPS` setting, as follows. The new line is highlighted in bold:

```
INSTALLED_APPS = [
    # ...
    'debug_toolbar',
    # ...
]
```

In the same file, add the following line highlighted in bold to the `MIDDLEWARE` setting:

```
MIDDLEWARE = [
    'debug_toolbar.middleware.DebugToolbarMiddleware',
    'django.middleware.security.SecurityMiddleware',
    'django.contrib.sessions.middleware.SessionMiddleware',
    'django.middleware.common.CommonMiddleware',
```

```
    'django.middleware.csrf.CsrfViewMiddleware',
    'django.contrib.auth.middleware.AuthenticationMiddleware',
    'django.contrib.messages.middleware.MessageMiddleware',
    'django.middleware.clickjacking.XFrameOptionsMiddleware',
]
```

Django Debug Toolbar is mostly implemented as middleware. The order of `MIDDLEWARE` is important. `DebugToolbarMiddleware` has to be placed before any other middleware, except for middleware that encodes the response's content, such as `GZipMiddleware`, which, if present, should come first.

Add the following lines at the end of the `settings.py` file:

```
INTERNAL_IPS = [
    '127.0.0.1',
]
```

Django Debug Toolbar will only display if your IP address matches an entry in the `INTERNAL_IPS` setting. To prevent showing debug information in production, Django Debug Toolbar checks that the `DEBUG` setting is `True`.

Edit the main `urls.py` file of your project and add the following URL pattern highlighted in bold to `urlpatterns`:

```
urlpatterns = [
    path('admin/', admin.site.urls),
    path('account/', include('account.urls')),
    path(
        'social-auth/',
        include('social_django.urls', namespace='social')
    ),
    path('images/', include('images.urls', namespace='images')),
    path('__debug__/', include('debug_toolbar.urls')),
]
```

Django Debug Toolbar is now installed in your project. Let's try it out!

Run the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/images/` with your browser. You should now see a collapsible sidebar on the right. It should look as follows:

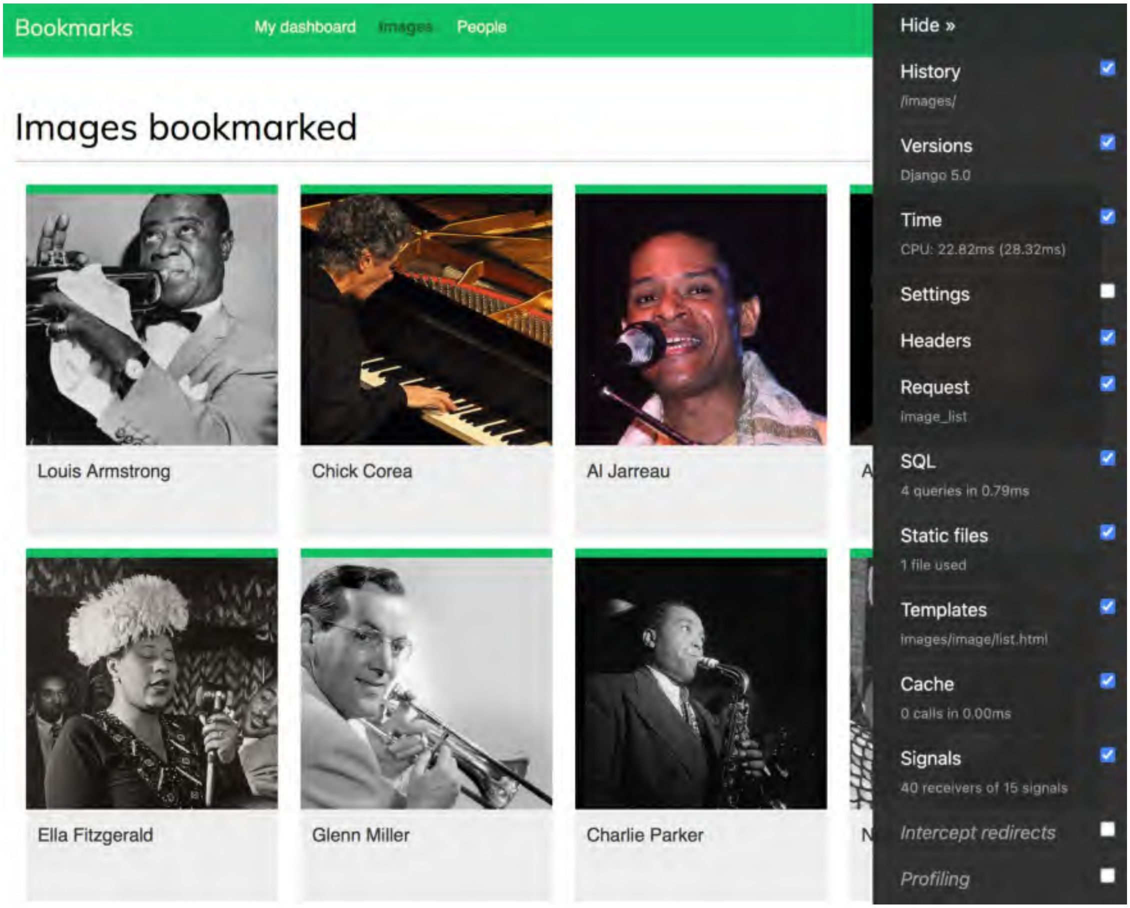

Figure 7.10: The Django Debug Toolbar sidebar

Figure 7.10 image attributions:

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If the Debug Toolbar doesn't appear, check the RunServer shell console log. If you see a MIME type error, it is most likely that your MIME map files are incorrect or need to be updated.

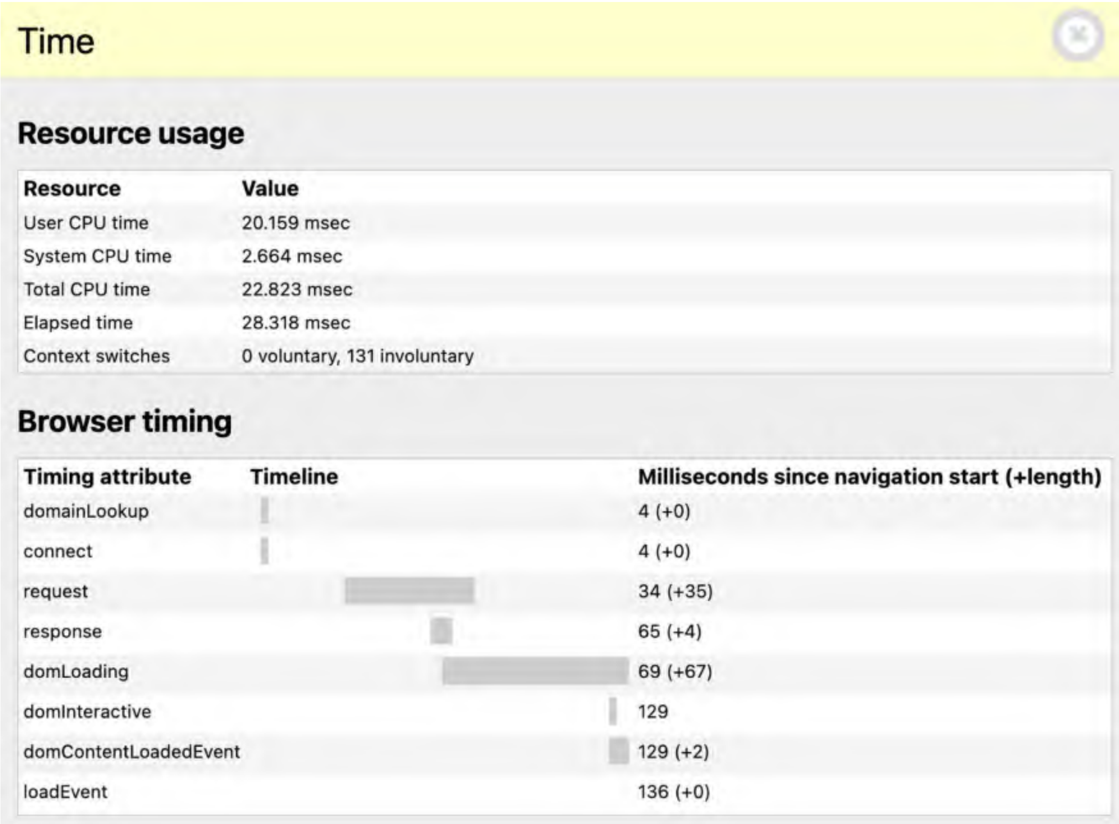
You can apply the correct mapping for JavaScript and CSS files by adding the following lines to the `settings.py` file:

```
if DEBUG:
    import mimetypes
    mimetypes.add_type('application/javascript', '.js', True)
    mimetypes.add_type('text/css', '.css', True)
```

Django Debug Toolbar panels

Django Debug Toolbar features multiple panels that organize the debug information for the request/response cycle. The sidebar contains links to each panel, and you can use the checkbox of any panel to activate or deactivate it. The change will be applied to the next request. This is useful when we are not interested in a specific panel, but the calculation adds too much overhead to the request.

Click on **Time** in the sidebar menu. You will see the following panel:



Time

Resource usage

Resource	Value
User CPU time	20.159 msec
System CPU time	2.664 msec
Total CPU time	22.823 msec
Elapsed time	28.318 msec
Context switches	0 voluntary, 131 involuntary

Browser timing

Timing attribute	Timeline	Milliseconds since navigation start (+length)
domainLookup		4 (+0)
connect		4 (+0)
request		34 (+35)
response		65 (+4)
domLoading		69 (+67)
domInteractive		129
domContentLoadedEvent		129 (+2)
loadEvent		136 (+0)

Figure 7.11: Time panel – Django Debug Toolbar

The **Time** panel includes a timer for the different phases of the request/response cycle. It also shows CPU, elapsed time, and the number of context switches. If you are using Windows, you won't be able to see the **Time** panel. In Windows, only the total time is available and displayed in the toolbar.

Click on **SQL** in the sidebar menu. You will see the following panel:

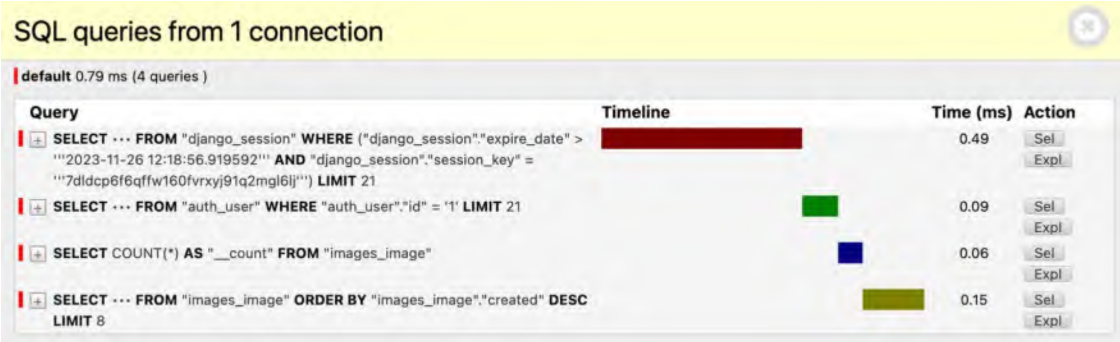


Figure 7.12: SQL panel – Django Debug Toolbar

Here, you can see the different SQL queries that have been executed. This information can help you identify unnecessary queries, duplicated queries that can be reused, or long-running queries that can be optimized. Based on your findings, you can improve QuerySets in your views, create new indexes on model fields if necessary, or cache information when needed. In this chapter, you learned how to optimize queries that involve relationships using `select_related()` and `prefetch_related()`. You will learn how to cache data in *Chapter 14*, *Rendering and Caching Content*.

Click on **Templates** in the sidebar menu. You will see the following panel:

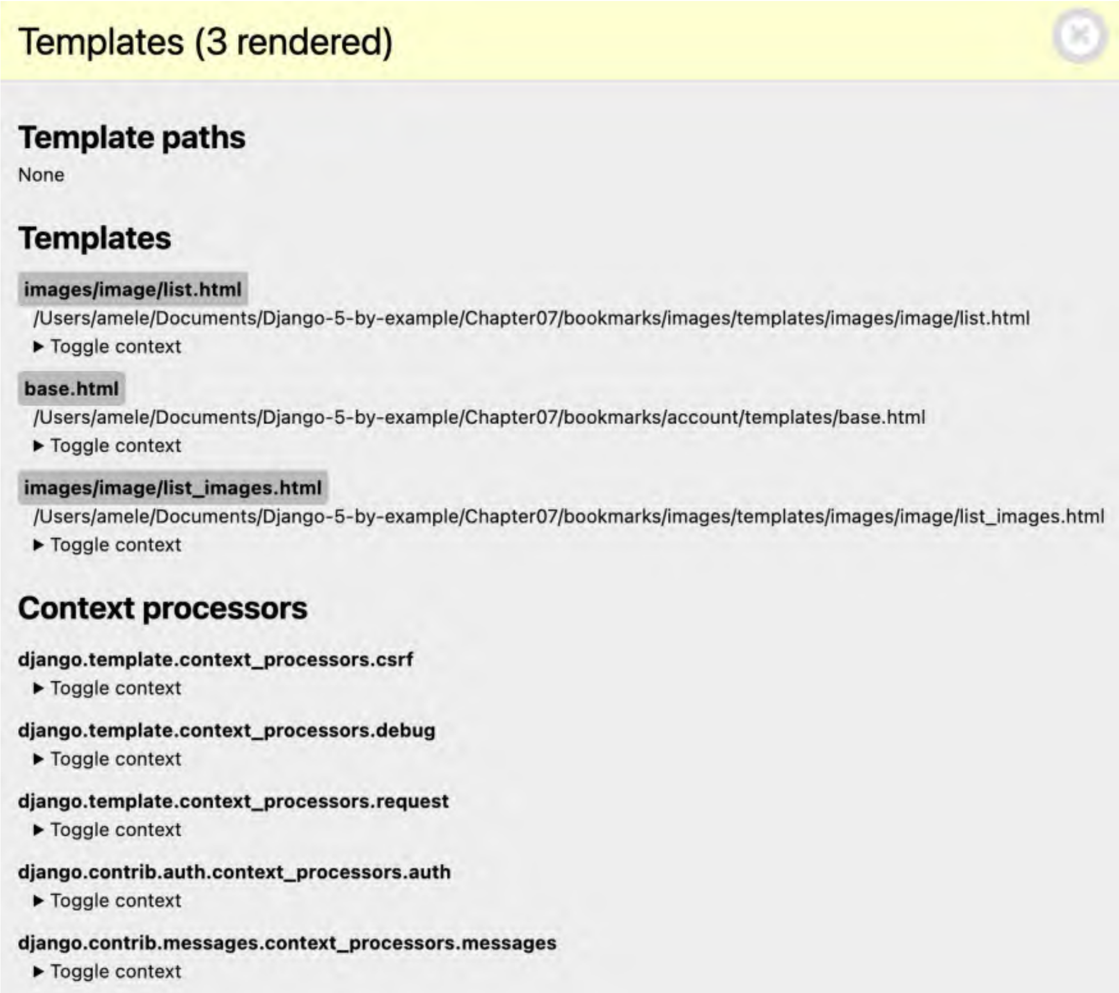


Figure 7.13: Templates panel – Django Debug Toolbar

This panel shows the different templates used when rendering the content, the template paths, and the context used. You can also see the different context processors used. You will learn about context processors in *Chapter 8*, *Building an Online Shop*.

Click on **Signals** in the sidebar menu. You will see the following panel:

Signals

Signal	Receivers
class_prepared	
connection_created	
got_request_exception	
m2m_changed	users_like_changed
post_delete	
post_init	
post_migrate	create_permissions, create_contenttypes
post_save	signal_committed_filefields
pre_delete	
pre_init	
pre_migrate	inject_rename_contenttypes_operations
pre_save	find_uncommitted_filefields
request_finished	close_caches, close_old_connections, reset_urlconf
request_started	reset_queries, close_old_connections
setting_changed	reset_cache, clear_cache_handlers, update_installed_apps, update_connections_time_zone, clear_routers_cache, reset_template_engines, storages_changed, clear_serializers_cache, language_changed, localize_settings_changed, file_storage_changed, complex_setting_changed, root_urlconf_changed, static_storage_changed, static_finders_changed, auth_password_validators_changed, user_model_swapped, update_toolbar_config, reset_hashers, update_level_tags, clear_caches, FileSystemStorage._clear_cached_properties, FileSystemStorage._clear_cached_properties, FileSystemStorage._clear_cached_properties, FileSystemStorage._clear_cached_properties, FileSystemStorage._clear_cached_properties, StaticFilesStorage._clear_cached_properties, FileSystemStorage._clear_cached_properties, ThumbnailFileSystemStorage._clear_cached_properties

Figure 7.14: Signals panel – Django Debug Toolbar

In this panel, you can see all the signals that are registered in your project and the receiver functions attached to each signal. For example, you can find the `users_like_changed` receiver function you created before, attached to the `m2m_changed` signal. The other signals and receivers are part of the different Django applications.

We have reviewed some of the panels that ship with Django Debug Toolbar. Besides the built-in panels, you can find additional third-party panels that you can download and use at `https://django-debug-toolbar.readthedocs.io/en/latest/panels.html#third-party-panels`.

Django Debug Toolbar commands

Besides the request/response debug panels, Django Debug Toolbar provides a management command to debug SQL for ORM calls. The management command `debugsqlshell` replicates the Django `shell` command but it outputs SQL statements for queries performed with the Django ORM.

Open the shell with the following command:

```
python manage.py debugsqlshell
```

Execute the following code:

```
>>> from images.models import Image
>>> Image.objects.get(id=1)
```

You will see the following output:

```
SELECT "images_image"."id",
       "images_image"."user_id",
       "images_image"."title",
       "images_image"."slug",
       "images_image"."url",
       "images_image"."image",
       "images_image"."description",
       "images_image"."created",
       "images_image"."total_likes"
FROM "images_image"
WHERE "images_image"."id" = 1
LIMIT 21 [0.44ms]
<Image: Django and Duke>
```

You can use this command to test ORM queries before adding them to your views. You can check the resulting SQL statement and the execution time for each ORM call.

In the next section, you will learn how to count image views using Redis, an in-memory database that provides low latency and high-throughput data access.

Counting image views with Redis

Redis is an advanced key/value database that allows you to save different types of data. It also has extremely fast I/O operations. Redis stores everything in memory, but the data can be persisted by dumping the dataset to disk every once in a while, or by adding each command to a log. Redis is very versatile compared to other key/value stores: it provides a set of powerful commands and supports diverse data structures, such as strings, hashes, lists, sets, ordered sets, and even `bitmap` or `HyperLogLog` methods.

Although SQL is best suited to schema-defined persistent data storage, Redis offers numerous advantages when dealing with rapidly changing data, volatile storage, or when a quick cache is needed. Let's take a look at how Redis can be used to build new functionality in your project.

You can find more information about Redis on its home page at `https://redis.io/`.

Redis provides a Docker image that makes it very easy to deploy a Redis server with a standard configuration.

Installing Redis

To install the Redis Docker image, make sure Docker is installed on your machine. You learned how to install Docker in *Chapter 3*, *Extending Your Blog Application*.

Run the following command from the shell:

```
docker pull redis:7.2.4
```

This will download the Redis Docker image to your local machine. You can find information about the official Redis Docker image at `https://hub.docker.com/_/redis`. You can find other alternative methods to install Redis at `https://redis.io/download/`.

Execute the following command in the shell to start the Redis Docker container:

```
docker run -it --rm --name redis -p 6379:6379 redis:7.2.4
```

With this command, we run Redis in a Docker container. The `-it` option tells Docker to take you straight inside the container for interactive input. The `--rm` option tells Docker to automatically clean up the container and remove the file system when the container exits. The `--name` option is used to assign a name to the container. The `-p` option is used to publish the `6379` port on which Redis runs to the same host interface port. `6379` is the default port for Redis.

You should see an output that ends with the following lines:

```
# Server initialized
* Ready to accept connections
```

Keep the Redis server running on port `6379` and open another shell. Start the Redis client with the following command:

```
docker exec -it redis sh
```

You will see a line with the hash symbol:

```
#
```

Start the Redis client with the following command:

```
# redis-cli
```

You will see the Redis client shell prompt, like this:

```
127.0.0.1:6379>
```

The Redis client allows you to execute Redis commands directly from the shell. Let's try some commands. Enter the `SET` command in the Redis shell to store a value in a key:

```
127.0.0.1:6379> SET name "Peter"
OK
```

The preceding command creates a `name` key with the string value `"Peter"` in the Redis database. The `OK` output indicates that the key has been saved successfully.

Next, retrieve the value using the `GET` command, as follows:

```
127.0.0.1:6379> GET name
```

```
"Peter"
```

You can also check whether a key exists using the `EXISTS` command. This command returns `1` if the given key exists and `0` otherwise:

```
127.0.0.1:6379> EXISTS name
(integer) 1
```

You can set the time for a key to expire using the `EXPIRE` command, which allows you to set the time-to-live in seconds. Another option is using the `EXPIREAT` command, which expects a Unix timestamp. Key expiration is useful for using Redis as a cache or to store volatile data:

```
127.0.0.1:6379> GET name
"Peter"
127.0.0.1:6379> EXPIRE name 2
(integer) 1
```

Wait for more than two seconds and try to get the same key again:

```
127.0.0.1:6379> GET name
(nil)
```

The `(nil)` response is a null response and means that no key has been found. You can also delete any key using the `DEL` command, as follows:

```
127.0.0.1:6379> SET total 1
OK
127.0.0.1:6379> DEL total
(integer) 1
127.0.0.1:6379> GET total
(nil)
```

These are just basic commands for key operations. You can find all Redis commands at `https://redis.io/commands/` and all Redis data types at `https://redis.io/docs/manual/data-types/`.

Using Redis with Python

You will need Python bindings for Redis. Install `redis-py` via `pip` using the following command:

```
python -m pip install redis==5.0.4
```

You can find the `redis-py` documentation at `https://redis-py.readthedocs.io/`.

The `redis-py` package interacts with Redis, providing a Python interface that follows the Redis command syntax. Open the Python shell with the following command:

```
python manage.py shell
```

Execute the following code:

```
>>> import redis
>>> r = redis.Redis(host='localhost', port=6379, db=0)
```

The preceding code creates a connection with the Redis database. In Redis, databases are identified by an integer index instead of a database name. By default, a client is connected to database `0`. The number of available Redis databases is set to `16` but you can change this in the `redis.conf` configuration file.

Next, set a key using the Python shell:

```
>>> r.set('foo', 'bar')
True
```

The command returns `True`, indicating that the key has been successfully created. Now you can retrieve the key using the `get()` command:

```
>>> r.get('foo')
b'bar'
```

As you will note from the preceding code, the methods of Redis follow the Redis command syntax.

Let's integrate Redis into your project. Edit the `settings.py` file of the `bookmarks` project and add the following settings to it:

```
REDIS_HOST = 'localhost'
REDIS_PORT = 6379
REDIS_DB = 0
```

These are the settings for the Redis server and the database that you will use for your project.

Storing image views in Redis

Let's find a way to store the total number of times an image has been viewed. If you implement this using the Django ORM, it will involve a SQL `UPDATE` query every time an image is displayed.

If you use Redis instead, you just need to increment a counter stored in memory, resulting in much better performance and less overhead.

Edit the `views.py` file of the `images` application and add the following code to it after the existing `import` statements:

```
import redis
from django.conf import settings

# connect to redis
r = redis.Redis(
    host=settings.REDIS_HOST,
    port=settings.REDIS_PORT,
```

```
    db=settings.REDIS_DB
)
```

With the preceding code, you establish the Redis connection in order to use it in your views. Edit the `views.py` file of the `images` application and modify the `image_detail` view, like this. The new code is highlighted in bold:

```
def image_detail(request, id, slug):
    image = get_object_or_404(Image, id=id, slug=slug)
    # increment total image views by 1
    total_views = r.incr(f'image:{image.id}:views')
    return render(
        request,
        'images/image/detail.html',
        {
            'section': 'images',
            'image': image,
            'total_views': total_views
        }
    )
```

In this view, you use the `incr` command, which increments the value of a given key by `1`. If the key doesn't exist, the `incr` command creates it. The `incr()` method returns the final value of the key after performing the operation. You store the value in the `total_views` variable and pass it into the template context. You build the Redis key using a notation such as `object-type:id:field` (for example, `image:33:id`).

The convention for naming Redis keys is to use a colon sign as a separator for creating namespaced keys. By doing so, the key names are especially verbose, and related keys share part of the same schema in their names.

Edit the `images/image/detail.html` template of the `images` application and add the following code highlighted in bold:

```
...
<div class="image-info">
  <div>
    <span class="count">
      <span class="total">{{ total_likes }}</span>
      like{{ total_likes|pluralize }}
    </span>
    <span class="count">
      {{ total_views }} view{{ total_views|pluralize }}
```

```
      </span>
      <a href="#" data-id="{{ image.id }}" data-action="{% if request.user in
users_like %}un{% endif %}like"
      class="like button">
        {% if request.user not in users_like %}
          Like
        {% else %}
          Unlike
        {% endif %}
      </a>
    </div>
    {{ image.description|linebreaks }}
  </div>
  ...
```

Run the development server with the following command:

```
python manage.py runserver
```

Open an image detail page in your browser and reload it several times. You will see that each time the view is processed, the total views displayed is incremented by 1. Take a look at the following example:

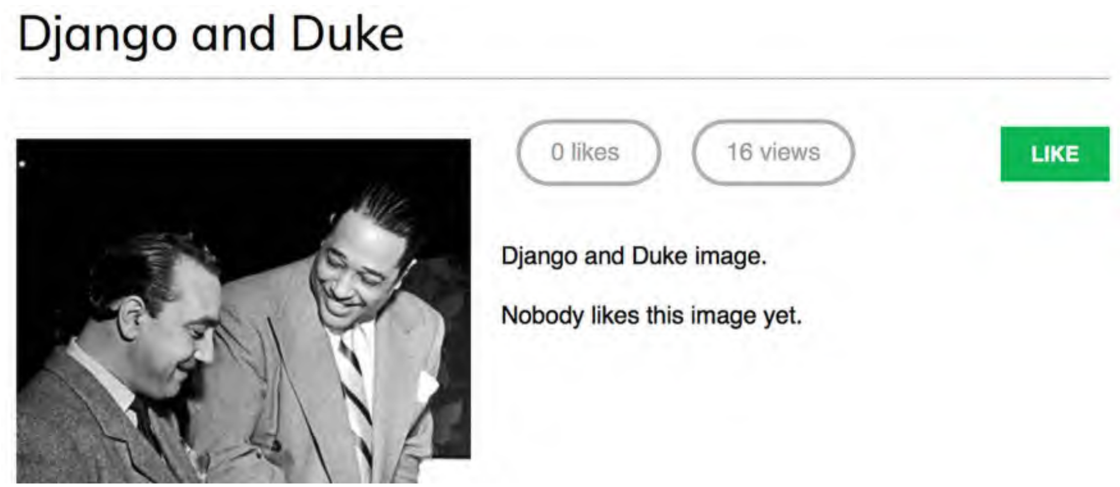


Figure 7.15: The image detail page, including the count of likes and views

Great! You have successfully integrated Redis into your project to count image views. In the next section, you will learn how to build a ranking of the most viewed images with Redis.

Storing a ranking in Redis

We will now create something more complex with Redis. We will use Redis to store a ranking of the most viewed images on the platform. We will use Redis sorted sets for this. A sorted set is a non-repeating collection of strings in which every member is associated with a score. Items are sorted by their score.

Edit the `views.py` file of the `images` application and add the following code highlighted in bold to the `image_detail` view:

```
def image_detail(request, id, slug):
    image = get_object_or_404(Image, id=id, slug=slug)
    # increment total image views by 1
    total_views = r.incr(f'image:{image.id}:views')
    # increment image ranking by 1
    r.zincrby('image_ranking', 1, image.id)
    return render(
        request,
        'images/image/detail.html',
        {
            'section': 'images',
            'image': image,
            'total_views': total_views
        }
    )
```

You use the `zincrby()` command to store image views in a sorted set with the `image:ranking` key. You will store the image `id` and a related score of `1`, which will be added to the total score of this element in the sorted set. This will allow you to keep track of all image views globally and have a sorted set ordered by the total number of views.

Now, create a new view to display the ranking of the most viewed images. Add the following code to the `views.py` file of the `images` application:

```
@login_required
def image_ranking(request):
    # get image ranking dictionary
    image_ranking = r.zrange(
        'image_ranking', 0, -1,
        desc=True
    )[:10]
    image_ranking_ids = [int(id) for id in image_ranking]
    # get most viewed images
    most_viewed = list(
        Image.objects.filter(
            id__in=image_ranking_ids
        )
    )
    most_viewed.sort(key=lambda x: image_ranking_ids.index(x.id))
    return render(
```

```
        request,
        'images/image/ranking.html',
        {'section': 'images', 'most_viewed': most_viewed}
    )
```

The `image_ranking` view works like this:

1. You use the `zrange()` command to obtain the elements in the sorted set. This command expects a custom range according to the lowest and highest scores. By using `0` as the lowest and `-1` as the highest score, you are telling Redis to return all elements in the sorted set. You also specify `desc=True` to retrieve the elements ordered by descending score. Finally, you slice the results using `[:10]` to get the first 10 elements with the highest score.
2. You build a list of returned image IDs and store it in the `image_ranking_ids` variable as a list of integers. You retrieve the `Image` objects for those IDs and force the query to be executed using the `list()` function. It is important to force the QuerySet execution because you will use the `sort()` method on it (at this point, you need a list of objects instead of a QuerySet).
3. You sort the `Image` objects by their index of appearance in the image ranking. Now you can use the `most_viewed` list in your template to display the 10 most viewed images.

Create a new `ranking.html` template inside the `images/image/` template directory of the `images` application and add the following code to it:

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

{% block title %}Images ranking{% endblock %}

{% block content %}
  <h1>Images ranking</h1>
  <ol>
    {% for image in most_viewed %}
      <li>
        <a href="{{ image.get_absolute_url }}">
          {{ image.title }}
        </a>
      </li>
    {% endfor %}
  </ol>
{% endblock %}
```

The template is pretty straightforward. You iterate over the `Image` objects contained in the `most_viewed` list and display their names, including a link to the image detail page.

Finally, you need to create a URL pattern for the new view. Edit the `urls.py` file of the `images` application and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    path('create/', views.image_create, name='create'),
    path('detail/<int:id>/<slug:slug>/',
         views.image_detail, name='detail'),
    path('like/', views.image_like, name='like'),
    path('', views.image_list, name='list'),
    path('ranking/', views.image_ranking, name='ranking'),
]
```

Run the development server, access your site in your web browser, and load the image detail page multiple times for different images. Then, access `http://127.0.0.1:8000/images/ranking/` from your browser. You should be able to see an image ranking, as follows:

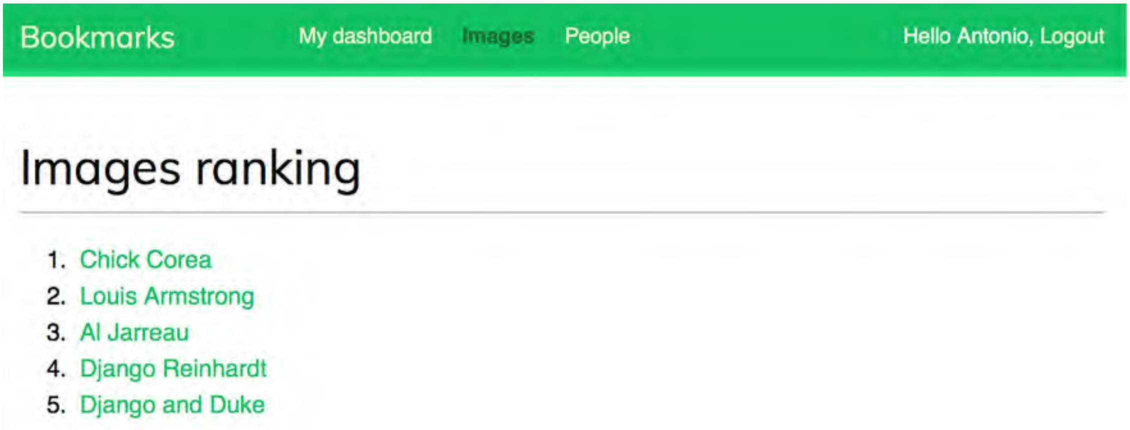


Figure 7.16: The ranking page built with data retrieved from Redis

Great! You just created a ranking with Redis.

Next steps with Redis

Redis is not a replacement for your SQL database but it does offer fast in-memory storage that is more suitable for certain tasks. Add it to your stack and use it when you really feel it's needed. The following are some scenarios in which Redis could be useful:

- **Counting:** As you have seen, it is very easy to manage counters with Redis. You can use `incr()` and `incrby()` for counting stuff.
- **Storing the latest items:** You can add items to the start/end of a list using `lpush()` and `rpush()`. Remove and return the first/last element using `lpop()`/`rpop()`. You can trim the list's length using `ltrim()` to maintain its length.
- **Queues:** In addition to push and pop commands, Redis offers the blocking of queue commands.
- **Caching:** Using `expire()` and `expireat()` allows you to use Redis as a cache. You can also find third-party Redis cache backends for Django.

- **Pub/sub**: Redis provides commands for subscribing/unsubscribing and sending messages to channels.
- **Rankings and leaderboards**: Redis's sorted sets with scores make it very easy to create leaderboards.
- **Real-time tracking**: Redis's fast I/O makes it perfect for real-time scenarios.

Summary

In this chapter, you built a follow system using many-to-many relationships with an intermediate model. You also created an activity stream using generic relations and you optimized QuerySets to retrieve related objects. This chapter then introduced you to Django signals, and you created a signal receiver function to denormalize related object counts. We covered application configuration classes, which you used to load your signal handlers. You added Django Debug Toolbar to your project. You also learned how to install and configure Redis in your Django project. Finally, you used Redis in your project to store item views, and you built an image ranking with Redis.

In the next chapter, you will learn how to build an online shop. You will create a product catalog and build a shopping cart using sessions. You will learn how to create custom context processors. You will also manage customer orders and send asynchronous notifications using Celery and RabbitMQ.

Expanding your project using AI

In this section, you are presented with a task to extend your project, accompanied by a sample prompt for ChatGPT to assist you. To engage with ChatGPT, visit `https://chat.openai.com/`. If this is your first interaction with ChatGPT, you can revisit the *Expanding your project using AI* section in *Chapter 3, Extending Your Blog Application*.

In this project example, you have learned how to use Django signals and successfully implemented a signal receiver to update the total number of image likes whenever there is a change in the like count. Now, let's leverage ChatGPT to explore the implementation of a signal receiver that automatically generates a related `Profile` object whenever a `User` object is created. You can use the prompt provided at `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter07/prompts/task.md`.

After successfully implementing the signal receiver, you can remove the manual profile creation steps previously included in the `register` view of the `account` application and from the social authentication pipeline. With the receiver function now attached to the `post_save` signal of the `User` model, profiles will be automatically created for new users.

> If you're having trouble understanding a particular concept or topic in the book, ask ChatGPT to provide additional examples or to explain the concept in a different way. This personalized approach can reinforce your learning and ensure you grasp complex topics.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter07`
- Custom user models: `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#specifying-a-custom-user-model`
- The `contenttypes` framework: `https://docs.djangoproject.com/en/5.0/ref/contrib/contenttypes/`
- Built-in Django signals: `https://docs.djangoproject.com/en/5.0/ref/signals/`
- Application configuration classes: `https://docs.djangoproject.com/en/5.0/ref/applications/`
- Django Debug Toolbar documentation: `https://django-debug-toolbar.readthedocs.io/`
- Django Debug Toolbar third-party panels: `https://django-debug-toolbar.readthedocs.io/en/latest/panels.html#third-party-panels`
- Redis in-memory data store: `https://redis.io/`
- Official Redis Docker image: `https://hub.docker.com/_/redis`.
- Redis download options: `https://redis.io/download/`
- Redis commands: `https://redis.io/commands/`
- Redis data types: `https://redis.io/docs/manual/data-types/`
- `redis-py` documentation: `https://redis-py.readthedocs.io/`

8

Building an Online Shop

In the previous chapter, you created a follow system and built a user activity stream. You also learned how Django signals work and integrated Redis into your project to count image views.

In this chapter, you will start a new Django project that consists of a fully featured online shop. This chapter and the following two chapters will show you how to build the essential functionalities of an e-commerce platform. Your online shop will enable clients to browse products, add them to the cart, apply discount codes, go through the checkout process, pay with a credit card, and obtain an invoice. You will also implement a recommendation engine to recommend products to your customers, and you will use internationalization to offer your site in multiple languages.

In this chapter, you will learn how to:

- Create a product catalog
- Build a shopping cart using Django sessions
- Create custom template context processors
- Manage customer orders
- Configure Celery in your project with RabbitMQ as a message broker
- Send asynchronous notifications to customers using Celery
- Monitor Celery using Flower

Functional overview

Figure 8.1 shows a representation of the views, templates, and main functionalities that will be built in this chapter:

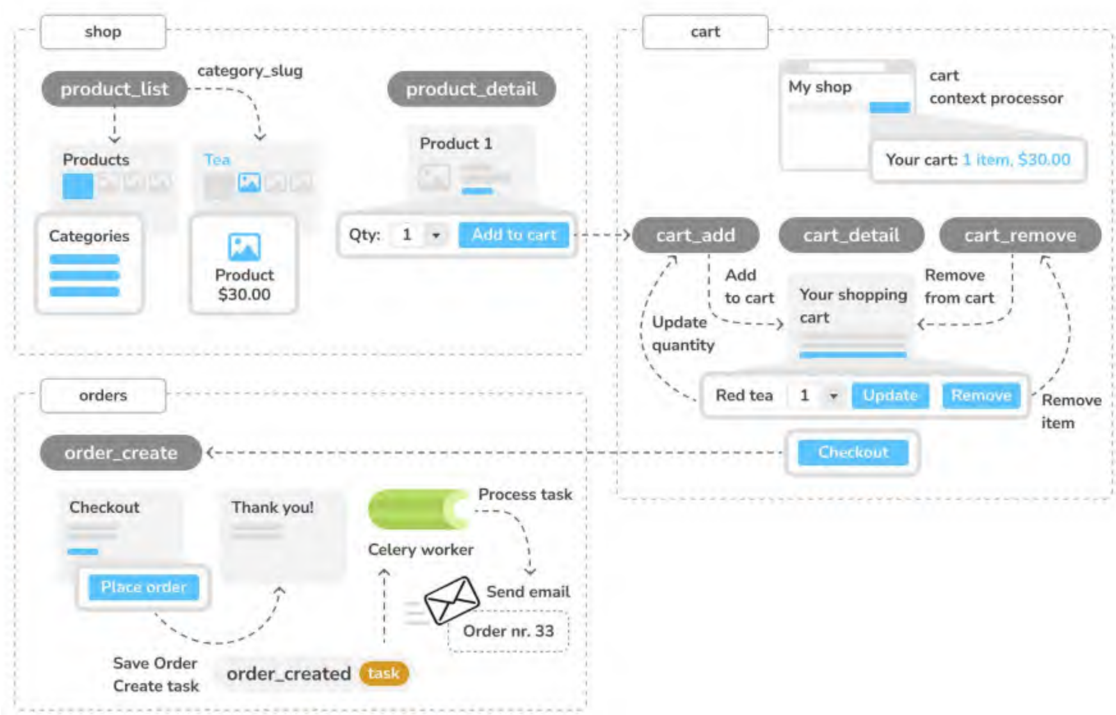


Figure 8.1: Diagram of functionalities built in Chapter 8

In this chapter, you will implement the `product_list` view to list all products and the `product_detail` view to display a single product. You will allow filtering products by category in the `product_list` view using the `category_slug` parameter. You will implement a shopping cart using sessions and you will build the `cart_detail` view to display the cart items. You will create the `cart_add` view to add products to the cart and update quantities, and the `cart_remove` view to remove products from the cart. You will implement the `cart` template context processor to display the number of cart items and total cost on the site header. You will also create the `order_create` view to place orders, and you will use Celery to implement the `order_created` asynchronous task that sends out an email confirmation to clients when they place an order. This chapter will provide you with the knowledge to implement user sessions in your application and show you how to work with asynchronous tasks. Both are very common use cases that you can apply to almost any project.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter08`.

All Python modules used in this chapter are included in the `requirements.txt` file in the source code that comes along with this chapter. You can follow the instructions to install each Python module below or you can install all requirements at once with the command `python -m pip install -r requirements.txt`.

Creating an online shop project

Let's start with a new Django project to build an online shop. Your users will be able to browse through a product catalog and add products to a shopping cart. Finally, they will be able to check out the cart and place an order. This chapter will cover the following functionalities of an online shop:

- Creating the product catalog models, adding them to the administration site, and building the basic views to display the catalog
- Building a shopping cart system using Django sessions to allow users to keep selected products while they browse the site
- Creating the form and functionality to place orders on the site
- Sending an asynchronous email confirmation to users when they place an order

Open a shell and use the following command to create a new virtual environment for this project within the `env/` directory:

```
python -m venv env/myshop
```

If you are using Linux or macOS, run the following command to activate your virtual environment:

```
source env/myshop/bin/activate
```

If you are using Windows, use the following command instead:

```
.\env\myshop\Scripts\activate
```

The shell prompt will display your active virtual environment, as follows:

```
(myshop)laptop:~ zenx$
```

Install Django in your virtual environment with the following command:

```
python -m pip install Django~=5.0.4
```

Start a new project called `myshop` with an application called `shop` by opening a shell and running the following command:

```
django-admin startproject myshop
```

The initial project structure has been created. Use the following commands to get into your project directory and create a new application named `shop`:

```
cd myshop/
django-admin startapp shop
```

Edit `settings.py` and add the following line highlighted in bold to the `INSTALLED_APPS` list:

```
INSTALLED_APPS = [
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.staticfiles',
    'shop.apps.ShopConfig',
]
```

Your application is now active for this project. Let's define the models for the product catalog.

Creating product catalog models

The catalog of your shop will consist of products that are organized into different categories. Each product will have a name, an optional description, an optional image, a price, and its availability.

Edit the `models.py` file of the `shop` application that you just created and add the following code:

```
from django.db import models


class Category(models.Model):
    name = models.CharField(max_length=200)
    slug = models.SlugField(max_length=200, unique=True)

    class Meta:
        ordering = ['name']
        indexes = [
            models.Index(fields=['name']),
        ]
        verbose_name = 'category'
        verbose_name_plural = 'categories'

    def __str__(self):
        return self.name


class Product(models.Model):
    category = models.ForeignKey(
        Category,
        related_name='products',
```

```
        on_delete=models.CASCADE
    )
    name = models.CharField(max_length=200)
    slug = models.SlugField(max_length=200)
    image = models.ImageField(
        upload_to='products/%Y/%m/%d',
        blank=True
    )
    description = models.TextField(blank=True)
    price = models.DecimalField(max_digits=10, decimal_places=2)
    available = models.BooleanField(default=True)
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)

    class Meta:
        ordering = ['name']
        indexes = [
            models.Index(fields=['id', 'slug']),
            models.Index(fields=['name']),
            models.Index(fields=['-created']),
        ]

    def __str__(self):
        return self.name
```

These are the `Category` and `Product` models. The `Category` model consists of a `name` field and a unique `slug` field (`unique` implies the creation of an index). In the `Meta` class of the `Category` model, we have defined an index for the `name` field.

The `Product` model fields are as follows:

- `category`: A `ForeignKey` to the `Category` model. This is a one-to-many relationship: a product belongs to one category and a category contains multiple products.
- `name`: The name of the product.
- `slug`: The slug for this product to build beautiful URLs.
- `image`: An optional product image.
- `description`: An optional description of the product.
- `price`: This field uses Python's `decimal.Decimal` type to store a fixed-precision decimal number. The maximum number of digits (including the decimal places) is set using the `max_digits` attribute and decimal places with the `decimal_places` attribute.
- `available`: A Boolean value that indicates whether the product is available or not. It will be used to enable/disable the product in the catalog.

- `created`: This field stores when the object was created.
- `updated`: This field stores when the object was last updated.

For the `price` field, we use `DecimalField` instead of `FloatField` to avoid rounding issues.

> Always use `DecimalField` to store monetary amounts. `FloatField` uses Python's `float` type internally, whereas `DecimalField` uses Python's `Decimal` type. By using the `Decimal` type, you will avoid `float` rounding issues.

In the `Meta` class of the `Product` model, we have defined a multiple-field index for the `id` and `slug` fields. Both fields are indexed together to improve performance for queries that utilize the two fields.

We plan to query products by both `id` and `slug`. We have added an index for the `name` field and an index for the `created` field. We have used a hyphen before the field name to define the index in descending order.

Figure 8.2 shows the two data models you have created:

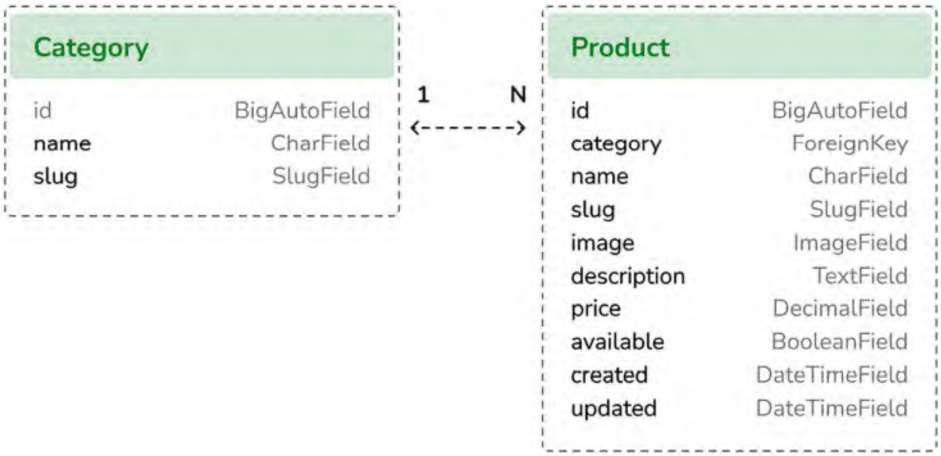


Figure 8.2: Models for the product catalog

In *Figure 8.2*, you can see the different fields of the data models and the one-to-many relationship between the `Category` and the `Product` models.

These models will result in the following database tables displayed in *Figure 8.3*:

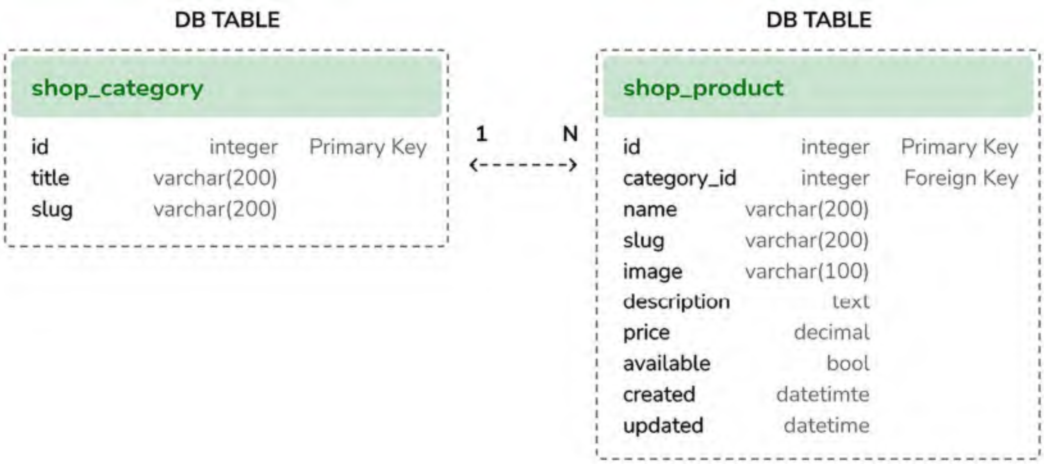


Figure 8.3: Database tables for the product catalog models

The one-to-many relationship between both tables is defined with the `category_id` field in the `shop_product` table, which is used to store the ID of the related `Category` for each `Product` object.

Let's create the initial database migrations for the `shop` application. Since you are going to deal with images in your models, you will need to install the Pillow library. Remember that in *Chapter 4*, *Building a Social Website*, you learned how to install the Pillow library to manage images. Open the shell and install `Pillow` with the following command:

```
python -m pip install Pillow==10.3.0
```

Now run the next command to create initial migrations for your project:

```
python manage.py makemigrations
```

You will see the following output:

```
Migrations for 'shop':
  shop/migrations/0001_initial.py
    - Create model Category
    - Create model Product
```

Run the next command to sync the database:

```
python manage.py migrate
```

You will see output that includes the following line:

```
Applying shop.0001_initial... OK
```

The database is now synced with your models.

Registering catalog models on the administration site

Let's add your models to the administration site so that you can easily manage categories and products. Edit the `admin.py` file of the `shop` application and add the following code to it:

```
from django.contrib import admin
from .models import Category, Product


@admin.register(Category)
class CategoryAdmin(admin.ModelAdmin):
    list_display = ['name', 'slug']
    prepopulated_fields = {'slug': ('name',)}


@admin.register(Product)
class ProductAdmin(admin.ModelAdmin):
    list_display = [
        'name',
        'slug',
        'price',
        'available',
        'created',
        'updated'
    ]
    list_filter = ['available', 'created', 'updated']
    list_editable = ['price', 'available']
    prepopulated_fields = {'slug': ('name',)}
```

Remember that you use the `prepopulated_fields` attribute to specify fields where the value is automatically set using the value of other fields. As you have seen before, this is convenient for generating slugs.

You use the `list_editable` attribute in the `ProductAdmin` class to set the fields that can be edited from the list display page of the administration site. This will allow you to edit multiple rows at once. Any field in `list_editable` must also be listed in the `list_display` attribute since only the fields displayed can be edited.

Now create a superuser for your site using the following command:

```
python manage.py createsuperuser
```

Enter the desired username, email, and password. Run the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/shop/product/add/` in your browser and log in with the user that you just created. Add a new category and product using the administration interface. The **Add product** form should look as follows:

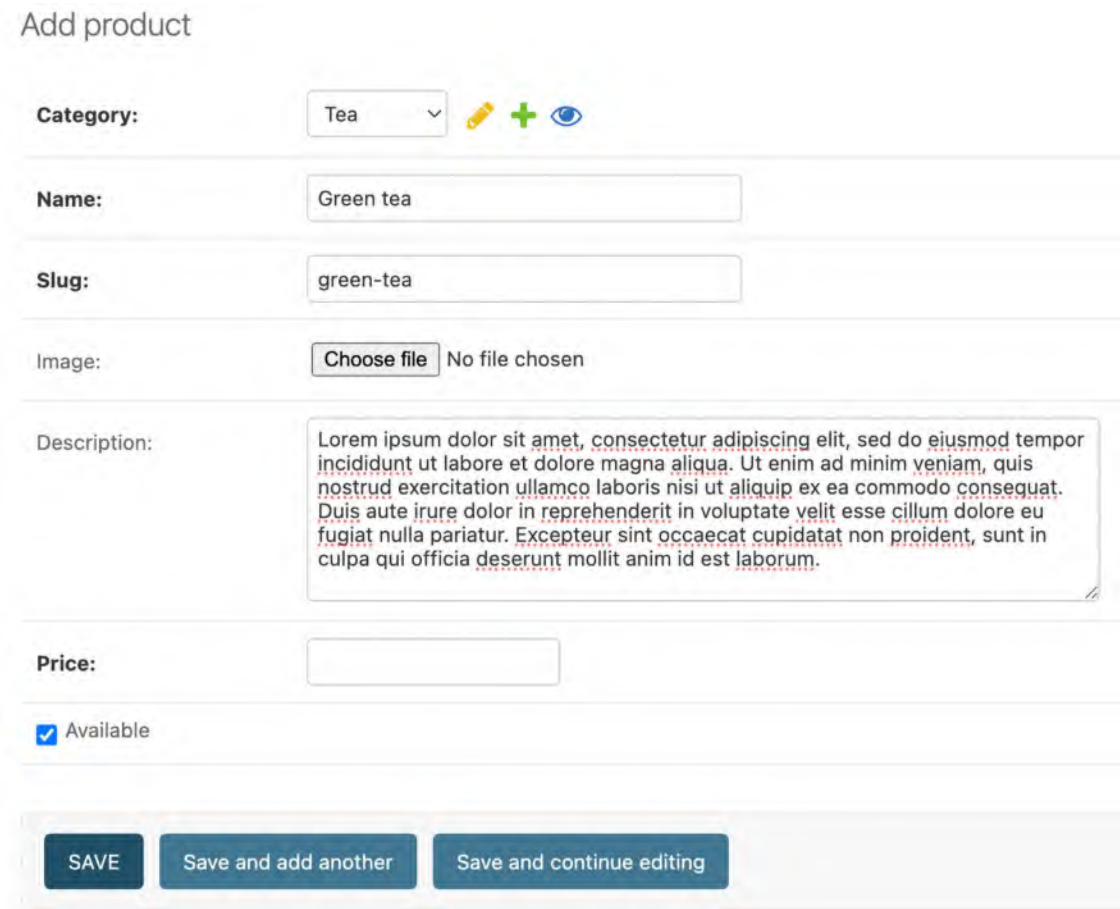


Figure 8.4: The product creation form

Click on the **SAVE** button. The product change list page of the administration page will then look like this:

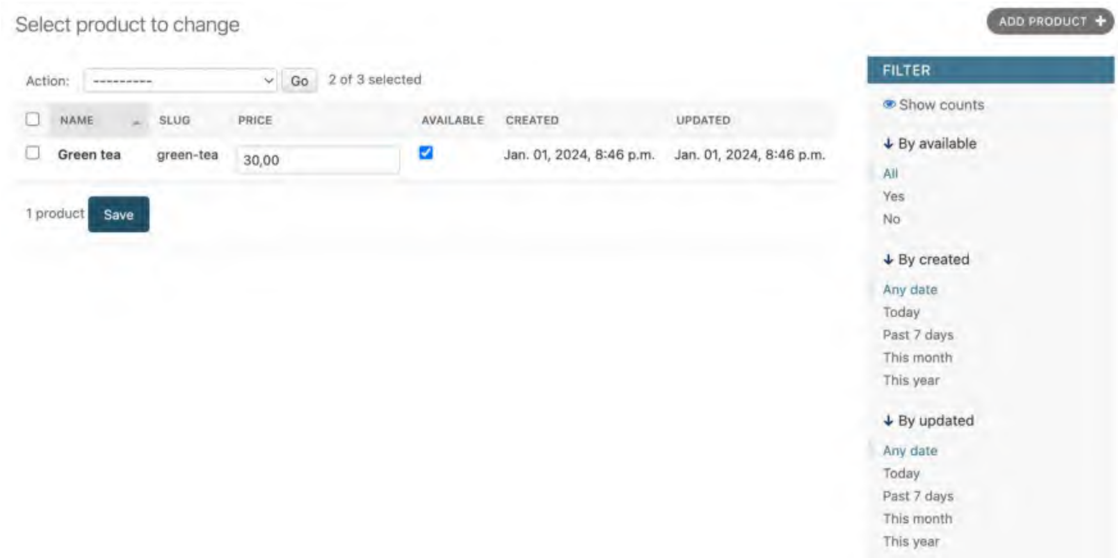


Figure 8.5: The product change list page

Building catalog views

In order to display the product catalog, you need to create a view to list all the products or filter products by a given category. Edit the `views.py` file of the `shop` application and add the following code highlighted in bold:

```
from django.shortcuts import get_object_or_404, render
from .models import Category, Product


def product_list(request, category_slug=None):
    category = None
    categories = Category.objects.all()
    products = Product.objects.filter(available=True)
    if category_slug:
        category = get_object_or_404(Category, slug=category_slug)
        products = products.filter(category=category)
    return render(
        request,
        'shop/product/list.html',
        {
```

```
            'category': category,
            'categories': categories,
            'products': products
        }
    )
```

In the preceding code, you filter the `QuerySet` with `available=True` to retrieve only available products. You use an optional `category_slug` parameter to optionally filter products by a given category.

You also need a view to retrieve and display a single product. Add the following view to the `views.py` file:

```
def product_detail(request, id, slug):
    product = get_object_or_404(
        Product, id=id, slug=slug, available=True
    )
    return render(
        request,
        shop/product/detail.html',
        {'product': product}
    )
```

The `product_detail` view expects the `id` and `slug` parameters in order to retrieve the `Product` instance. You can get this instance just through the ID since it's a unique attribute. However, you include the slug in the URL to build SEO-friendly URLs for products.

After building the product list and detail views, you have to define URL patterns for them. Create a new file inside the `shop` application directory and name it `urls.py`. Add the following code to it:

```
from django.urls import path
from . import views


app_name = 'shop'

urlpatterns = [
    path('', views.product_list, name='product_list'),
    path(
        '<slug:category_slug>/',
        views.product_list,
        name='product_list_by_category'
    ),
    path(
        '<int:id>/<slug:slug>/',
        views.product_detail,
```

```
        name='product_detail'
    ),
]
```

These are the URL patterns for your product catalog. You have defined two different URL patterns for the `product_list` view: a pattern named `product_list`, which calls the `product_list` view without any parameters, and a pattern named `product_list_by_category`, which provides a `category_slug` parameter to the view for filtering products according to a given category. You added a pattern for the `product_detail` view, which passes the `id` and `slug` parameters to the view in order to retrieve a specific product.

Edit the `urls.py` file of the `myshop` project to make it look like this:

```
from django.contrib import admin
from django.urls import include, path


urlpatterns = [
    path('admin/', admin.site.urls),
    path('', include('shop.urls', namespace='shop')),
]
```

In the main URL patterns of the project, you include URLs for the `shop` application under a custom namespace named `shop`.

Next, edit the `models.py` file of the `shop` application, import the `reverse()` function, and add a `get_absolute_url()` method to the `Category` and `Product` models, as follows. The new code is highlighted in bold:

```
from django.db import models
from django.urls import reverse


class Category(models.Model):
    # ...
    def get_absolute_url(self):
        return reverse(
            'shop:product_list_by_category', args=[self.slug]
        )

class Product(models.Model):
    # ...
    def get_absolute_url(self):
        return reverse('shop:product_detail', args=[self.id, self.slug])
```

As you already know, `get_absolute_url()` is the convention to retrieve the URL for a given object. Here, you use the URL patterns that you just defined in the `urls.py` file.

Creating catalog templates

Now you need to create templates for the product list and detail views. Create the following directory and file structure inside the `shop` application directory:

```
templates/
    shop/
        base.html
        product/
            list.html
            detail.html
```

You need to define a base template and then extend it in the product list and detail templates. Edit the `shop/base.html` template and add the following code to it:

```
{% load static %}
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8" />
    <title>{% block title %}My shop{% endblock %}</title>
    <link href="{% static "css/base.css" %}" rel="stylesheet">
  </head>
  <body>
    <div id="header">
      <a href="/" class="logo">My shop</a>
    </div>
    <div id="subheader">
      <div class="cart">
        Your cart is empty.
      </div>
    </div>
    <div id="content">
      {% block content %}
      {% endblock %}
    </div>
  </body>
</html>
```

This is the base template that you will use for your shop. In order to include the CSS styles and images that are used by the templates, you need to copy the static files that accompany this chapter, which are located in the `static/` directory of the `shop` application. Copy them to the same location in your project. You can find the contents of the directory at `https://github.com/PacktPublishing/Django-5-by-Example/tree/main/Chapter08/myshop/shop/static`.

Edit the `shop/product/list.html` template and add the following code to it:

```
{% extends "shop/base.html" %}
{% load static %}

{% block title %}
  {% if category %}{{ category.name }}{% else %}Products{% endif %}
{% endblock %}

{% block content %}
  <div id="sidebar">
    <h3>Categories</h3>
    <ul>
      <li {% if not category %}class="selected"{% endif %}>
        <a href="{% url "shop:product_list" %}">All</a>
      </li>
      {% for c in categories %}
        <li {% if category.slug == c.slug %}class="selected"
        {% endif %}>
          <a href="{{ c.get_absolute_url }}">{{ c.name }}</a>
        </li>
      {% endfor %}
    </ul>
  </div>
  <div id="main" class="product-list">
    <h1>{% if category %}{{ category.name }}{% else %}Products
    {% endif %}</h1>
    {% for product in products %}
      <div class="item">
        <a href="{{ product.get_absolute_url }}">
          <img src="{% if product.image %}{{ product.image.url }}{% else %}{% 
static "img/no_image.png" %}{% endif %}">
        </a>
        <a href="{{ product.get_absolute_url }}">{{ product.name }}</a>
        <br>
        ${{ product.price }}
      </div>
```

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

Make sure that no template tag is split across multiple lines.

This is the product list template. It extends the `shop/base.html` template and uses the `categories` context variable to display all the categories in a sidebar, and `products` to display the products of the current page. The same template is used for both listing all available products and listing products filtered by category. Since the `image` field of the `Product` model can be blank, you need to provide a default image for the products that don't have an image. The image is located in your static files directory with the relative path `img/no_image.png`.

Since you are using `ImageField` to store product images, you need the development server to serve uploaded image files.

Edit the `settings.py` file of `myshop` and add the following settings:

```
MEDIA_URL = 'media/'
MEDIA_ROOT = BASE_DIR / 'media'
```

`MEDIA_URL` is the base URL that serves media files uploaded by users. `MEDIA_ROOT` is the local path where these files reside, which you build by dynamically prepending the `BASE_DIR` variable.

For Django to serve the uploaded media files using the development server, edit the main `urls.py` file of `myshop` and add the following code highlighted in bold:

```
from django.conf import settings
from django.conf.urls.static import static
from django.contrib import admin
from django.urls import include, path


urlpatterns = [
    path('admin/', admin.site.urls),
    path('', include('shop.urls', namespace='shop')),
]

if settings.DEBUG:
    urlpatterns += static(
        settings.MEDIA_URL, document_root=settings.MEDIA_ROOT
    )
```

Remember that you only serve static files this way during development. In a production environment, you should never serve static files with Django; the Django development server doesn't serve static files in an efficient manner. *Chapter 17*, *Going Live*, will teach you how to serve static files in a production environment.

Run the development server with the following command:

```
python manage.py runserver
```

Add a couple of products to your shop using the administration site and open `http://127.0.0.1:8000/` in your browser. You will see the product list page, which will look similar to this:

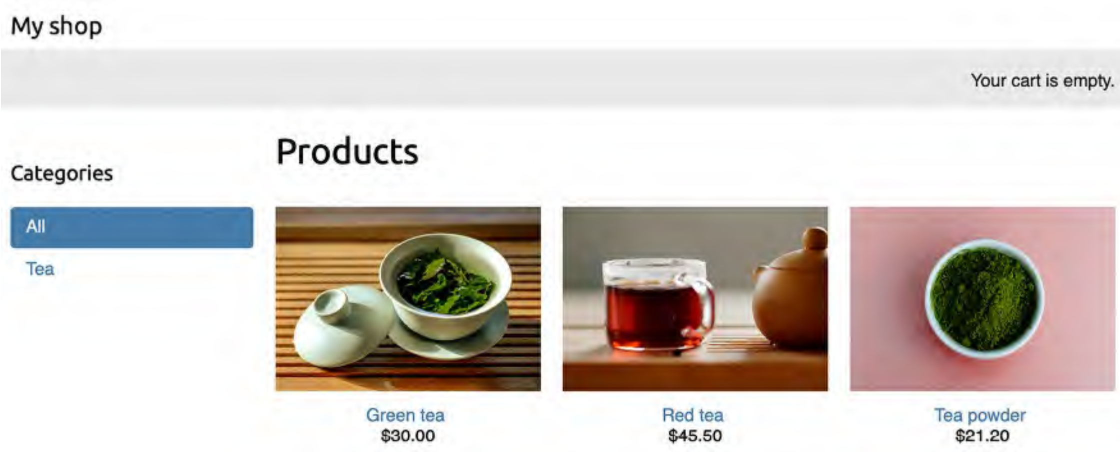


Figure 8.6: The product list page

Credits for images in this chapter:

- *Green tea*: Photo by Jia Ye on Unsplash
- *Red tea*: Photo by Manki Kim on Unsplash
- *Tea powder*: Photo by Phuong Nguyen on Unsplash

If you create a product using the administration site and don't upload an image for it, the default `no_image.png` image will be displayed instead:

Figure 8.7: The product list displaying a default image for products that have no image

Edit the `shop/product/detail.html` template and add the following code to it:

```
{% extends "shop/base.html" %}
{% load static %}

{% block title %}
  {{ product.name }}
{% endblock %}

{% block content %}
  <div class="product-detail">
    <img src="{% if product.image %}{{ product.image.url }}{% else %}
    {% static "img/no_image.png" %}{% endif %}">
    <h1>{{ product.name }}</h1>
    <h2>
      <a href="{{ product.category.get_absolute_url }}">
        {{ product.category }}
      </a>
    </h2>
    <p class="price">${{ product.price }}</p>
    {{ product.description|linebreaks }}
  </div>
{% endblock %}
```

In the preceding code, you call the `get_absolute_url()` method on the related category object to display the available products that belong to the same category.

Now open `http://127.0.0.1:8000/` in your browser and click on any product to see the product detail page. It will look as follows:

Figure 8.8: The product detail page

You have now created a basic product catalog. Next, you will implement a shopping cart that allows users to add any product to it while browsing the online shop.

Building a shopping cart

After building the product catalog, the next step is to create a shopping cart so that users can pick the products that they want to purchase. A shopping cart allows users to select products and set the amount they want to order, and then store this information temporarily while they browse the site until they eventually place an order. The cart has to be persisted in the session so that the cart items are maintained during a user's visit.

You will use Django's session framework to persist the cart. The cart will be kept in the session until it finishes or the user checks out the cart. You will also need to build additional Django models for the cart and its items.

Using Django sessions

Django provides a session framework that supports anonymous and user sessions. The session framework allows you to store arbitrary data for each visitor. Session data is stored on the server side, and cookies contain the session ID unless you use the cookie-based session engine. The session middleware manages the sending and receiving of cookies. The default session engine stores session data in the database, but you can choose other session engines.

To use sessions, you have to make sure that the `MIDDLEWARE` setting of your project contains `django.contrib.sessions.middleware.SessionMiddleware`. This middleware manages sessions. It's added by default to the `MIDDLEWARE` setting when you create a new project using the `startproject` command.

The session middleware makes the current session available in the `request` object. You can access the current session using `request.session`, treating it like a Python dictionary to store and retrieve session data. The `session` dictionary accepts any Python object by default that can be serialized to JSON. You can set a variable in the session like this:

```
request.session['foo'] = 'bar'
```

You can retrieve a session key as follows:

```
request.session.get('foo')
```

You can delete a key you previously stored in the session as follows:

```
del request.session['foo']
```

When users log in to the site, their anonymous session is lost, and a new session is created for authenticated users. If you store items in an anonymous session that you need to keep after the user logs in, you will have to copy the old session data into the new session. You can do this by retrieving the session data before you log in the user using the `login()` function of the Django authentication system and storing it in the session after that.

Session settings

There are several settings you can use to configure sessions for your project. The most important is `SESSION_ENGINE`. This setting allows you to set the place where sessions are stored. By default, Django stores sessions in the database using the `Session` model of the `django.contrib.sessions` application.

Django offers the following options for storing session data:

- **Database sessions:** Session data is stored in the database. This is the default session engine.
- **File-based sessions:** Session data is stored in the filesystem.
- **Cached sessions:** Session data is stored in a cache backend. You can specify cache backends using the `CACHES` setting. Storing session data in a cache system provides the best performance.
- **Cached database sessions:** Session data is stored in a write-through cache and database. Reads only use the database if the data is not already in the cache.
- **Cookie-based sessions:** Session data is stored in the cookies that are sent to the browser.

> For better performance use a cache-based session engine. Django supports Memcached out of the box and you can find third-party cache backends for Redis and other cache systems.

You can customize sessions with specific settings. Here are some of the important session-related settings:

- `SESSION_COOKIE_AGE`: The duration of session cookies in seconds. The default value is `1209600` (two weeks).
- `SESSION_COOKIE_DOMAIN`: The domain used for session cookies. Set this to `mydomain.com` to enable cross-domain cookies or use `None` for a standard domain cookie.
- `SESSION_COOKIE_HTTPONLY`: Whether to use the `HttpOnly` flag on the session cookie. If this is set to `True`, client-side JavaScript will not be able to access the session cookie. The default value is `True` for increased security against user session hijacking.
- `SESSION_COOKIE_SECURE`: A Boolean indicating that the cookie should only be sent if the connection is an HTTPS connection. The default value is `False`.
- `SESSION_EXPIRE_AT_BROWSER_CLOSE`: A Boolean indicating that the session has to expire when the browser is closed. The default value is `False`.
- `SESSION_SAVE_EVERY_REQUEST`: A Boolean that, if `True`, will save the session to the database on every request. The session expiration is also updated each time it's saved. The default value is `False`.

You can see all the session settings and their default values at `https://docs.djangoproject.com/en/5.0/ref/settings/#sessions`.

Session expiration

You can choose to use browser-length sessions or persistent sessions using the `SESSION_EXPIRE_AT_BROWSER_CLOSE` setting. This is set to `False` by default, forcing the session duration to the value stored in the `SESSION_COOKIE_AGE` setting. If you set `SESSION_EXPIRE_AT_BROWSER_CLOSE` to `True`, the session will expire when the user closes the browser, and the `SESSION_COOKIE_AGE` setting will not have any effect.

You can use the `set_expiry()` method of `request.session` to overwrite the duration of the current session.

Storing shopping carts in sessions

You need to create a simple structure that can be serialized to JSON for storing cart items in a session. The cart has to include the following data for each item contained in it:

- The ID of a `Product` instance
- The quantity selected for the product
- The unit price for the product

Since product prices may vary, let's take the approach of storing the product's price along with the product itself when it's added to the cart. By doing so, you use the current price of the product when users add it to their cart, no matter whether the product's price is changed afterward. This means that the price that the item has when the client adds it to the cart is maintained for that client in the session until checkout is completed or the session finishes.

Next, you have to build functionality to create shopping carts and associate them with sessions. This has to work as follows:

- When a cart is needed, you check whether a custom session key is set. If no cart is set in the session, you create a new cart and save it in the cart session key.
- For successive requests, you perform the same check and get the cart items from the cart session key. You retrieve the cart items from the session and their related `Product` objects from the database.

Edit the `settings.py` file of your project and add the following setting to it:

```
CART_SESSION_ID = 'cart'
```

This is the key that you are going to use to store the cart in the user session. Since Django sessions are managed per visitor, you can use the same cart session key for all sessions.

Let's create an application for managing shopping carts. Open the terminal and create a new application, running the following command from the project directory:

```
python manage.py startapp cart
```

Then, edit the `settings.py` file of your project and add the new application to the `INSTALLED_APPS` setting with the following line highlighted in bold:

```
INSTALLED_APPS = [
```

```
    # ...
    'cart.apps.CartConfig',
    'shop.apps.ShopConfig',
]
```

Create a new file inside the `cart` application directory and name it `cart.py`. Add the following code to it:

```
from decimal import Decimal
from django.conf import settings
from shop.models import Product


class Cart:
    def __init__(self, request):
        """
        Initialize the cart.
        """
        self.session = request.session
        cart = self.session.get(settings.CART_SESSION_ID)
        if not cart:
            # save an empty cart in the session
            cart = self.session[settings.CART_SESSION_ID] = {}
        self.cart = cart
```

This is the `Cart` class that will allow you to manage the shopping cart. You require the cart to be initialized with a `request` object. You store the current session using `self.session = request.session` to make it accessible to the other methods of the `Cart` class.

First, you try to get the cart from the current session using `self.session.get(settings.CART_SESSION_ID)`. If no cart is present in the session, you create an empty cart by setting an empty dictionary in the session.

You will build your `cart` dictionary with product IDs as keys, and for each product key, a dictionary will be a value that includes quantity and price. By doing this, you can guarantee that a product will not be added more than once to the cart. This way, you can also simplify retrieving cart items.

Let's create a method to add products to the cart or update their quantity. Add the following `add()` and `save()` methods to the `Cart` class:

```
class Cart:
    # ...
    def add(self, product, quantity=1, override_quantity=False):
        """
        Add a product to the cart or update its quantity.
        """
```

```
        product_id = str(product.id)
        if product_id not in self.cart:
            self.cart[product_id] = {
                'quantity': 0,
                'price': str(product.price)
            }
        if override_quantity:
            self.cart[product_id]['quantity'] = quantity
        else:
            self.cart[product_id]['quantity'] += quantity
        self.save()

    def save(self):
        # mark the session as "modified" to make sure it gets saved
        self.session.modified = True
```

The `add()` method takes the following parameters as input:

- `product`: The `product` instance to add or update in the cart.
- `quantity`: An optional integer with the product quantity. This defaults to `1`.
- `override_quantity`: A Boolean that indicates whether the quantity needs to be overridden with the given quantity (`True`) or whether the new quantity has to be added to the existing quantity (`False`).

You use the product ID as a key in the cart's content dictionary. You convert the product ID into a string because Django uses JSON to serialize session data, and JSON only allows string key names. The product ID is the key, and the value that you persist is a dictionary with quantity and price figures for the product. The product's price is converted from decimal into a string to serialize it. Finally, you call the `save()` method to save the cart in the session.

The `save()` method marks the session as modified using `session.modified = True`. This tells Django that the session has changed and needs to be saved.

You also need a method for removing products from the cart. Add the following method to the `Cart` class:

```
class Cart:
    # ...
    def remove(self, product):
        """
        Remove a product from the cart.
        """
        product_id = str(product.id)
        if product_id in self.cart:
```

```
            del self.cart[product_id]
            self.save()
```

The `remove()` method removes a given product from the `cart` dictionary and calls the `save()` method to update the cart in the session.

You will have to iterate through the items contained in the cart and access the related `Product` instances. To do so, you can define an `__iter__()` method in your class. Add the following method to the `Cart` class:

```
class Cart:
    # ...
    def __iter__(self):
        """
        Iterate over the items in the cart and get the products
        from the database.
        """
        product_ids = self.cart.keys()
        # get the product objects and add them to the cart
        products = Product.objects.filter(id__in=product_ids)
        cart = self.cart.copy()
        for product in products:
            cart[str(product.id)]['product'] = product
        for item in cart.values():
            item['price'] = Decimal(item['price'])
            item['total_price'] = item['price'] * item['quantity']
            yield item
```

In the `__iter__()` method, you retrieve the `Product` instances that are present in the cart to include them in the cart items. You copy the current cart in the `cart` variable and add the `Product` instances to it. Finally, you iterate over the cart items, converting each item's price back into decimal, and adding a `total_price` attribute to each item. This `__iter__()` method will allow you to easily iterate over the items in the cart in views and templates.

You also need a way to return the total number of items in the cart. When the `len()` function is executed on an object, Python calls its `__len__()` method to retrieve its length. Next, you are going to define a custom `__len__()` method to return the total number of items stored in the cart.

Add the following `__len__()` method to the `Cart` class:

```
class Cart:
    # ...
    def __len__(self):
        """
        Count all items in the cart.
```

```
        """
        return sum(item['quantity'] for item in self.cart.values())
```

You return the sum of the quantities of all the cart items.

Add the following method to calculate the total cost of the items in the cart:

```
class Cart:
    # ...
    def get_total_price(self):
        return sum(
            Decimal(item['price']) * item['quantity']
            for item in self.cart.values()
        )
```

Finally, add a method to clear the cart session:

```
class Cart:
    # ...
    def clear(self):
        # remove cart from session
        del self.session[settings.CART_SESSION_ID]
        self.save()
```

Your `Cart` class is now ready to manage shopping carts.

Creating shopping cart views

Now that you have a `Cart` class to manage the cart, you need to create the views to add, update, or remove items from it. You need to create the following views:

- A view to add or update items in the cart that can handle current and new quantities
- A view to remove items from the cart
- A view to display cart items and totals

Adding items to the cart

To add items to the cart, you need a form that allows the user to select a quantity. Create a `forms.py` file inside the `cart` application directory and add the following code to it:

```
from django import forms


PRODUCT_QUANTITY_CHOICES = [(i, str(i)) for i in range(1, 21)]

class CartAddProductForm(forms.Form):
    quantity = forms.TypedChoiceField(
```

```
            choices=PRODUCT_QUANTITY_CHOICES,
            coerce=int
        )
        override = forms.BooleanField(
            required=False,
            initial=False,
            widget=forms.HiddenInput
        )
```

You will use this form to add products to the cart. Your `CartAddProductForm` class contains the following two fields:

- `quantity`: This allows the user to select a quantity between 1 and 20. You use a `TypedChoiceField` field with `coerce=int` to convert the input into an integer.
- `override`: This allows you to indicate whether the quantity has to be added to any existing quantity in the cart for this product (`False`) or whether the existing quantity has to be overridden with the given quantity (`True`). You use a `HiddenInput` widget for this field since you don't want to display it to the user.

Let's create a view for adding items to the cart. Edit the `views.py` file of the `cart` application and add the following code highlighted in bold:

```
from django.shortcuts import get_object_or_404, redirect, render
from django.views.decorators.http import require_POST
from shop.models import Product
from .cart import Cart
from .forms import CartAddProductForm


@require_POST
def cart_add(request, product_id):
    cart = Cart(request)
    product = get_object_or_404(Product, id=product_id)
    form = CartAddProductForm(request.POST)
    if form.is_valid():
        cd = form.cleaned_data
        cart.add(
            product=product,
            quantity=cd['quantity'],
            override_quantity=cd['override']
        )
    return redirect('cart:cart_detail')
```

This is the view for adding products to the cart or updating quantities for existing products. You use the `require_POST` decorator to allow only `POST` requests. The view receives the product ID as a parameter. You retrieve the `Product` instance with the given ID and validate `CartAddProductForm`. If the form is valid, you either add or update the product in the cart. The view redirects to the `cart_detail` URL, which will display the contents of the cart. You are going to create the `cart_detail` view shortly.

You also need a view to remove items from the cart. Add the following code to the `views.py` file of the `cart` application:

```
@require_POST
def cart_remove(request, product_id):
    cart = Cart(request)
    product = get_object_or_404(Product, id=product_id)
    cart.remove(product)
    return redirect('cart:cart_detail')
```

The `cart_remove` view receives the product ID as a parameter. You use the `require_POST` decorator to allow only `POST` requests. You retrieve the `Product` instance with the given ID and remove the product from the cart. Then, you redirect the user to the `cart_detail` URL.

Finally, you need a view to display the cart and its items. Add the following view to the `views.py` file of the `cart` application:

```
def cart_detail(request):
    cart = Cart(request)
    return render(request, 'cart/detail.html', {'cart': cart})
```

The `cart_detail` view gets the current cart to display it.

You have created views to add items to the cart, update quantities, remove items from the cart, and display the cart's contents. Let's add URL patterns for these views. Create a new file inside the `cart` application directory and name it `urls.py`. Add the following URL patterns to it:

```
from django.urls import path
from . import views

app_name = 'cart'

urlpatterns = [
    path('', views.cart_detail, name='cart_detail'),
    path('add/<int:product_id>/', views.cart_add, name='cart_add'),
    path(
        'remove/<int:product_id>/',
        views.cart_remove,
        name='cart_remove'
```

```
    ),
]
```

Edit the main `urls.py` file of the `myshop` project and add the following URL pattern highlighted in bold to include the cart URLs:

```
urlpatterns = [
    path('admin/', admin.site.urls),
    path('cart/', include('cart.urls', namespace='cart')),
    path('', include('shop.urls', namespace='shop')),
]
```

Make sure that you include this URL pattern before the `shop.urls` pattern since it's more restrictive than the latter.

Building a template to display the cart

The `cart_add` and `cart_remove` views don't render any templates, but you need to create a template for the `cart_detail` view to display cart items and totals.

Create the following file structure inside the `cart` application directory:

```
templates/
    cart/
        detail.html
```

Edit the `cart/detail.html` template and add the following code to it:

```
{% extends "shop/base.html" %}
{% load static %}

{% block title %}
  Your shopping cart
{% endblock %}

{% block content %}
  <h1>Your shopping cart</h1>
  <table class="cart">
    <thead>
      <tr>
        <th>Image</th>
        <th>Product</th>
        <th>Quantity</th>
        <th>Remove</th>
        <th>Unit price</th>
        <th>Price</th>
```

```
        </tr>
      </thead>
      <tbody>
        {% for item in cart %}
          {% with product=item.product %}
            <tr>
              <td>
                <a href="{{ product.get_absolute_url }}">
                  <img src="{% if product.image %}{{ product.image.url }}
                  {% else %}{% static "img/no_image.png" %}{% endif %}">
                </a>
              </td>
              <td>{{ product.name }}</td>
              <td>{{ item.quantity }}</td>
              <td>
                <form action="{% url "cart:cart_remove" product.id %}"
method="post">
                  <input type="submit" value="Remove">
                  {% csrf_token %}
                </form>
              </td>
              <td class="num">${{ item.price }}</td>
              <td class="num">${{ item.total_price }}</td>
            </tr>
          {% endwith %}
        {% endfor %}
        <tr class="total">
          <td>Total</td>
          <td colspan="4"></td>
          <td class="num">${{ cart.get_total_price }}</td>
        </tr>
      </tbody>
    </table>
    <p class="text-right">
      <a href="{% url "shop:product_list" %}" class="button
      light">Continue shopping</a>
      <a href="#" class="button">Checkout</a>
    </p>
  {% endblock %}
```

Make sure that no template tag is split across multiple lines.

This is the template that is used to display the cart's contents. It contains a table with the items stored in the current cart. You allow users to change the quantity of the selected products using a form that is posted to the `cart_add` view. You also allow users to remove items from the cart by providing a **Remove** button for each of them. Finally, you use an HTML form with an `action` attribute that points to the `cart_remove` URL including the product ID.

Adding products to the cart

Now you need to add an **Add to cart** button to the product detail page. Edit the `views.py` file of the `shop` application and add `CartAddProductForm` to the `product_detail` view, as follows:

```
from cart.forms import CartAddProductForm

# ...

def product_detail(request, id, slug):
    product = get_object_or_404(
        Product, id=id, slug=slug, available=True
    )
    cart_product_form = CartAddProductForm()
    return render(
        request,
        'shop/product/detail.html',
        {'product': product, 'cart_product_form': cart_product_form}
    )
```

Edit the `shop/product/detail.html` template of the `shop` application and add the following form to the product price, as follows. New lines are highlighted in bold:

```
...
<p class="price">${{ product.price }}</p>
<form action="{% url "cart:cart_add" product.id %}" method="post">
  {{ cart_product_form }}
  {% csrf_token %}
  <input type="submit" value="Add to cart">
</form>
{{ product.description|linebreaks }}
...
```

Run the development server with the following command:

```
python manage.py runserver
```

Now open `http://127.0.0.1:8000/` in your browser and navigate to a product's detail page. It will contain a form to choose a quantity before adding the product to the cart. The page will look like this:

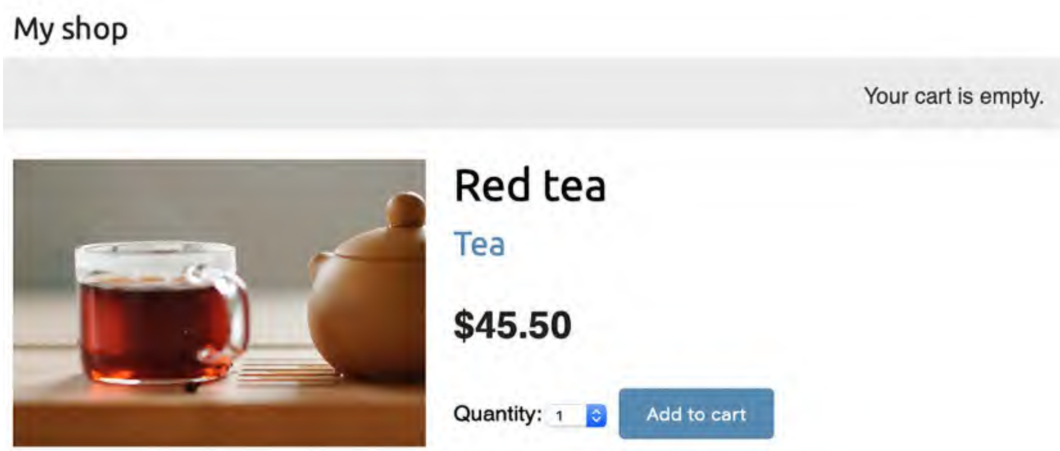


Figure 8.9: The product detail page, including the Add to cart button

Choose a quantity and click on the **Add to cart** button. The form is submitted to the `cart_add` view via `POST`. The view adds the product to the cart in the session, including its current price and the selected quantity. Then, it redirects the user to the cart detail page, which will look like *Figure 8.10*:

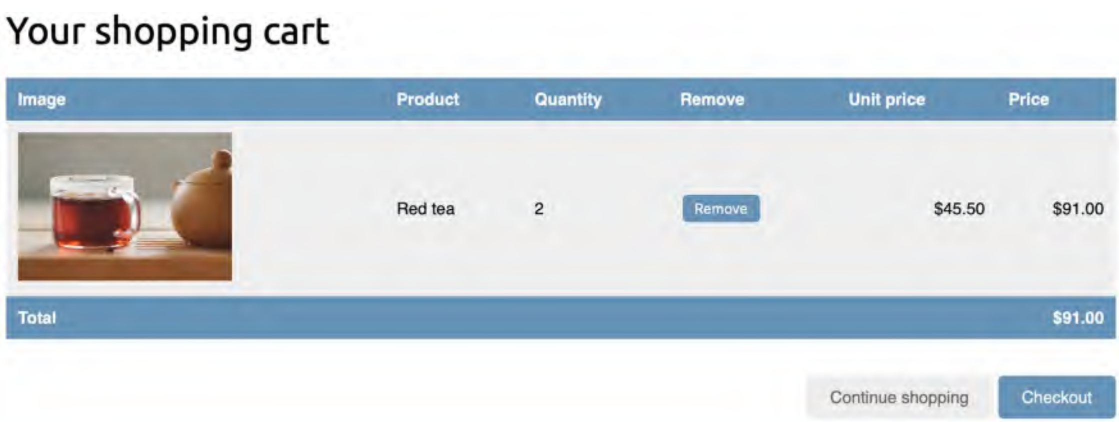


Figure 8.10: The cart detail page

Updating product quantities in the cart

When users see the cart, they might want to change product quantities before placing an order. You are going to allow users to change quantities from the cart detail page.

Edit the `views.py` file of the `cart` application and add the following lines highlighted in bold to the `cart_detail` view:

```
def cart_detail(request):
    cart = Cart(request)
    for item in cart:
        item['update_quantity_form'] = CartAddProductForm(
            initial={'quantity': item['quantity'], 'override': True}
        )
    return render(request, 'cart/detail.html', {'cart': cart})
```

You create an instance of `CartAddProductForm` for each item in the cart to allow changing product quantities. You initialize the form with the current item quantity and set the `override` field to `True` so that when you submit the form to the `cart_add` view, the current quantity is replaced with the new one.

Now edit the `cart/detail.html` template of the `cart` application and find the following line:

```
<td>{{ item.quantity }}</td>
```

Replace the previous line with the following code:

```
<td>
  <form action="{% url "cart:cart_add" product.id %}" method="post">
    {{ item.update_quantity_form.quantity }}
    {{ item.update_quantity_form.override }}
    <input type="submit" value="Update">
    {% csrf_token %}
  </form>
</td>
```

Run the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/cart/` in your browser.

You will see a form to edit the quantity for each cart item, as follows:

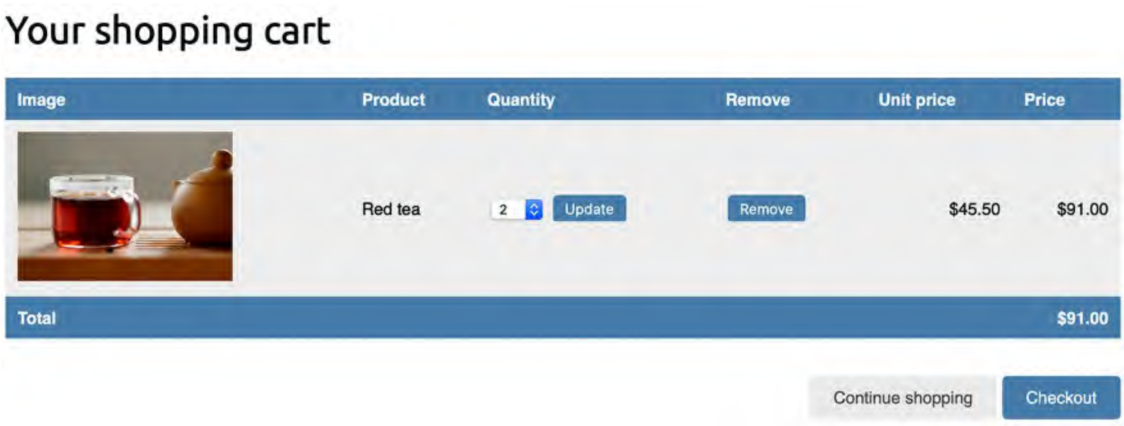


Figure 8.11: The cart detail page, including the form to update product quantities

Change the quantity of an item and click on the **Update** button to test the new functionality. You can also remove an item from the cart by clicking the **Remove** button.

Creating a context processor for the current cart

You might have noticed that the message **Your cart is empty** is displayed in the header of the site, even when the cart contains items. You should display the total number of items in the cart and the total cost instead. Since this has to be displayed on all pages, you need to build a context processor to include the current cart in the request context, regardless of the view that processes the request.

Context processors

A context processor is a Python function that takes the `request` object as an argument and returns a dictionary that gets added to the request context. Context processors come in handy when you need to make something available globally to all templates.

By default, when you create a new project using the `startproject` command, your project contains the following template context processors in the `context_processors` option inside the `TEMPLATES` setting:

- `django.template.context_processors.debug`: This sets the Boolean `debug` and `sql_queries` variables in the context, representing the list of SQL queries executed in the request.
- `django.template.context_processors.request`: This sets the `request` variable in the context.
- `django.contrib.auth.context_processors.auth`: This sets the `user` variable in the request.
- `django.contrib.messages.context_processors.messages`: This sets a `messages` variable in the context containing all the messages that have been generated using the messages framework.

Django also enables `django.template.context_processors.csrf` to avoid **cross-site request forgery** (**CSRF**) attacks. This context processor is not present in the settings, but it is always enabled and can't be turned off for security reasons.

You can see the list of all built-in context processors at `https://docs.djangoproject.com/en/5.0/ref/templates/api/#built-in-template-context-processors`.

Setting the cart in the request context

Let's create a context processor to set the current cart in the request context. With it, you will be able to access the cart in any template.

Create a new file inside the `cart` application directory and name it `context_processors.py`. Context processors can reside anywhere in your code but creating them here will keep your code well organized. Add the following code to the file:

```
from .cart import Cart


def cart(request):
    return {'cart': Cart(request)}
```

In your context processor, you instantiate the cart using the `request` object and make it available for the templates as a variable named `cart`.

Edit the `settings.py` file of your project and add `cart.context_processors.cart` to the `context_processors` option inside the `TEMPLATES` setting, as follows. The new line is highlighted in bold:

```
TEMPLATES = [
    {
        'BACKEND': 'django.template.backends.django.DjangoTemplates',
        'DIRS': [],
        'APP_DIRS': True,
        'OPTIONS': {
            'context_processors': [
                'django.template.context_processors.debug',
                'django.template.context_processors.request',
                'django.contrib.auth.context_processors.auth',
                'django.contrib.messages.context_processors.messages',
                'cart.context_processors.cart',
            ],
        },
    },
]
```

The `cart` context processor will be executed every time a template is rendered using Django's `RequestContext`. The `cart` variable will be set in the context of your templates. You can read more about `RequestContext` at `https://docs.djangoproject.com/en/5.0/ref/templates/api/#django.template.RequestContext`.

Context processors are executed in all the requests that use `RequestContext`. You might want to create a custom template tag instead of a context processor if your functionality is not needed in all templates, especially if it involves database queries.

Next, edit the `shop/base.html` template of the `shop` application and find the following lines:

```
<div class="cart">
  Your cart is empty.
</div>
```

Replace the previous lines with the following code:

```
<div class="cart">
  {% with total_items=cart|length %}
    {% if total_items > 0 %}
      Your cart:
      <a href="{% url "cart:cart_detail" %}">
        {{ total_items }} item{{ total_items|pluralize }},
        ${{ cart.get_total_price }}
      </a>
    {% else %}
      Your cart is empty.
    {% endif %}
  {% endwith %}
</div>
```

Restart the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/` in your browser and add some products to the cart.

In the header of the website, you can now see the total number of items in the cart and the total cost, as follows:

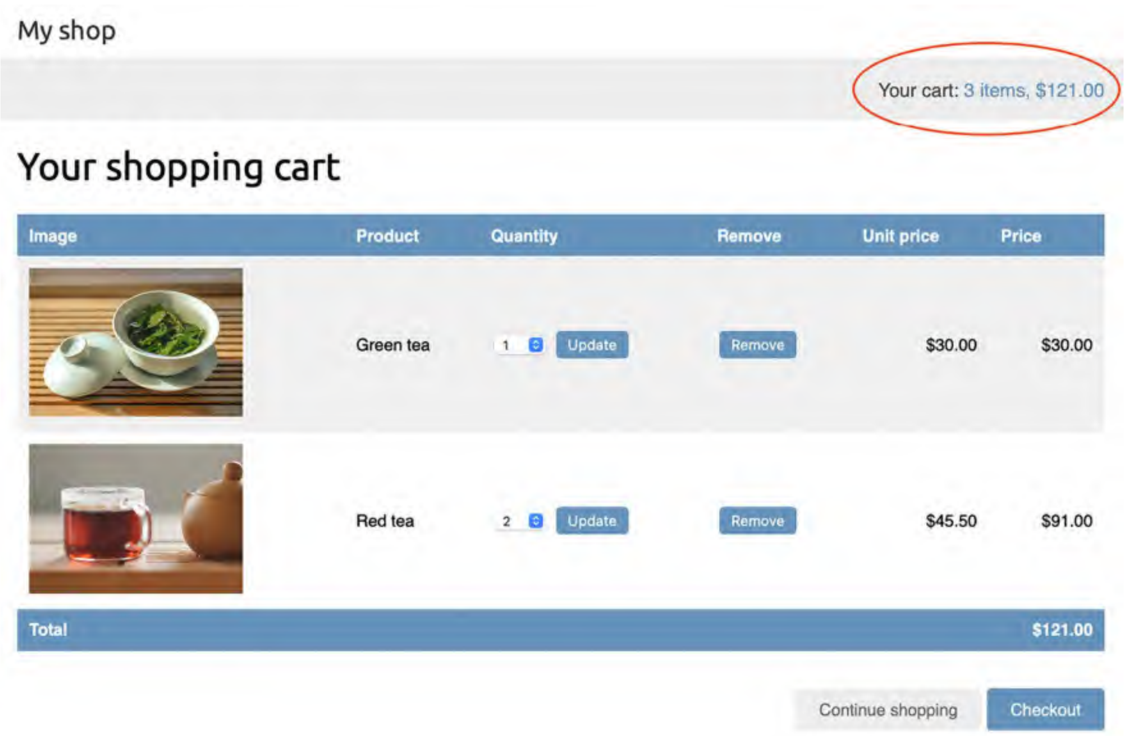


Figure 8.12: The site header displaying the current items in the cart

Congratulations! You have completed the shopping cart functionality. This is a significant milestone in your online shop project. Next, you are going to create the functionality to register customer orders, which is another foundational element of any e-commerce platform.

Registering customer orders

When a shopping cart is checked out, you need to save an order in the database. Orders will contain information about customers and the products they are buying.

Create a new application for managing customer orders using the following command:

```
python manage.py startapp orders
```

Edit the `settings.py` file of your project and add the new application to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'cart.apps.CartConfig',
    'orders.apps.OrdersConfig',
    'shop.apps.ShopConfig',
]
```

You have activated the `orders` application.

Creating order models

You will need a model to store the order details and a second model to store items bought, including their price and quantity. Edit the `models.py` file of the `orders` application and add the following code to it:

```
from django.db import models


class Order(models.Model):
    first_name = models.CharField(max_length=50)
    last_name = models.CharField(max_length=50)
    email = models.EmailField()
    address = models.CharField(max_length=250)
    postal_code = models.CharField(max_length=20)
    city = models.CharField(max_length=100)
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)
    paid = models.BooleanField(default=False)

    class Meta:
        ordering = ['-created']
        indexes = [
            models.Index(fields=['-created']),
        ]

    def __str__(self):
        return f'Order {self.id}'

    def get_total_cost(self):
        return sum(item.get_cost() for item in self.items.all())
```

```
class OrderItem(models.Model):
    order = models.ForeignKey(
        Order,
        related_name='items',
        on_delete=models.CASCADE
)
    product = models.ForeignKey(
        'shop.Product',
        related_name='order_items',
        on_delete=models.CASCADE
    )
    price = models.DecimalField(
        max_digits=10,
        decimal_places=2
    )
    quantity = models.PositiveIntegerField(default=1)

    def __str__(self):
        return str(self.id)

    def get_cost(self):
        return self.price * self.quantity
```

The order model contains several fields to store customer information and a `paid` Boolean field, which defaults to `False`. Later on, you are going to use this field to differentiate between paid and unpaid orders. We have also defined a `get_total_cost()` method to obtain the total cost of the items bought in this order.

The `OrderItem` model allows you to store the product, quantity, and price paid for each item. We have defined a `get_cost()` method that returns the cost of the item by multiplying the item price with the quantity. In the `product` field, we use the string `'shop.Product'` with the format `app.Model`, which is another way to point to related models and also a good method to avoid circular imports.

Run the next command to create initial migrations for the `orders` application:

```
python manage.py makemigrations
```

You will see output similar to the following:

```
Migrations for 'orders':
  orders/migrations/0001_initial.py
    - Create model Order
    - Create model OrderItem
```

Run the following command to apply the new migration:

```
python manage.py migrate
```

You will see the following output:

```
Applying orders.0001_initial... OK
```

Your order models are now synced to the database.

Including order models in the administration site

Let's add the order models to the administration site. Edit the `admin.py` file of the `orders` application and add the following code highlighted in bold:

```
from django.contrib import admin
from .models import Order, OrderItem


class OrderItemInline(admin.TabularInline):
    model = OrderItem
    raw_id_fields = ['product']


@admin.register(Order)
class OrderAdmin(admin.ModelAdmin):
    list_display = [
        'id',
        'first_name',
        'last_name',
        'email',
        'address',
        'postal_code',
        'city',
        'paid',
        'created',
        'updated'
    ]
    list_filter = ['paid', 'created', 'updated']
    inlines = [OrderItemInline]
```

You use a `ModelInline` class for the `OrderItem` model to include it as an *inline* in the `OrderAdmin` class. An inline allows you to include a model on the same edit page as its related model.

Run the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/orders/order/add/` in your browser. You will see the following page:

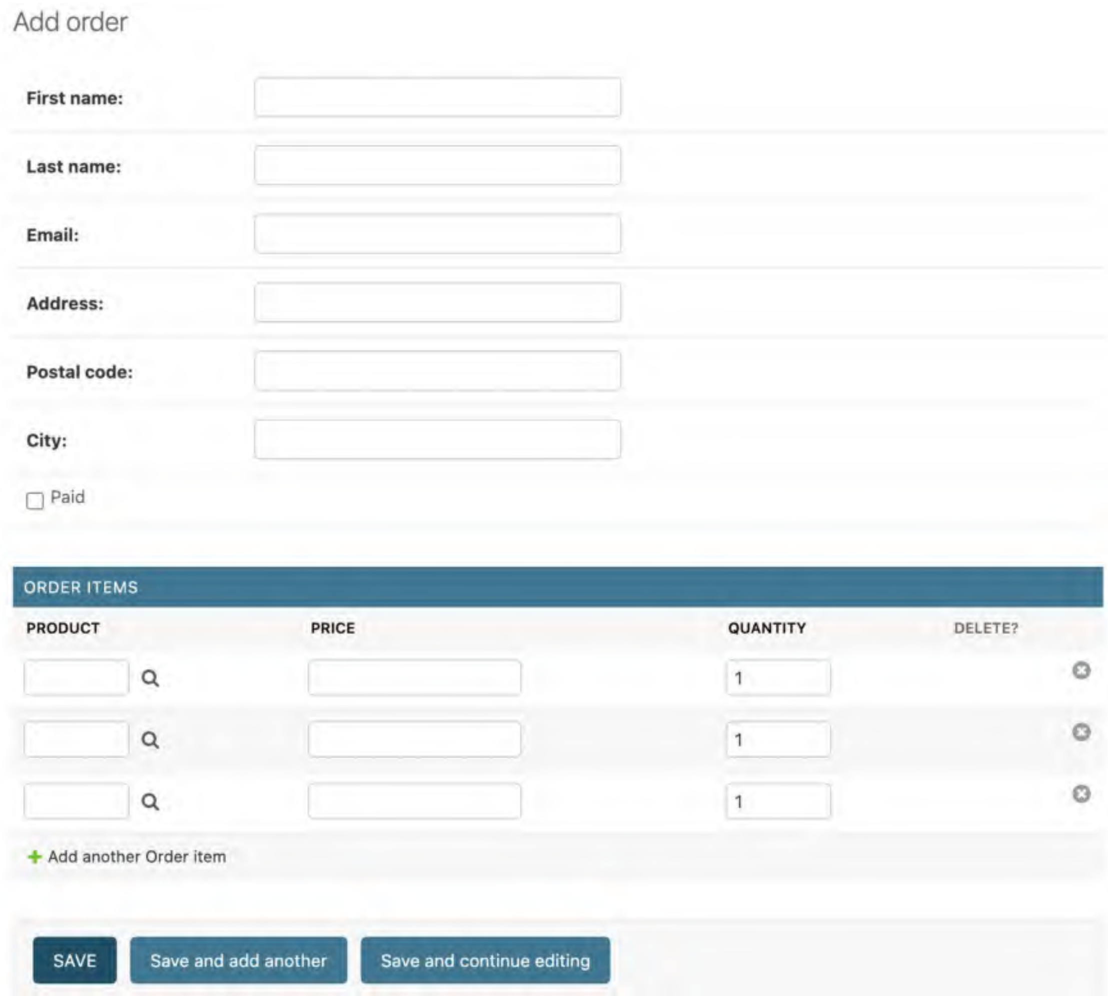


Figure 8.13: The Add order form, including OrderItemInline

Creating customer orders

You will use the order models that you created to persist the items contained in the shopping cart when the user finally places an order. A new order will be created following these steps:

1. Present a user with an order form to fill in their data.
2. Create a new `Order` instance with the data entered, and create an associated `OrderItem` instance for each item in the cart.
3. Clear all the cart's contents and redirect the user to a success page.

First, you need a form to enter the order details. Create a new file inside the `orders` application directory and name it `forms.py`. Add the following code to it:

```
from django import forms
from .models import Order


class OrderCreateForm(forms.ModelForm):
    class Meta:
        model = Order
        fields = [
            'first_name',
            'last_name',
            'email',
            'address',
            'postal_code',
            'city'
        ]
```

This is the form that you are going to use to create new `Order` objects. Now you need a view to handle the form and create a new order. Edit the `views.py` file of the `orders` application and add the following code highlighted in bold:

```
from cart.cart import Cart
from django.shortcuts import render
from .forms import OrderCreateForm
from .models import OrderItem


def order_create(request):
    cart = Cart(request)
    if request.method == 'POST':
        form = OrderCreateForm(request.POST)
        if form.is_valid():
            order = form.save()
            for item in cart:
                OrderItem.objects.create(
                    order=order,
                    product=item['product'],
                    price=item['price'],
                    quantity=item['quantity']
                )
            # clear the cart
```

```
            cart.clear()
            return render(
                request, 'orders/order/created.html', {'order': order}
            )
    else:
        form = OrderCreateForm()
    return render(
        request,
        'orders/order/create.html',
        {'cart': cart, 'form': form}
    )
```

In the `order_create` view, you obtain the current cart from the session with `cart = Cart(request)`. Depending on the request method, you perform the following tasks:

- **GET request:** Instantiates the `OrderCreateForm` form and renders the `orders/order/create.html` template.
- **POST request**: Validates the data sent in the request. If the data is valid, you create a new order in the database using `order = form.save()`. You iterate over the cart items and create an `OrderItem` for each of them. Finally, you clear the cart's contents and render the template `orders/order/created.html`.

Create a new file inside the `orders` application directory and name it `urls.py`. Add the following code to it:

```
from django.urls import path
from . import views


app_name = 'orders'

urlpatterns = [
    path('create/', views.order_create, name='order_create'),
]
```

This is the URL pattern for the `order_create` view.

Edit the `urls.py` file of `myshop` and include the following pattern. Remember to place it before the `shop.urls` pattern, as follows. The new line is highlighted in bold:

```
urlpatterns = [
    path('admin/', admin.site.urls),
    path('cart/', include('cart.urls', namespace='cart')),
    path('orders/', include('orders.urls', namespace='orders')),
    path('', include('shop.urls', namespace='shop')),
]
```

Edit the `cart/detail.html` template of the `cart` application and find this line:

```
<a href="#" class="button">Checkout</a>
```

Add the `order_create` URL to the `href` HTML attribute, as follows:

```
<a href="{% url "orders:order_create" %}" class="button">
  Checkout
</a>
```

Users can now navigate from the cart detail page to the order form.

You still need to define templates for creating orders. Create the following file structure inside the `orders` application directory:

```
templates/
    orders/
        order/
            create.html
            created.html
```

Edit the `orders/order/create.html` template and add the following code:

```
{% extends "shop/base.html" %}

{% block title %}
  Checkout
{% endblock %}

{% block content %}
  <h1>Checkout</h1>
  <div class="order-info">
    <h3>Your order</h3>
    <ul>
```

```
      {% for item in cart %}
        <li>
          {{ item.quantity }}x {{ item.product.name }}
          <span>${{ item.total_price }}</span>
        </li>
      {% endfor %}
    </ul>
    <p>Total: ${{ cart.get_total_price }}</p>
  </div>
  <form method="post" class="order-form">
    {{ form.as_p }}
    <p><input type="submit" value="Place order"></p>
    {% csrf_token %}
  </form>
{% endblock %}
```

This template displays the cart items, including totals and the form to place an order.

Edit the `orders/order/created.html` template and add the following code:

```
{% extends "shop/base.html" %}

{% block title %}
  Thank you
{% endblock %}

{% block content %}
  <h1>Thank you</h1>
  <p>Your order has been successfully completed. Your order number is
  <strong>{{ order.id }}</strong>.</p>
{% endblock %}
```

This is the template that you render when the order is successfully created.

Start the web development server to load new files. Open `http://127.0.0.1:8000/` in your browser, add a couple of products to the cart, and continue to the checkout page. You will see the following form:

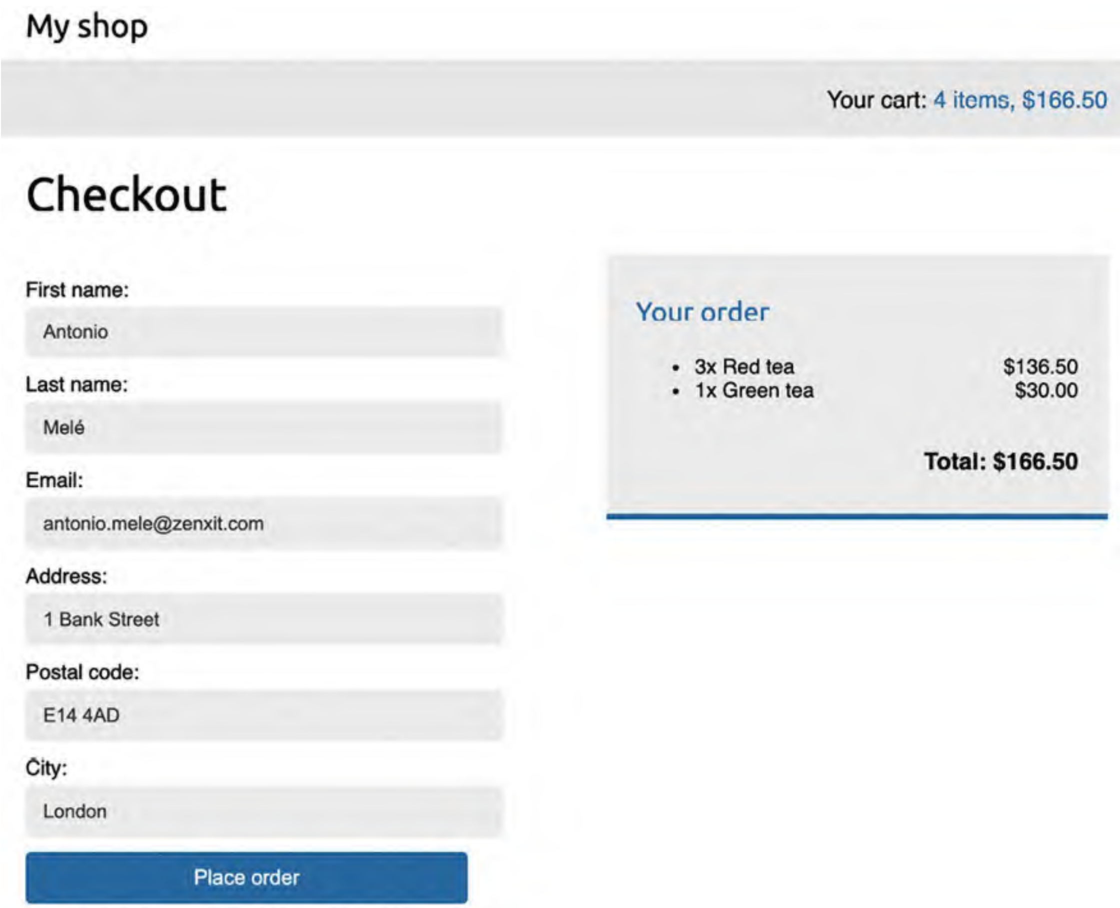


Figure 8.14: The order creation page, including the chart checkout form and order details

Fill in the form with valid data and click on the **Place order** button. The order will be created, and you will see a success page like this:

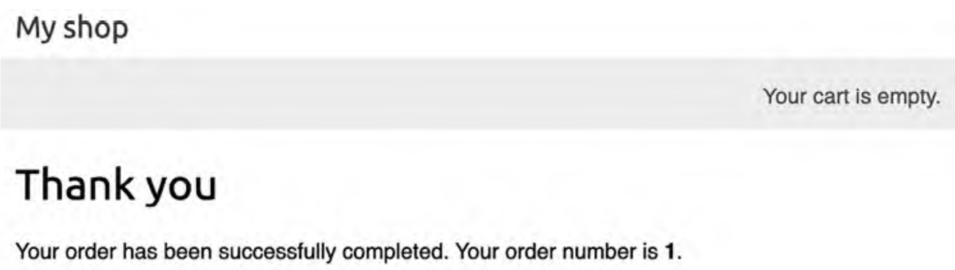


Figure 8.15: The order created template displaying the order number

The order has been registered and the cart has been cleared.

You might have noticed that the message **Your cart is empty** is displayed in the header when an order is completed. This is because the cart has been cleared. We can easily avoid this message for views that have an `order` object in the template context.

Edit the `shop/base.html` template of the `shop` application and replace the following line highlighted in bold:

```
...
<div class="cart">
  {% with total_items=cart|length %}
    {% if total_items > 0 %}
      Your cart:
      <a href="{% url "cart:cart_detail" %}">
        {{ total_items }} item{{ total_items|pluralize }},
        ${{ cart.get_total_price }}
      </a>
    {% elif not order %}
      Your cart is empty.
    {% endif %}
  {% endwith %}
</div>
...
```

The message **Your cart is empty** will not be displayed anymore when an order is created.

Now open the administration site at `http://127.0.0.1:8000/admin/orders/order/`. You will see that the order has been successfully created, like this:

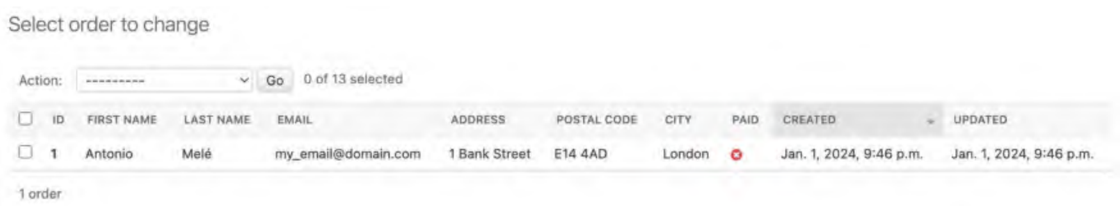


Figure 8.16: The order change list section of the administration site, including the order created

You have implemented the order system. Now you will learn how to create asynchronous tasks to send confirmation emails to users when they place an order.

Creating asynchronous tasks

When receiving an HTTP request, you need to return a response to the user as quickly as possible. Remember that in *Chapter 7*, *Tracking User Actions*, you used the Django Debug Toolbar to check the time for the different phases of the request/response cycle and the execution time for the SQL queries performed.

Every task executed during the course of the request/response cycle adds up to the total response time. Long-running tasks can seriously slow down the server response. How do we return a fast response to the user while still completing time-consuming tasks? We can do it with asynchronous execution.

Working with asynchronous tasks

We can offload work from the request/response cycle by executing certain tasks in the background. For example, a video-sharing platform allows users to upload videos but requires a long time to transcode uploaded videos. When the user uploads a video, the site might return a response informing them that the transcoding will start soon and start transcoding the video asynchronously. Another example is sending emails to users. If your site sends email notifications from a view, the **Simple Mail Transfer Protocol** (**SMTP**) connection might fail or slow down the response. By sending the email asynchronously, you avoid blocking the code execution.

Asynchronous execution is especially relevant for data-intensive, resource-intensive, and time-consuming processes or processes subject to failure, which might require a retry policy.

Workers, message queues, and message brokers

While your web server processes requests and returns responses, you need a second task-based server, named **worker**, to process the asynchronous tasks. One or multiple workers can be running and executing tasks in the background. These workers can access the database, process files, send emails, and so on. Workers can even queue future tasks, all while keeping the main web server free to process HTTP requests.

To tell the workers what tasks to execute, we need to send **messages**. We communicate with brokers by adding messages to a **message queue**, which is basically a **first in, first out** (**FIFO**) data structure. When a broker becomes available, it takes the first message from the queue and starts executing the corresponding task. When finished, the broker takes the next message from the queue and executes the corresponding task. Brokers become idle when the message queue is empty. When using multiple brokers, each broker takes the first available message in order when they become available. The queue ensures that each broker only gets one task at a time and that no task is processed by more than one worker.

Figure 8.17 shows how a message queue works:

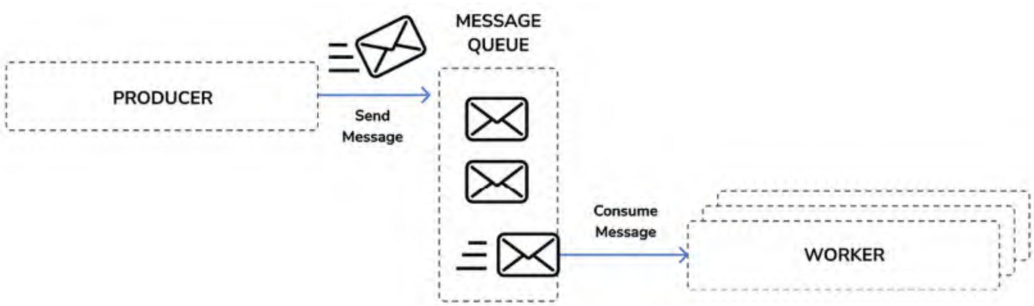


Figure 8.17: Asynchronous execution using a message queue and workers

A producer sends a message to the queue, and the worker(s) consumes the messages on a first-come, first-served basis; the first message added to the message queue is the first message to be processed by the worker(s).

In order to manage the message queue, we need a **message broker**. The message broker is used to translate messages to a formal messaging protocol and manage message queues for multiple receivers. It provides reliable storage and guaranteed message delivery. The message broker allows us to create message queues, route messages, distribute messages among workers, and so on.

To implement asynchronous tasks in your project, you will use Celery for managing task queues and RabbitMQ as the message broker Celery employs. Both technologies will be introduced in the following section.

Using Django with Celery and RabbitMQ

Celery is a distributed task queue that can process vast amounts of messages. We will use Celery to define asynchronous tasks as Python functions within our Django applications. We will run Celery workers that will listen to the message broker to get new messages to process asynchronous tasks.

Using Celery, not only can you create asynchronous tasks easily and let them be executed by workers as soon as possible but you can also schedule them to run at a specific time. You can find the Celery documentation at `https://docs.celeryq.dev/en/stable/index.html`.

Celery communicates via messages and requires a message broker to mediate between clients and workers. There are several options for a message broker for Celery, including key/value stores such as Redis, or an actual message broker such as RabbitMQ.

RabbitMQ is the most widely deployed message broker. It supports multiple messaging protocols, such as the **Advanced Message Queuing Protocol** (**AMQP**), and it is the recommended message worker for Celery. RabbitMQ is lightweight, easy to deploy, and can be configured for scalability and high availability.

Figure 8.18 shows how we will use Django, Celery, and RabbitMQ to execute asynchronous tasks:

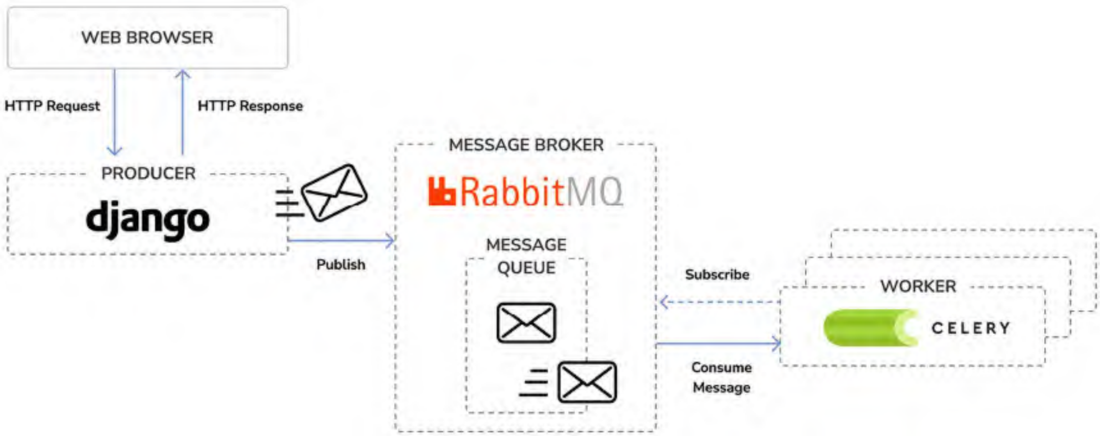


Figure 8.18: Architecture for asynchronous tasks with Django, RabbitMQ, and Celery

Installing Celery

Let's install Celery and integrate it into the project. Install Celery via `pip` using the following command:

```
python -m pip install celery==5.4.0
```

You can find an introduction to Celery at `https://docs.celeryq.dev/en/stable/getting-started/introduction.html`.

Installing RabbitMQ

The RabbitMQ community provides a Docker image that makes it very easy to deploy a RabbitMQ server with a standard configuration. Remember that you learned how to install Docker in *Chapter 3, Extending Your Blog Application*.

After installing Docker on your machine, you can easily pull the RabbitMQ Docker image by running the following command from the shell:

```
docker pull rabbitmq:3.13.1-management
```

This will download the RabbitMQ Docker image to your local machine. You can find information about the official RabbitMQ Docker image at `https://hub.docker.com/_/rabbitmq`.

If you want to install RabbitMQ natively on your machine instead of using Docker, you will find detailed installation guides for different operating systems at `https://www.rabbitmq.com/download.html`.

Execute the following command in the shell to start the RabbitMQ server with Docker:

```
docker run -it --rm --name rabbitmq -p 5672:5672 -p 15672:15672
rabbitmq:3.13.1-management
```

With this command, we are telling RabbitMQ to run on port `5672`, and we are running its web-based management user interface on port `15672`.

You will see output that includes the following lines:

```
Starting broker...
...
completed with 4 plugins.
Server startup complete; 4 plugins started.
```

RabbitMQ is running on port `5672` and ready to receive messages.

Accessing RabbitMQ's management interface

Open `http://127.0.0.1:15672/` in your browser. You will see the login screen for the management UI of RabbitMQ. It will look like this:

Figure 8.19: The RabbitMQ management UI login screen

Enter `guest` as both the username and the password and click on **Login**. You will see the following screen:

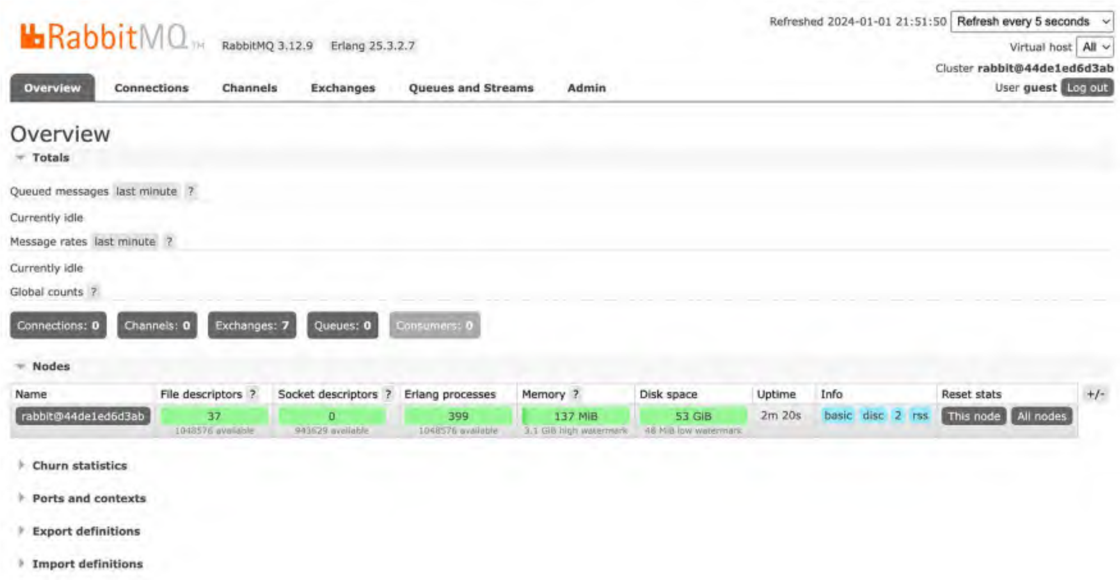


Figure 8.20: The RabbitMQ management UI dashboard

This is the default admin user for RabbitMQ. On this screen, you can monitor the current activity for RabbitMQ. You can see that there is one node running with no connections or queues registered.

If you use RabbitMQ in a production environment, you will need to create a new admin user and remove the default `guest` user. You can do that in the **Admin** section of the management UI.

Now we will add Celery to the project. Then, we will run Celery and test the connection to RabbitMQ.

Adding Celery to your project

You have to provide a configuration for the Celery instance. Create a new file next to the settings.py file of myshop and name it celery.py. This file will contain the Celery configuration for your project. Add the following code to it:

```
import os
from celery import Celery

# set the default Django settings module for the 'celery' program.
os.environ.setdefault('DJANGO_SETTINGS_MODULE', 'myshop.settings')

app = Celery('myshop')
app.config_from_object('django.conf:settings', namespace='CELERY')
app.autodiscover_tasks()
```

In this code, you do the following:

- You set the DJANGO_SETTINGS_MODULE variable for the Celery command-line program.
- You create an instance of the application with app = Celery('myshop').
- You load any custom configuration from your project settings using the config_from_object() method. The namespace attribute specifies the prefix that Celery-related settings will have in your settings.py file. By setting the CELERY namespace, all Celery settings need to include the CELERY_ prefix in their name (for example, CELERY_BROKER_URL).
- Finally, you tell Celery to auto-discover asynchronous tasks for your applications. Celery will look for a tasks.py file in each application directory of applications added to INSTALLED_APPS in order to load asynchronous tasks defined in it.

You need to import the celery module in the __init__.py file of your project to ensure it is loaded when Django starts.

Edit the myshop/__init__.py file and add the following code to it:

```
# import celery
from .celery import app as celery_app

__all__ = ['celery_app']
```

You have added Celery to the Django project, and you can now start using it.

Running a Celery worker

A Celery worker is a process that handles bookkeeping features like sending/receiving queue messages, registering tasks, killing hung tasks, tracking status, and so on. A worker instance can consume from any number of message queues.

Open another shell and start a Celery worker from your project directory, using the following command:

```
celery -A myshop worker -l info
```

The Celery worker is now running and ready to process tasks. Let's check if there is a connection between Celery and RabbitMQ.

Open `http://127.0.0.1:15672/` in your browser to access the RabbitMQ management UI. You will now see a graph under **Queued messages** and another graph under **Message rates**, as in *Figure 8.21*:

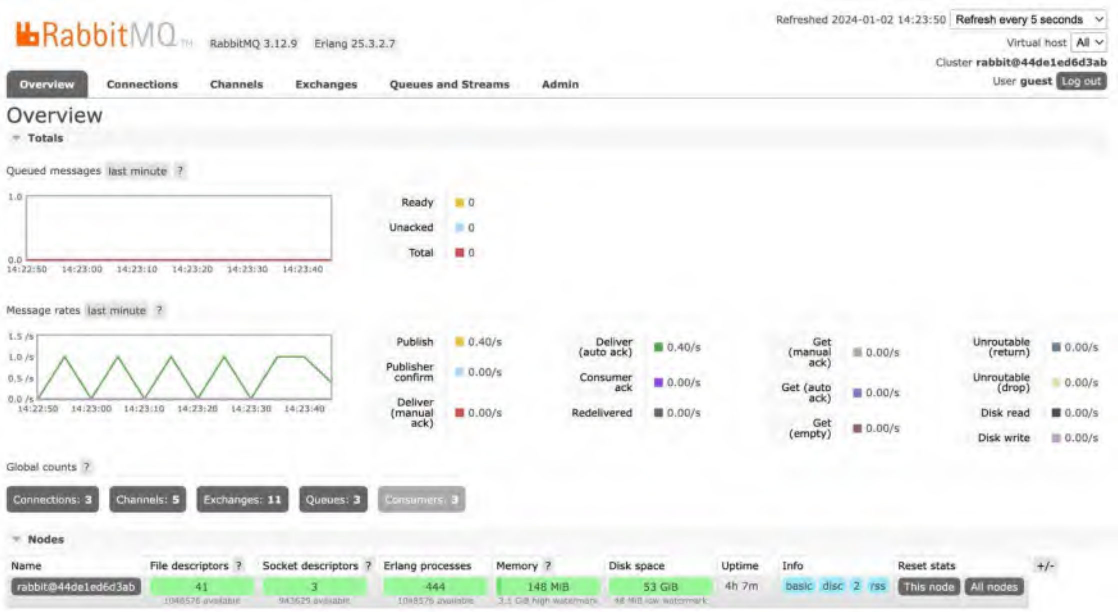


Figure 8.21: The RabbitMQ management dashboard displaying connections and queues

Obviously, there are no queued messages as we haven't sent any messages to the message queue yet. The graph under **Message rates** should update every five seconds; you can see the refresh rate at the top right of the screen. This time, both **Connections** and **Queues** should display a number higher than zero.

Now we can start programming asynchronous tasks.

> The `CELERY_ALWAYS_EAGER` setting allows you to execute tasks locally in a synchronous manner instead of sending them to the queue. This is useful for running unit tests or executing the application in your local environment without running Celery.

Adding asynchronous tasks to your application

Let's send a confirmation email to the user whenever an order is placed in the online shop. We will implement sending the email in a Python function and register it as a task with Celery. Then, we will add it to the `order_create` view to execute the task asynchronously.

When the `order_create` view is executed, Celery will send the message to a message queue managed by RabbitMQ and then a Celery broker will execute the asynchronous task that we defined with a Python function.

The convention for easy task discovery by Celery is to define asynchronous tasks for your application in a `tasks` module within the application directory.

Create a new file inside the `orders` application and name it `tasks.py`. This is the place where Celery will look for asynchronous tasks. Add the following code to it:

```
from celery import shared_task
from django.core.mail import send_mail
from .models import Order


@shared_task
def order_created(order_id):
    """
    Task to send an e-mail notification when an order is
    successfully created.
    """
    order = Order.objects.get(id=order_id)
    subject = f'Order nr. {order.id}'
    message = (
        f'Dear {order.first_name},\n\n'
        f'You have successfully placed an order.'
        f'Your order ID is {order.id}.'
    )
    mail_sent = send_mail(
        subject, message, 'admin@myshop.com', [order.email]
    )
    return mail_sent
```

We have defined the `order_created` task by using the `@shared_task` decorator. As you can see, a Celery task is just a Python function decorated with `@shared_task`. The `order_created` task function receives an `order_id` parameter. It's always recommended to only pass IDs to task functions and retrieve objects from the database when the task is executed. By doing so, we avoid accessing outdated information since the data in the database might have changed while the task was queued. We have used the `send_mail()` function provided by Django to send an email notification to the user who placed the order.

You learned how to configure Django to use your SMTP server in *Chapter 2, Enhancing Your Blog with Advanced Features*. If you don't want to set up email settings, you can tell Django to write emails to the console by adding the following setting to the `settings.py` file:

```
EMAIL_BACKEND = 'django.core.mail.backends.console.EmailBackend'
```

Use asynchronous tasks not only for time-consuming processes but also for other processes that do not take so much time to be executed but that are subject to connection failures or require a retry policy.

Now you have to add the task to your `order_create` view. Edit the `views.py` file of the `orders` application, import the task, and call the `order_created` asynchronous task after clearing the cart, as follows:

```
# ...
from .tasks import order_created


def order_create(request):
    # ...
    if request.method == 'POST':
        # ...
        if form.is_valid():
            # ...
            cart.clear()
            # launch asynchronous task
            order_created.delay(order.id)
        # ...
```

You call the `delay()` method of the task to execute it asynchronously. The task will be added to the message queue and executed by the Celery worker as soon as possible.

Make sure RabbitMQ is running. Then, stop the Celery worker process and start it again with the following command:

```
celery -A myshop worker -l info
```

The Celery worker has now registered the task. In another shell, start the development server from the project directory with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/` in your browser, add some products to your shopping cart, and complete an order. In the shell where you started the Celery worker, you will see output similar to the following:

```
[2024-01-02 20:25:19,569: INFO/MainProcess] Task orders.tasks.order_
created[a94dc22e-372b-4339-bff7-52bc83161c5c] received
...
[2024-01-02 20:25:19,605: INFO/ForkPoolWorker-8] Task orders.tasks.
order_created[a94dc22e-372b-4339-bff7-52bc83161c5c] succeeded in
0.015824042027816176s: 1
```

The `order_created` task has been executed and an email notification for the order has been sent. If you are using the email backend `console.EmailBackend`, no email is sent but you should see the rendered text of the email in the output of the console.

Monitoring Celery with Flower

Besides the RabbitMQ management UI, you can use other tools to monitor the asynchronous tasks that are executed with Celery. Flower is a useful web-based tool for monitoring Celery. You can find the documentation for Flower at `https://flower.readthedocs.io/`.

Install Flower using the following command:

```
python -m pip install flower==2.0.1
```

Once installed, you can launch Flower by running the following command in a new shell from your project directory:

```
celery -A myshop flower
```

Open `http://localhost:5555/` in your browser. You will be able to see the active Celery workers and asynchronous task statistics. The screen should look as follows:

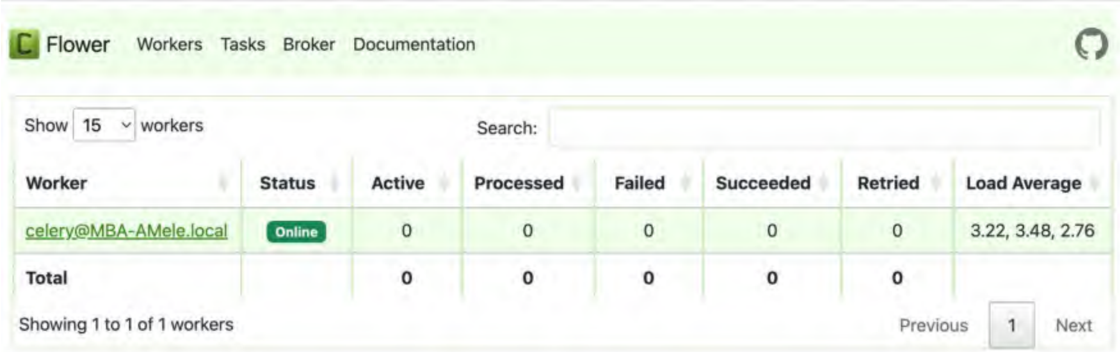


Figure 8.22: The Flower dashboard

You will see an active worker whose name starts with **celery@** and whose status is **Online**.

Click on the worker's name and then click on the **Queues** tab. You will see the following screen:

Figure 8.23: Flower – Worker Celery task queues

Here you can see the active queue named **celery**. This is the active queue consumer connected to the message broker.

Click the **Tasks** tab. You will see the following screen:

Processed tasks

orders.tasks.order_created	1

Figure 8.24: Flower – Worker Celery tasks

Here you can see the tasks that have been processed and the number of times that they have been executed. You should see the `order_created` task and the total times that it has been executed. This number might vary depending on how many orders you have placed.

Open `http://localhost:8000/` in your browser. Add some items to the cart and then complete the checkout process.

Open `http://localhost:5555/` in your browser. Flower has registered the task as processed. You should now see `1` under **Processed** and `1` under **Succeeded** as well:

Worker	Status	Active	Processed	Failed	Succeeded	Retried	Load Average
celery@MBA-AMele.local	Online	0	1	0	1	0	3.49, 3.58, 2.93
Total		0	1	0	1	0	

Figure 8.25: Flower – Celery workers

Under **Tasks**, you can see additional details about each task registered with Celery:

Name	UUID	State	args	kwargs	Result	Received	Started	Runtime	Worker
orders.tasks.order_created	e27d6bd0-1e10-4e39-8a40-cb64501da5e0	SUCCESS	(17,)	{}	1	2024-01-02 20:31:19.043	2024-01-02 20:31:19.046	0.03	celery@MBA-AMele.local

Figure 8.26: Flower – Celery tasks

Flower should never be deployed openly in a production environment without security. Let's add authentication to the Flower instance. Stop Flower using *Ctrl* + *C*, and restart it with the `--basic-auth` option by executing the following command:

```
celery -A myshop flower --basic-auth=user:pwd
```

Replace `user` and `pwd` with your desired username and password. Open `http://localhost:5555/` in your browser. The browser will now prompt you for credentials, as shown in *Figure 8.27*:

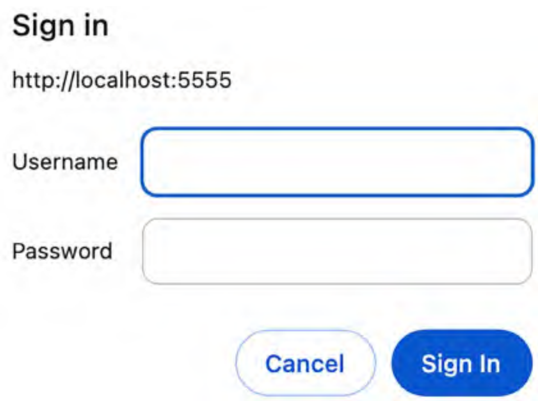


Figure 8.27: Basic authentication required to access Flower

Flower provides other authentication options, such as Google, GitHub, or Okta OAuth. You can read more about Flower's authentication methods at `https://flower.readthedocs.io/en/latest/auth.html`.

Summary

In this chapter, you created a basic e-commerce application. You made a product catalog and built a shopping cart using sessions. You implemented a custom context processor to make the cart available to all templates and created a form for placing orders. You also learned how to implement asynchronous tasks using Celery and RabbitMQ. Having completed this chapter, you now understand the foundational elements of building an e-commerce platform with Django, including managing products, processing orders, and handling asynchronous tasks. You are now also capable of developing projects that efficiently process user transactions and scale to handle complex background operations seamlessly.

In the next chapter, you will discover how to integrate a payment gateway into your shop, add custom actions to the administration site, export data in CSV format, and generate PDF files dynamically.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter – `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter08`
- Static files for the project – `https://github.com/PacktPublishing/Django-5-by-Example/tree/main/Chapter08/myshop/shop/static`

- Django session settings – `https://docs.djangoproject.com/en/5.0/ref/settings/#sessions`
- Django built-in context processors – `https://docs.djangoproject.com/en/5.0/ref/templates/api/#built-in-template-context-processors`
- Information about `RequestContext` – `https://docs.djangoproject.com/en/5.0/ref/templates/api/#django.template.RequestContext`
- Celery documentation – `https://docs.celeryq.dev/en/stable/index.html`
- Introduction to Celery – `https://docs.celeryq.dev/en/stable/getting-started/introduction.html`
- Official RabbitMQ Docker image – `https://hub.docker.com/_/rabbitmq`
- RabbitMQ installation instructions – `https://www.rabbitmq.com/download.html`
- Flower documentation – `https://flower.readthedocs.io/`
- Flower authentication methods – `https://flower.readthedocs.io/en/latest/auth.html`

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`https://packt.link/Django5ByExample`

9

Managing Payments and Orders

In the previous chapter, you created a basic online shop with a product catalog and a shopping cart. You learned how to use Django sessions and built a custom context processor. You also learned how to launch asynchronous tasks using Celery and RabbitMQ.

In this chapter, you will learn how to integrate a payment gateway into your site to let users pay by credit card and manage order payments. You will also extend the administration site with different features.

In this chapter, you will:

- Integrate the Stripe payment gateway into your project
- Process credit card payments with Stripe
- Handle payment notifications and mark orders as paid
- Export orders to CSV files
- Create custom views for the administration site
- Generate PDF invoices dynamically

Functional overview

Figure 9.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

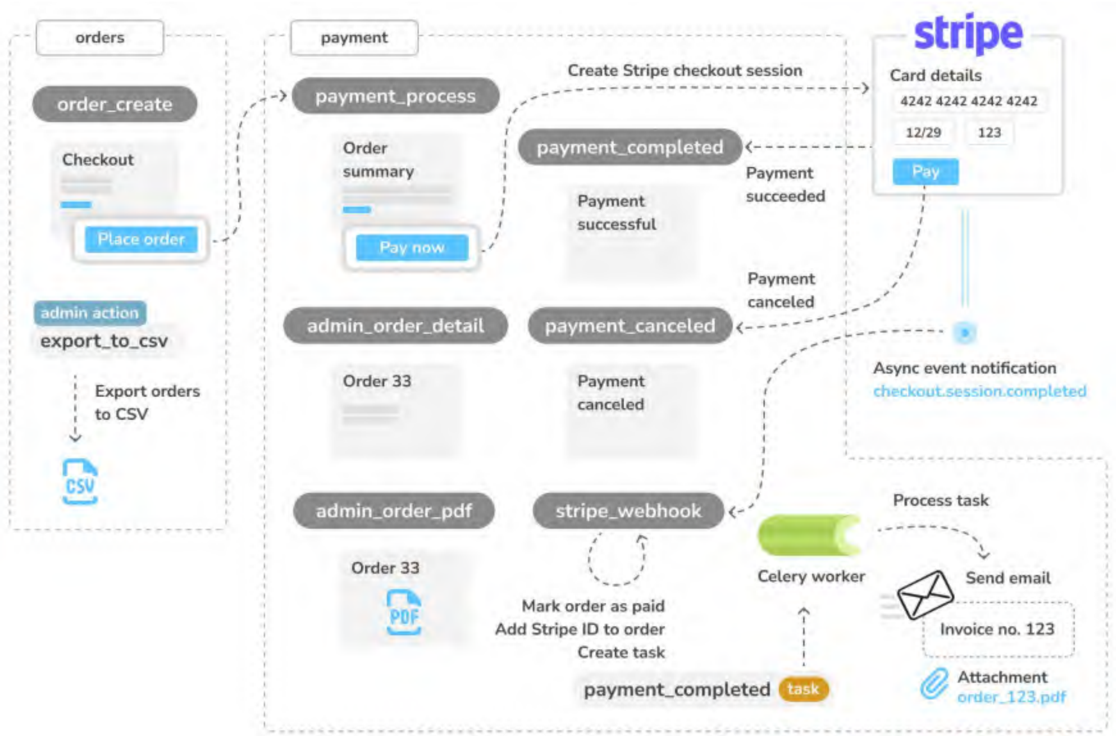


Figure 9.1: Diagram of the functionalities built in Chapter 9

In this chapter, you will create a new `payment` app, where you will implement the `payment_process` view to initiate a checkout session to pay orders with Stripe. You will build the `payment_completed` view to redirect users after successful payments and the `payment_canceled` view to redirect users if the payment is canceled. You will implement the `export_to_csv` admin action to export orders in CSV format in the administration site. You will also build the admin view `admin_order_detail` to display order details and the `admin_order_pdf` view to generate PDF invoices dynamically. You will implement the `stripe_webhook` webhook to receive asynchronous payment notifications from Stripe, and you will implement the `payment_completed` asynchronous task to send invoices to clients when orders are paid.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter09`.

All Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all the requirements at once with the command `python -m pip install -r requirements.txt`.

Integrating a payment gateway

A payment gateway is a technology used by merchants to process payments from customers online. Using a payment gateway, you can manage customers' orders and delegate payment processing to a reliable, secure third party. By using a trusted payment gateway, you won't have to worry about the technical, security, and regulatory complexity of processing credit cards in your own system.

There are several payment gateway providers to choose from. We are going to integrate Stripe, which is a very popular payment gateway used by online services such as Shopify, Uber, Twitch, and GitHub, among others.

Stripe provides an **Application Programming Interface** (**API**) that allows you to process online payments with multiple payment methods, such as credit card, Google Pay, and Apple Pay. You can learn more about Stripe at `https://www.stripe.com/`.

Stripe provides different products related to payment processing. It can manage one-off payments, recurring payments for subscription services, multiparty payments for platforms and marketplaces, and more.

Stripe offers different integration methods, from Stripe-hosted payment forms to fully customizable checkout flows. We will integrate the *Stripe Checkout* product, which consists of a payment page optimized for conversion. Users will be able to easily pay with a credit card or other payment methods for the items they order. We will receive payment notifications from Stripe. You can see the *Stripe Checkout* documentation at `https://stripe.com/docs/payments/checkout`.

By leveraging *Stripe Checkout* to process payments, you rely on a solution that is secure and compliant with **Payment Card Industry** (**PCI**) requirements. You will be able to collect payments from Google Pay, Apple Pay, Afterpay, Alipay, SEPA direct debits, Bacs direct debits, BECS direct debits, iDEAL, Sofort, GrabPay, FPX, and other payment methods.

Creating a Stripe account

You need a Stripe account to integrate the payment gateway into your site. Let's create an account to test the Stripe API. Open `https://dashboard.stripe.com/register` in your browser.

You will see a form like the following one:

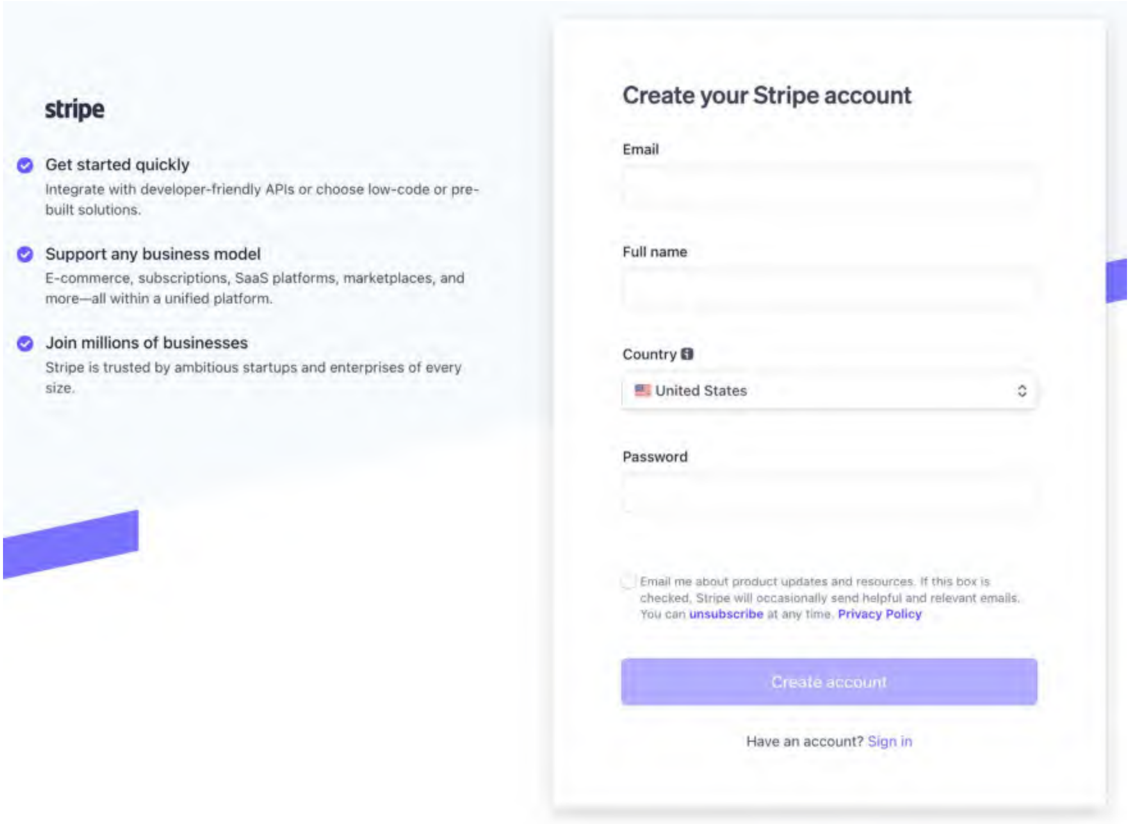


Figure 9.2: The Stripe signup form

Fill in the form with your own data and click on **Create account**. You will receive an email from Stripe with a link to verify your email address. The email will look like this:

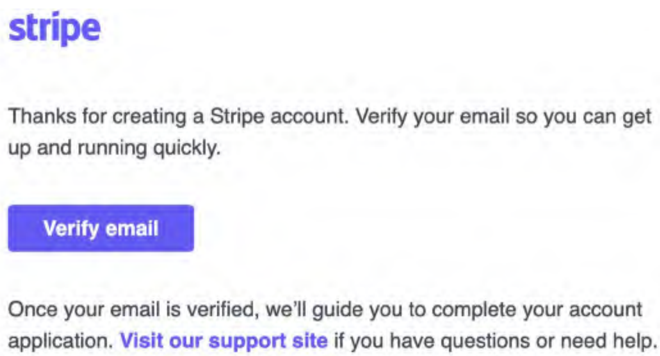


Figure 9.3: The verification email to verify your email address

Open the email in your inbox and click on **Verify email**.

You will be redirected to the Stripe dashboard screen, which will look like this:

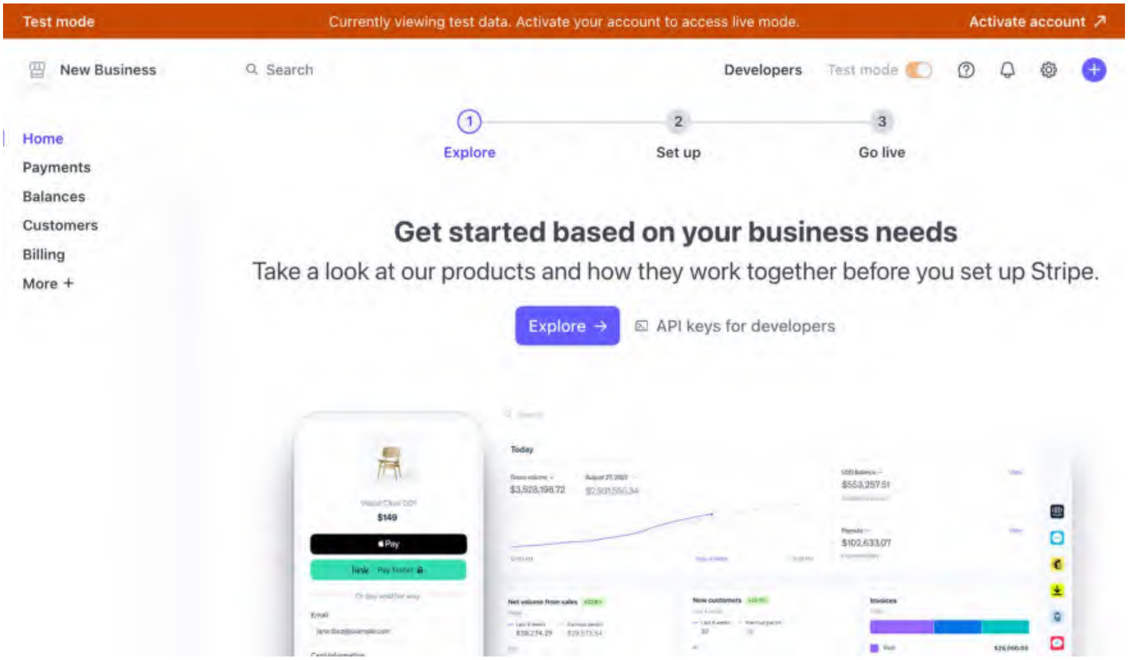


Figure 9.4: The Stripe dashboard after verifying the email address

At the top right of the screen, you can see that **Test mode** is activated. Stripe provides you with a test environment and a production environment. If you own a business or are a freelancer, you can add your business details to activate the account and get access to process real payments. However, this is not necessary to implement and test payments through Stripe, as we will be working in the test environment.

You need to add an account name to process payments. Open `https://dashboard.stripe.com/settings/account` in your browser.

You will see the following screen:

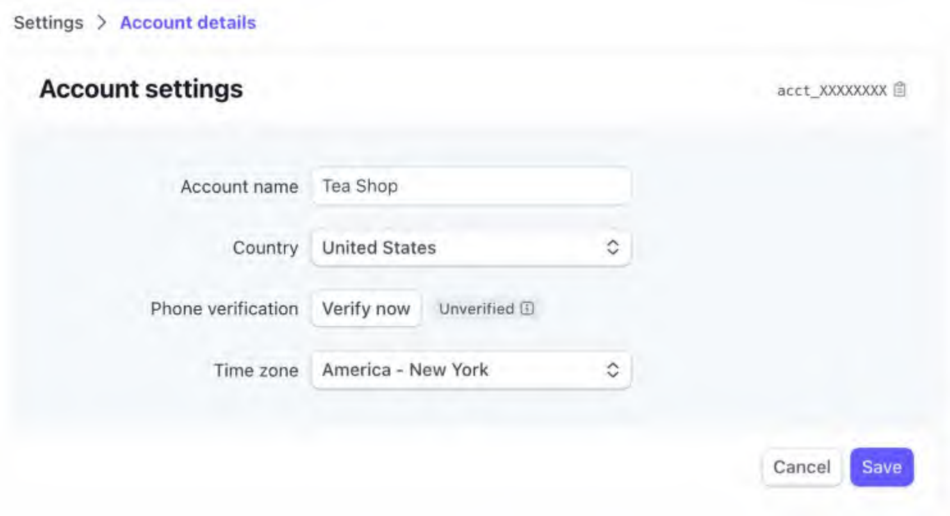


Figure 9.5: The Stripe account settings

Under **Account name**, enter the name of your choice and then click on **Save**. Go back to the Stripe dashboard. You will see your account name displayed in the header:

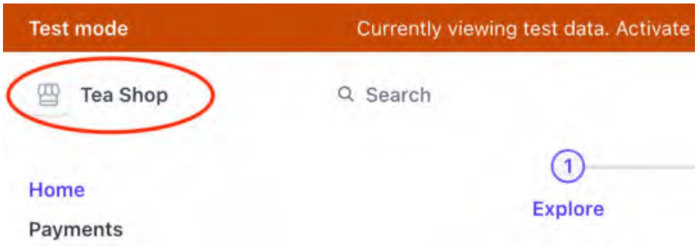


Figure 9.6: The Stripe dashboard header including the account name

We will continue by installing the Stripe Python SDK and adding Stripe to our Django project.

Installing the Stripe Python library

Stripe provides a Python library that simplifies dealing with its API. We are going to integrate the payment gateway into the project using the `stripe` library.

You can find the source code for the Stripe Python library at `https://github.com/stripe/stripe-python`.

Install the `stripe` library from the shell using the following command:

```
python -m pip install stripe==9.3.0
```

Adding Stripe to your project

Open `https://dashboard.stripe.com/test/apikeys` in your browser. You can also access this page from the Stripe dashboard by clicking on **Developers** and then clicking on **API keys**. You will see the following screen:

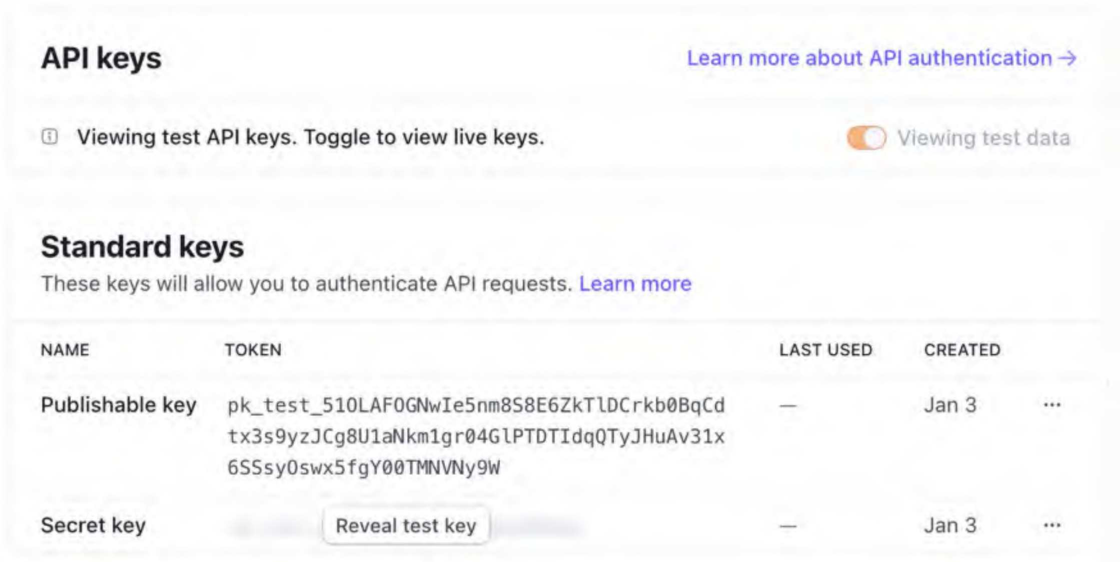


Figure 9.7: The Stripe test API keys screen

Stripe provides a key pair for the two different environments, test and production. There is a **Publishable key** and a **Secret key** for each environment. Test mode publishable keys have the prefix `pk_test_` and live mode publishable keys have the prefix `pk_live_`. Test mode secret keys have the prefix `sk_test_` and live mode secret keys have the prefix `sk_live_`.

You will need this information to authenticate requests to the Stripe API. You should always keep your private key secret and store it securely. The publishable key can be used in client-side code such as JavaScript scripts. You can read more about Stripe API keys at `https://stripe.com/docs/keys`.

To facilitate separating configuration from code, we are going to use `python-decouple`. You already used this library in *Chapter 2*, *Enhancing Your Blog and Adding Social Features*.

Create a new file inside your project's root directory and name it `.env`. The `.env` file will contain key-value pairs of environment variables. Add the Stripe credentials to the new file, as follows:

```
STRIPE_PUBLISHABLE_KEY=pk_test_XXXX
STRIPE_SECRET_KEY=sk_test_XXXX
```

Replace the `STRIPE_PUBLISHABLE_KEY` and `STRIPE_SECRET_KEY` values with the test **Publishable key** and **Secret key** values provided by Stripe.

If you are using a `git` repository for your code, make sure to include `.env` in the `.gitignore` file of your repository. By doing so, you ensure that credentials are excluded from the repository.

Install `python-decouple` via `pip` by running the following command:

```
python -m pip install python-decouple==3.8
```

Edit the `settings.py` file of your project and add the following code to it:

```
from decouple import config
# ...
STRIPE_PUBLISHABLE_KEY = config('STRIPE_PUBLISHABLE_KEY')
STRIPE_SECRET_KEY = config('STRIPE_SECRET_KEY')
STRIPE_API_VERSION = '2024-04-10'
```

You will use Stripe API version `2024-04-10`. You can see the release notes for this API version at `https://stripe.com/docs/upgrades#2024-04-10`.

> You are using the test environment keys for the project. Once you go live and validate your Stripe account, you will obtain the production environment keys. In *Chapter 17*, *Going Live*, you will learn how to configure settings for multiple environments.

Let's integrate the payment gateway into the checkout process. You can find the Python documentation for Stripe at `https://stripe.com/docs/api?lang=python`.

Building the payment process

The checkout process will work as follows:

1. Add items to the shopping cart.
2. Check out the shopping cart.
3. Enter credit card details and pay.

We are going to create a new application to manage payments. Create a new application in your project using the following command:

```
python manage.py startapp payment
```

Edit the `settings.py` file of the project and add the new application to the `INSTALLED_APPS` setting, as follows. The new line is highlighted in bold:

```
INSTALLED_APPS = [
    # ...
    'cart.apps.CartConfig',
    'orders.apps.OrdersConfig',
    'payment.apps.PaymentConfig',
    'shop.apps.ShopConfig',
]
```

The payment application is now active in the project.

Currently, users are able to place orders but they cannot pay for them. After clients place an order, we need to redirect them to the payment process.

Edit the `views.py` file of the `orders` application and include the following import:

```
from django.shortcuts import redirect, render
```

In the same file, find the following lines of the `order_create` view:

```
# launch asynchronous task
order_created.delay(order.id)
return render(
  request, 'orders/order/created.html', {'order': order}
)
```

Replace them with the following code:

```
# launch asynchronous task
order_created.delay(order.id)
# set the order in the session
request.session['order_id'] = order.id
# redirect for payment
return redirect('payment:process')
```

The edited view should look as follows:

```
from django.shortcuts import redirect, render
# ...

def order_create(request):
    cart = Cart(request)
    if request.method == 'POST':
        form = OrderCreateForm(request.POST)
        if form.is_valid():
            order = form.save()
            for item in cart:
                OrderItem.objects.create(
                    order=order,
                    product=item['product'],
                    price=item['price'],
                    quantity=item['quantity']
                )
            # clear the cart
            cart.clear()
```

```
            # launch asynchronous task
            order_created.delay(order.id)
            # set the order in the session
            request.session['order_id'] = order.id
            # redirect for payment
            return redirect('payment:process')
    else:
        form = OrderCreateForm()
    return render(
        request,
        'orders/order/create.html',
        {'cart': cart, 'form': form}
    )
```

Instead of rendering the template `orders/order/created.html` when placing a new order, the order ID is stored in the user session and the user is redirected to the `payment:process` URL. We are going to implement this URL later. Remember that Celery has to be running for the `order_created` task to be queued and executed.

Let's integrate the payment gateway.

Integrating Stripe Checkout

The Stripe Checkout integration consists of a checkout page hosted by Stripe that allows the user to enter the payment details, usually a credit card, and then it collects the payment. If the payment is successful, Stripe redirects the client to a success page. If the payment is canceled by the client, it redirects the client to a cancel page.

We will implement three views:

- `payment_process`: Creates a Stripe **Checkout Session** and redirects the client to the Stripe-hosted payment form. A checkout session is a programmatic representation of what the client sees when they are redirected to the payment form, including the products, quantities, currency, and amount to charge.
- `payment_completed`: Displays a message for successful payments. The user is redirected to this view if the payment is successful.
- `payment_canceled`: Displays a message for canceled payments. The user is redirected to this view if the payment is canceled.

Figure 9.8 shows the checkout payment flow:

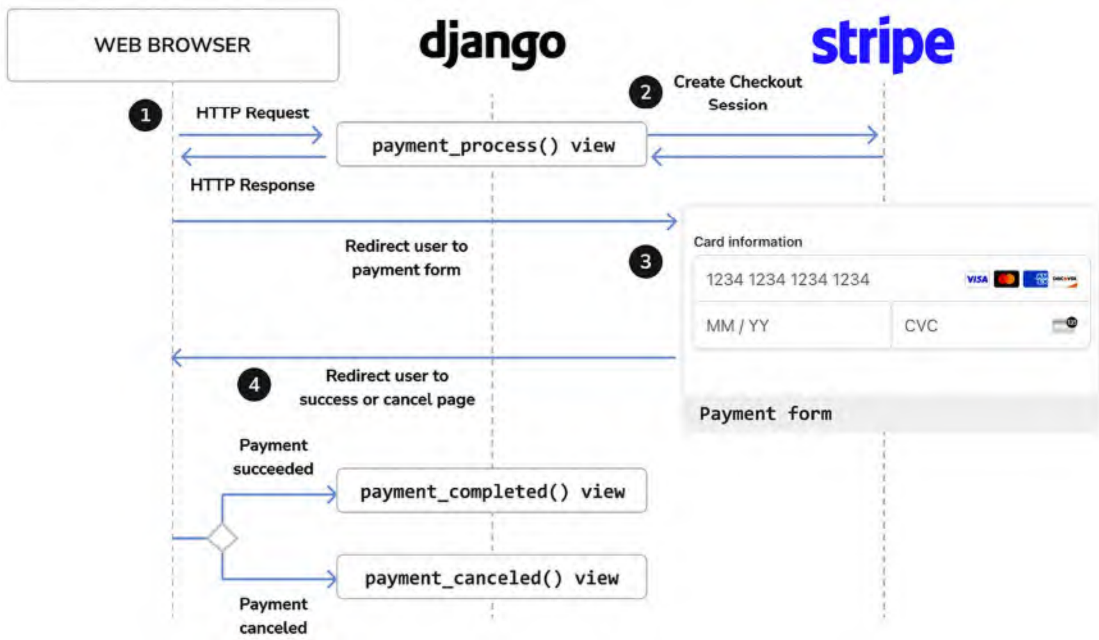


Figure 9.8: The checkout payment flow

The complete checkout process will work as follows:

1. After an order is created, the user is redirected to the `payment_process` view. The user is presented with an order summary and a button to proceed with the payment.
2. When the user proceeds to pay, a Stripe checkout session is created. The checkout session includes the list of items that the user will purchase, a URL to redirect the user to after a successful payment, and a URL to redirect the user to if the payment is canceled.
3. The view redirects the user to the Stripe-hosted checkout page. This page includes the payment form. The client enters their credit card details and submits the form.
4. Stripe processes the payment and redirects the client to the `payment_completed` view. If the client doesn't complete the payment, Stripe redirects the client to the `payment_canceled` view instead.

Let's start building the payment views. Edit the `views.py` file of the `payment` application and add the following code to it:

```
from decimal import Decimal
import stripe
from django.conf import settings
from django.shortcuts import get_object_or_404, redirect, render
from django.urls import reverse
from orders.models import Order


# create the Stripe instance
stripe.api_key = settings.STRIPE_SECRET_KEY
stripe.api_version = settings.STRIPE_API_VERSION


def payment_process(request):
    order_id = request.session.get('order_id')
    order = get_object_or_404(Order, id=order_id)

    if request.method == 'POST':
        success_url = request.build_absolute_uri(
            reverse('payment:completed')
        )
        cancel_url = request.build_absolute_uri(
            reverse('payment:canceled')
        )
        # Stripe checkout session data
        session_data = {
            'mode': 'payment',
            'client_reference_id': order.id,
            'success_url': success_url,
            'cancel_url': cancel_url,
            'line_items': []
        }
        # create Stripe checkout session
        session = stripe.checkout.Session.create(**session_data)
        # redirect to Stripe payment form
        return redirect(session.url, code=303)

    else:
        return render(request, 'payment/process.html', locals())
```

In the previous code, the stripe module is imported and the Stripe API key is set using the value of the STRIPE_SECRET_KEY setting. The API version to use is also set using the value of the STRIPE_API_VERSION setting.

The payment_process view performs the following tasks:

1. The current Order object is retrieved from the database using the order_id session key, which was stored previously in the session by the order_create view.
2. The Order object for the given ID is retrieved. By using the shortcut function get_object_or_404(), an Http404 (page not found) exception is raised if no order is found with the given ID.
3. If the view is loaded with a GET request, the template payment/process.html is rendered and returned. This template will include the order summary and a button to proceed with the payment, which will generate a POST request to the view.
4. Alternatively, if the view is loaded with a POST request, a Stripe checkout session is created with stripe.checkout.Session.create() using the following parameters:
    - mode: The mode of the checkout session. We use payment for a one-time payment. You can see the different values accepted for this parameter at https://stripe.com/docs/api/checkout/sessions/object#checkout_session_object-mode.
    - client_reference_id: The unique reference for this payment. We will use this to reconcile the Stripe checkout session with our order. By passing the order ID, we link Stripe payments to orders in our system and we will be able to receive payment notifications from Stripe to mark the orders as paid.
    - success_url: The URL for Stripe to redirect the user to if the payment is successful. We use request.build_absolute_uri() to generate an absolute URI from the URL path. You can see the documentation for this method at https://docs.djangoproject.com/en/5.0/ref/request-response/#django.http.HttpRequest.build_absolute_uri.
    - cancel_url: The URL for Stripe to redirect the user to if the payment is canceled.
    - line_items: This is an empty list. We will next populate it with the order items to be purchased.
5. After creating the checkout session, an HTTP redirect with status code 303 is returned to redirect the user to Stripe. The status code 303 is recommended to redirect web applications to a new URI after an HTTP POST has been performed.

You can see all the parameters to create a Stripe session object at https://stripe.com/docs/api/checkout/sessions/create.

Let's populate the line_items list with the order items to create the checkout session. Each item will contain the name of the item, the amount to charge, the currency to use, and the quantity purchased.

Add the following code highlighted in bold to the payment_process view:

```
def payment_process(request):
    order_id = request.session.get('order_id')
    order = get_object_or_404(Order, id=order_id)
```

```
    if request.method == 'POST':
        success_url = request.build_absolute_uri(
            reverse('payment:completed')
        )
        cancel_url = request.build_absolute_uri(
            reverse('payment:canceled')
        )
        # Stripe checkout session data
        session_data = {
            'mode': 'payment',
            'success_url': success_url,
            'cancel_url': cancel_url,
            'line_items': []
        }
        # add order items to the Stripe checkout session
        for item in order.items.all():
            session_data['line_items'].append(
                {
                    'price_data': {
                        'unit_amount': int(item.price * Decimal('100')),
                        'currency': 'usd',
                        'product_data': {
                            'name': item.product.name,
                        },
                    },
                    'quantity': item.quantity,
                }
            )
        # create Stripe checkout session
        session = stripe.checkout.Session.create(**session_data)
        # redirect to Stripe payment form
        return redirect(session.url, code=303)

    else:
        return render(request, 'payment/process.html', locals())
```

We use the following information for each item:

- `price_data`: Price-related information:

- unit_amount: The amount in cents to be collected by the payment. This is a positive integer representing how much to charge in the smallest currency unit with no decimal places. For example, to charge $10.00, this would be 1000 (that is, 1,000 cents). The item price, item.price, is multiplied by Decimal('100') to obtain the value in cents, and then it is converted into an integer.
- currency: The currency to use in the three-letter ISO format. We use usd for US dollars. You can see a list of supported currencies at https://stripe.com/docs/currencies.

- product_data: Product-related information:
  - name: The name of the product
- quantity: The number of units to purchase

The payment_process view is now ready. Let's create simple views for the payment success and cancel pages.

Add the following code to the views.py file of the payment application:

```
def payment_completed(request):
    return render(request, 'payment/completed.html')

def payment_canceled(request):
    return render(request, 'payment/canceled.html')
```

Create a new file inside the payment application directory and name it urls.py. Add the following code to it:

```
from django.urls import path
from . import views

app_name = 'payment'

urlpatterns = [
    path('process/', views.payment_process, name='process'),
    path('completed/', views.payment_completed, name='completed'),
    path('canceled/', views.payment_canceled, name='canceled'),
]
```

These are the URLs for the payment workflow. We have included the following URL patterns:

- process: The view that displays the order summary to the user, creates the Stripe checkout session, and redirects the user to the Stripe-hosted payment form
- completed: The view for Stripe to redirect the user to if the payment is successful
- canceled: The view for Stripe to redirect the user to if the payment is canceled

Edit the main `urls.py` file of the `myshop` project and include the URL patterns for the `payment` application, as follows:

```
urlpatterns = [
    path('admin/', admin.site.urls),
    path('cart/', include('cart.urls', namespace='cart')),
    path('orders/', include('orders.urls', namespace='orders')),
    path('payment/', include('payment.urls', namespace='payment')),
    path('', include('shop.urls', namespace='shop')),
]
```

We have placed the new path before the `shop.urls` pattern to avoid an unintended pattern match with a pattern defined in `shop.urls`. Remember that Django runs through each URL pattern in order and stops at the first one that matches the requested URL.

Let's build a template for each view. Create the following file structure inside the `payment` application directory:

```
templates/
    payment/
        process.html
        completed.html
        canceled.html
```

Edit the `payment/process.html` template and add the following code to it:

```
{% extends "shop/base.html" %}
{% load static %}

{% block title %}Pay your order{% endblock %}

{% block content %}
  <h1>Order summary</h1>
  <table class="cart">
    <thead>
      <tr>
        <th>Image</th>
        <th>Product</th>
        <th>Price</th>
        <th>Quantity</th>
        <th>Total</th>
      </tr>
    </thead>
    <tbody>
```

```
        {% for item in order.items.all %}
          <tr class="row{% cycle "1" "2" %}">
            <td>
              <img src="{% if item.product.image %}{{ item.product.image.url }}
              {% else %}{% static "img/no_image.png" %}{% endif %}">
            </td>
            <td>{{ item.product.name }}</td>
            <td class="num">${{ item.price }}</td>
            <td class="num">{{ item.quantity }}</td>
            <td class="num">${{ item.get_cost }}</td>
          </tr>
        {% endfor %}
        <tr class="total">
          <td colspan="4">Total</td>
          <td class="num">${{ order.get_total_cost }}</td>
        </tr>
      </tbody>
    </table>
    <form action="{% url "payment:process" %}" method="post">
      <input type="submit" value="Pay now">
      {% csrf_token %}
    </form>
  {% endblock %}
```

This is the template to display the order summary to the user and allow the client to proceed with the payment. It includes a form and a **Pay now** button to submit it via `POST`. When the form is submitted, the `payment_process` view creates the Stripe checkout session and redirects the user to the Stripe-hosted payment form.

Edit the `payment/completed.html` template and add the following code to it:

```
{% extends "shop/base.html" %}

{% block title %}Payment successful{% endblock %}

{% block content %}
  <h1>Your payment was successful</h1>
  <p>Your payment has been processed successfully.</p>
{% endblock %}
```

This is the template for the page that the user is redirected to after a successful payment.

Edit the `payment/canceled.html` template and add the following code to it:

```
{% extends "shop/base.html" %}

{% block title %}Payment canceled{% endblock %}

{% block content %}
  <h1>Your payment has not been processed</h1>
  <p>There was a problem processing your payment.</p>
{% endblock %}
```

This is the template for the page that the user is redirected to when the payment is canceled.

We have implemented the necessary views to process payments, including their URL patterns and templates. It's time to try out the checkout process.

Testing the checkout process

Execute the following command in the shell to start the RabbitMQ server with Docker:

```
docker run -it --rm --name rabbitmq -p 5672:5672 -p 15672:15672
rabbitmq:3.13.1-management
```

This will run RabbitMQ on port `5672` and the web-based management interface on port `15672`.

Open another shell and start the Celery worker from your project directory with the following command:

```
celery -A myshop worker -l info
```

Open one more shell and start the development server from your project directory with this command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/` in your browser, add some products to the shopping cart, and fill in the checkout form. Click the **Place order** button. The order will be persisted to the database, the order ID will be saved in the current session, and you will be redirected to the payment process page.

The payment process page will look as follows:

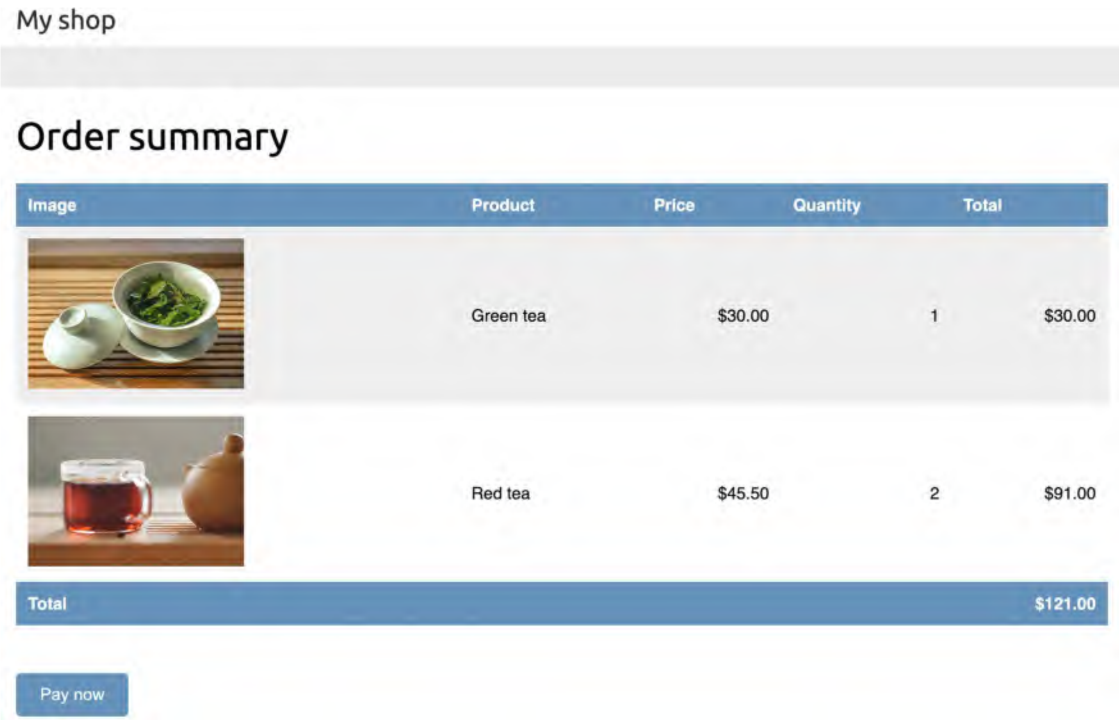


Figure 9.9: The payment process page including an order summary

Images in this chapter:

- *Green tea*: Photo by Jia Ye on Unsplash
- *Red tea*: Photo by Manki Kim on Unsplash

On this page, you can see an order summary and a **Pay now** button. Click on **Pay now**. The `payment_process` view will create a Stripe checkout session, and you will be redirected to the Stripe-hosted payment form.

You will see the following page:

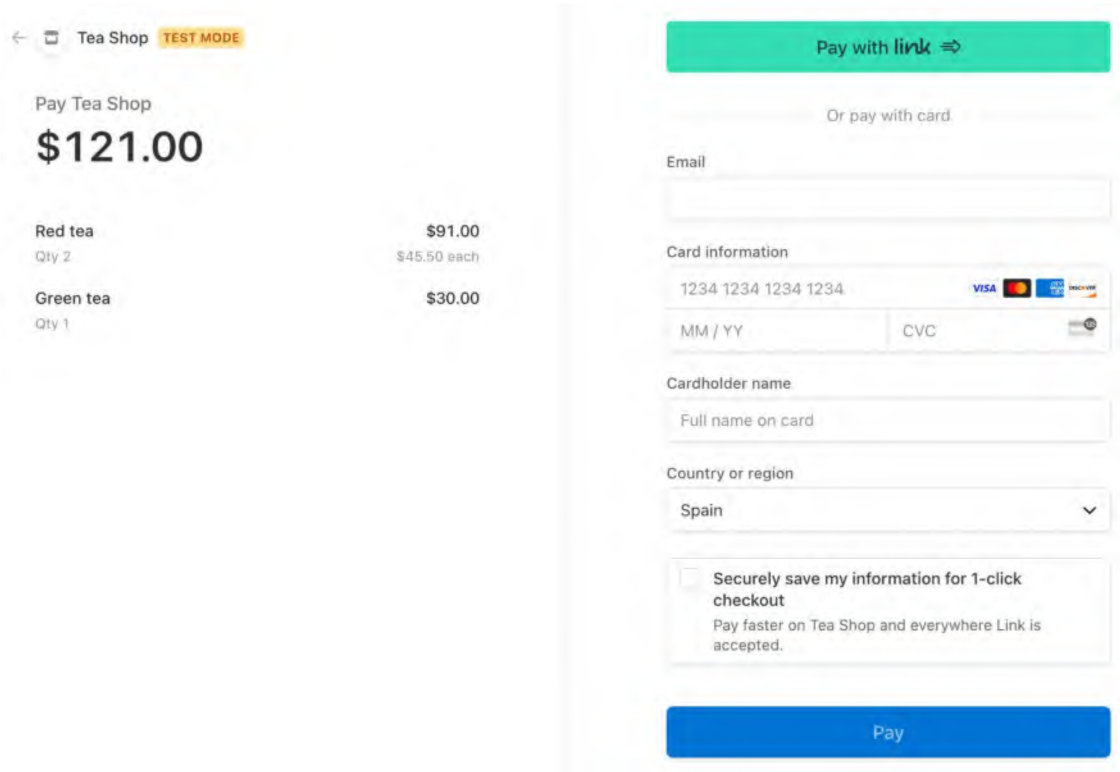


Figure 9.10: The Stripe checkout payment from

Using test credit cards

Stripe provides different test credit cards from different card issuers and countries, which allows you to simulate payments to test all possible scenarios (successful payment, declined payment, etc.). The following table shows some of the cards you can test for different scenarios:

Result	Test Credit Card	CVC	Expiry date
Successful payment	`4242 4242 4242 4242`	Any 3 digits	Any future date
Failed payment	`4000 0000 0000 0002`	Any 3 digits	Any future date
Requires 3D secure authentication	`4000 0025 0000 3155`	Any 3 digits	Any future date

You can find the complete list of credit cards for testing at `https://stripe.com/docs/testing`.

We are going to use the test card `4242 4242 4242 4242`, which is a Visa card that returns a successful purchase. We will use the CVC `123` and any future expiration date, such as `12/29`. Enter the credit card details in the payment form as follows:

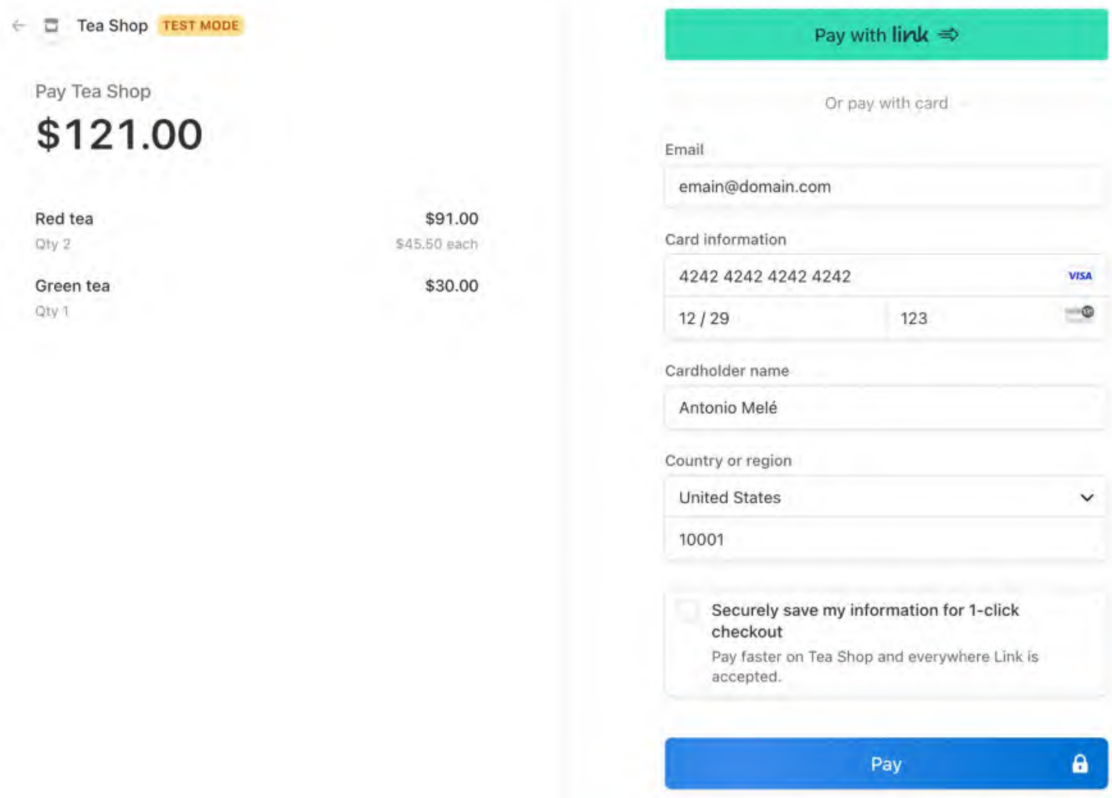


Figure 9.11: The payment form with the valid test credit card details

Click the **Pay** button. The button text will change to **Processing...**, as shown in *Figure 9.12*:

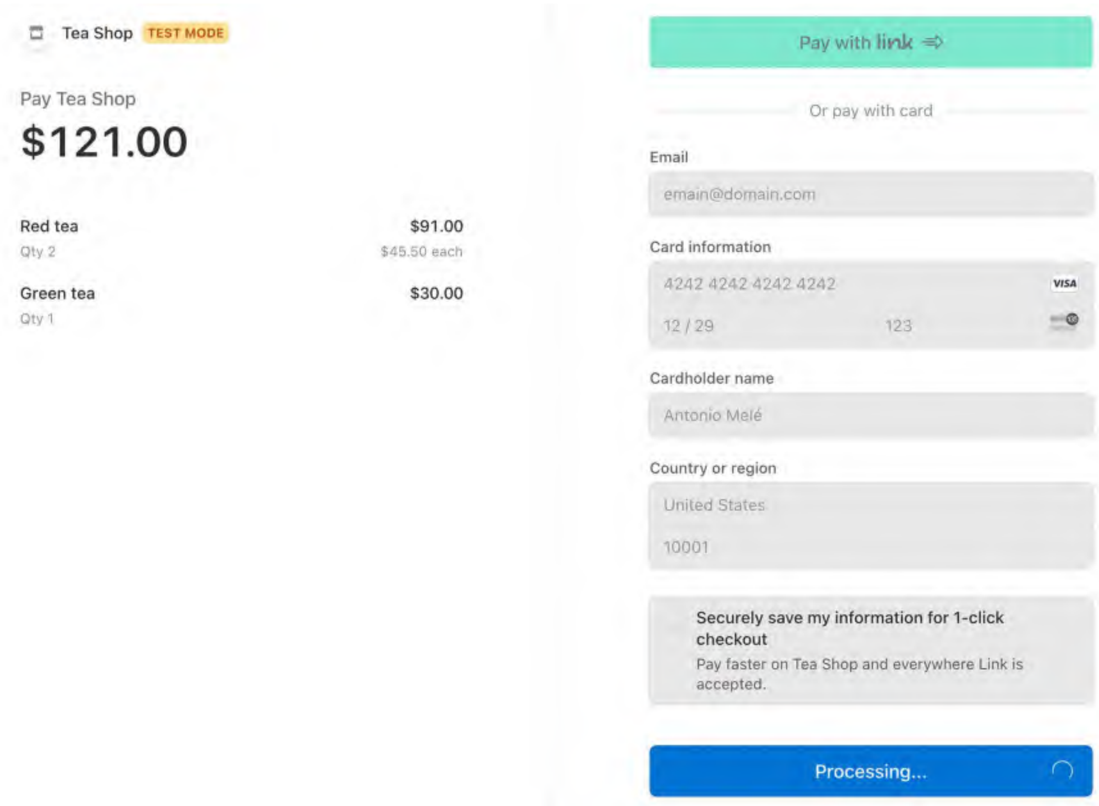


Figure 9.12: The payment form being processed

After a couple of seconds, you will see the button turn green, as in *Figure 9.13*:

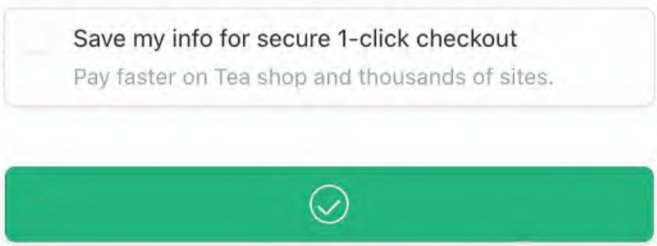


Figure 9.13: The payment form after the payment is successful

Then, Stripe redirects your browser to the payment completed URL you provided when creating the checkout session. You will see the following page:

Figure 9.14: The successful payment page

Checking the payment information in the Stripe dashboard

Access the Stripe dashboard at `https://dashboard.stripe.com/test/payments`. Under **Payments**, you will be able to see the payment, as in *Figure 9.15*:

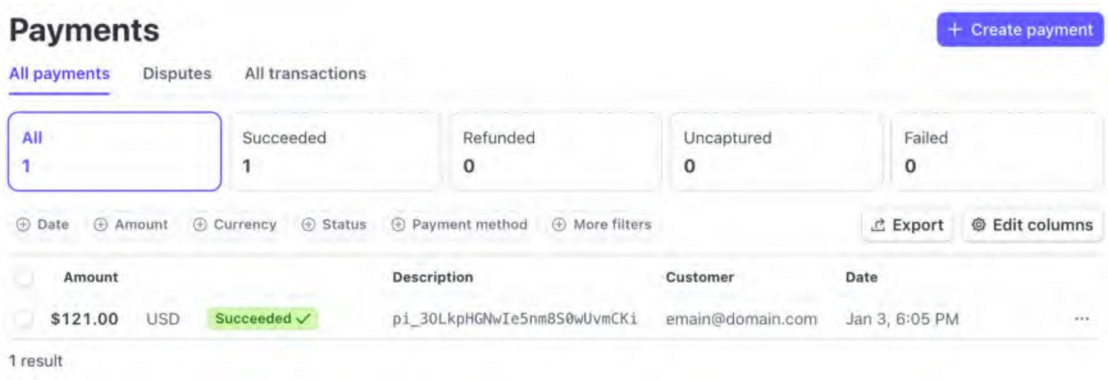


Figure 9.15: The payment object with the status Succeeded in the Stripe dashboard

The payment status is **Succeeded.** The payment description includes the **payment intent** ID that starts with `pi_`. When a checkout session is confirmed, Stripe creates a payment intent associated with the session. A payment intent is used to collect a payment from the user. Stripe records all attempted payments as payment intents. Each payment intent has a unique ID, and it encapsulates the details of the transaction, such as the supported payment methods, the amount to collect, and the desired currency. Click on the transaction to access the payment details.

You will see the following screen:

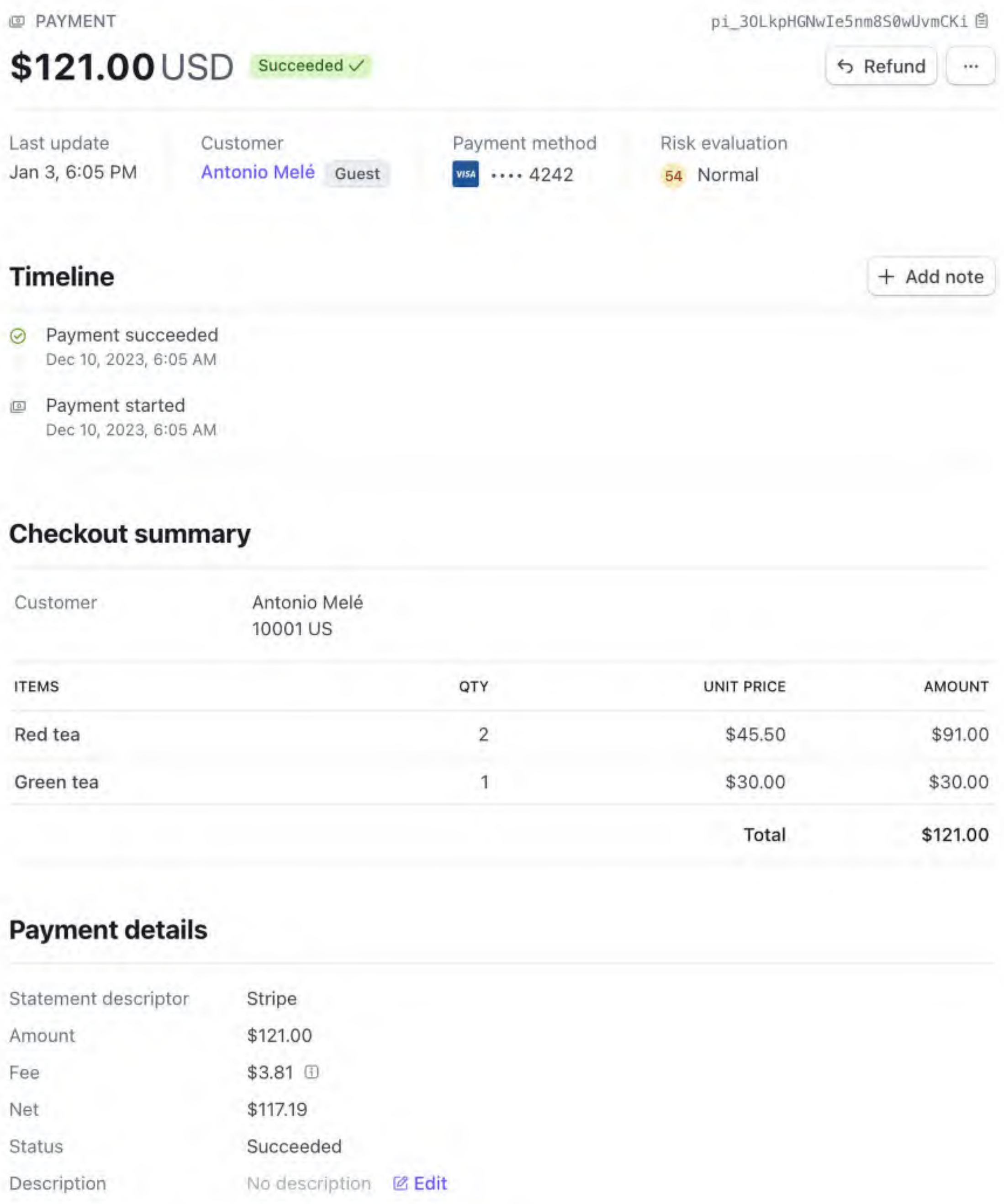


Figure 9.16: Payment details for a Stripe transaction

Here, you can see the payment information and the payment timeline, including payment changes. Under **Checkout summary**, you can find the line items purchased, including the name, quantity, unit price, and amount.

Under **Payment details**, you can see a breakdown of the amount paid and the Stripe fee for processing the payment.

Under this section, you will find a **Payment method** section, including details about the payment method and the credit card checks performed by Stripe, as in *Figure 9.17*:

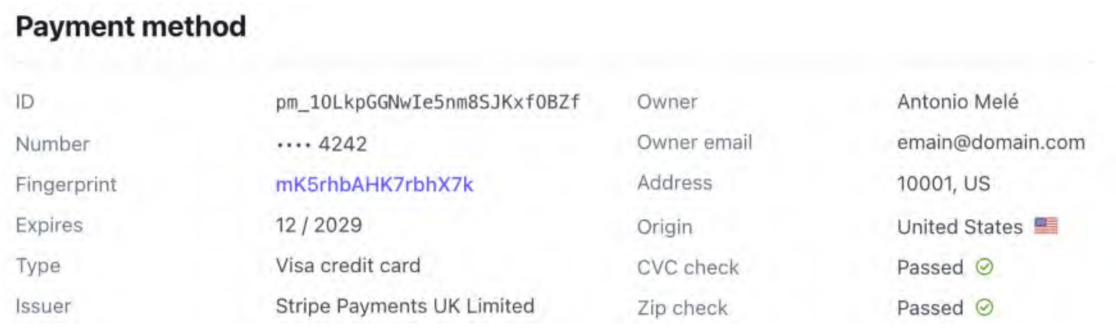


Figure 9.17: Payment method used in the Stripe transaction

Under this section, you will find another section named **Events and logs**, as in *Figure 9.18*:

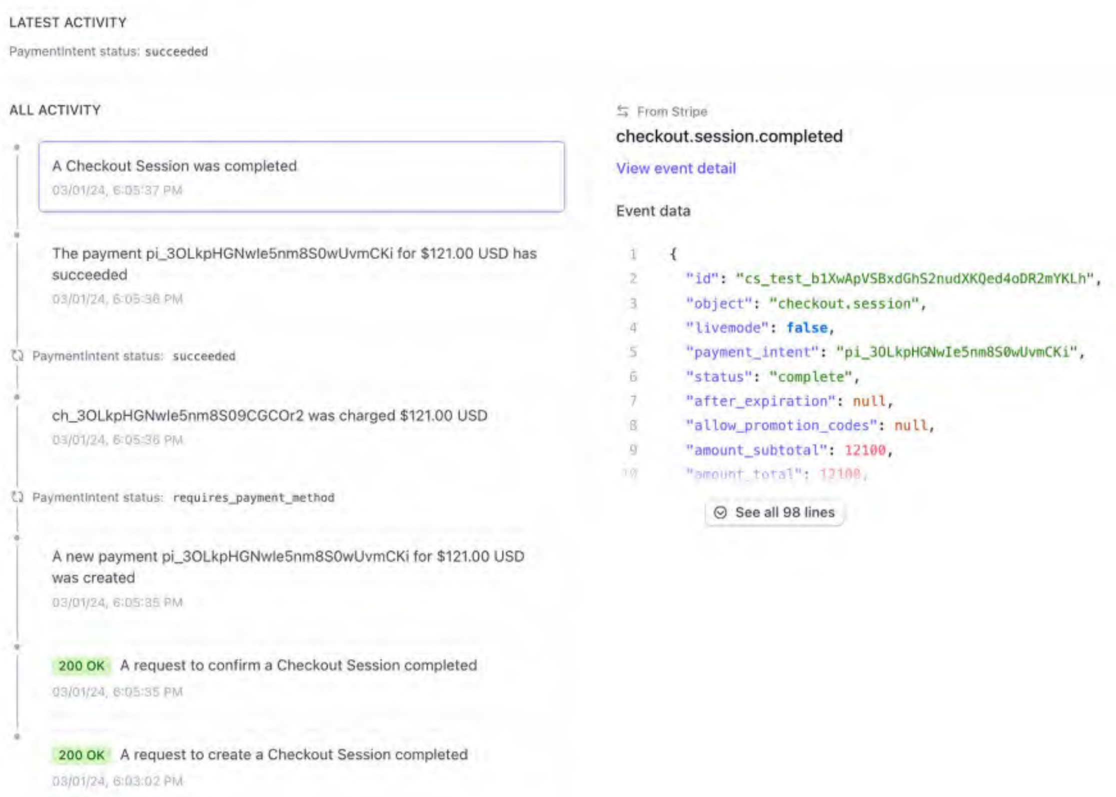


Figure 9.18: Events and logs for a Stripe transaction

This section contains all the activity related to the transaction, including requests to the Stripe API. You can click on any request to see the HTTP request to the Stripe API and the response in the JSON format.

Let's review the activity events in chronological order, from bottom to top:

1. First, a new checkout session is created by sending a `POST` request to the Stripe API endpoint `/v1/checkout/sessions`. The Stripe SDK method `stripe.checkout.Session.create()` that is used in the `payment_process` view builds and sends the request to the Stripe API, handling the response to return a `session` object.
2. The user is redirected to the checkout page where they submit the payment form. A request to confirm the checkout session is sent by the Stripe checkout page.
3. A new payment intent is created.
4. A charge related to the payment intent is created.
5. The payment intent is now completed with a successful payment.
6. The checkout session is completed.

Congratulations! You have successfully integrated Stripe Checkout into your project. Next, you will learn how to receive payment notifications from Stripe and how to reference Stripe payments in your shop orders.

Using webhooks to receive payment notifications

Stripe can push real-time events to our application by using webhooks. A **webhook**, also called a callback, can be thought of as an event-driven API instead of a request-driven API. Instead of polling the Stripe API frequently to know when a new payment is completed, Stripe can send an HTTP request to a URL of our application to notify us of successful payments in real time. The notification of these events will be asynchronous, when the event occurs, regardless of our synchronous calls to the Stripe API.

We will build a webhook endpoint to receive Stripe events. The webhook will consist of a view that will receive a JSON payload, with the event information to process it. We will use the event information to mark orders as paid when the checkout session is successfully completed.

Creating a webhook endpoint

You can add webhook endpoint URLs to your Stripe account to receive events. Since we are using webhooks and we don't have a hosted website accessible through a public URL, we will use the Stripe **Command-Line Interface** (**CLI**) to listen to events and forward them to our local environment.

Open `https://dashboard.stripe.com/test/webhooks` in your browser. You will see the following screen:

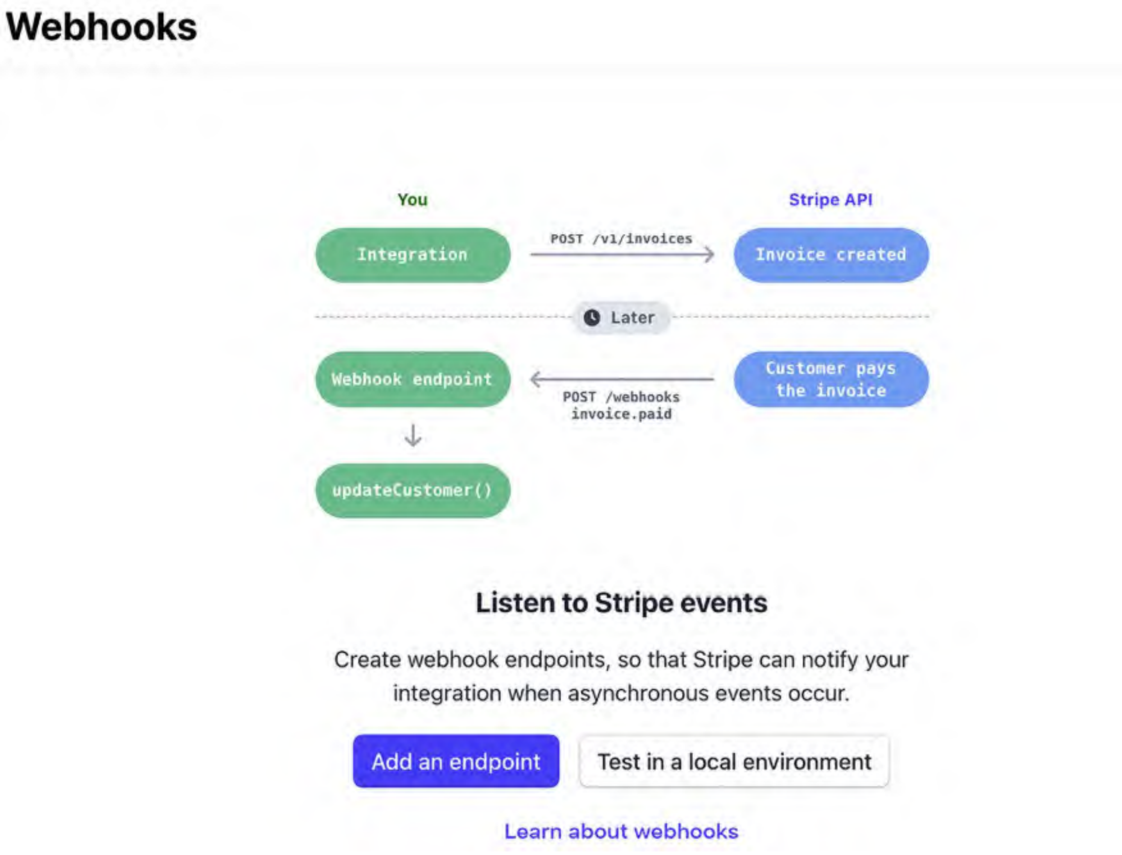


Figure 9.19: The Stripe webhooks default screen

Here, you can see a schema of how Stripe notifies your integration asynchronously. You will get Stripe notifications in real time whenever an event happens. Stripe sends different types of events, like checkout session created, payment intent created, payment intent updated, or checkout session completed. You can find a list of all the types of events that Stripe sends at `https://stripe.com/docs/api/events/types`.

Click on **Test in a local environment**. You will see the following screen:

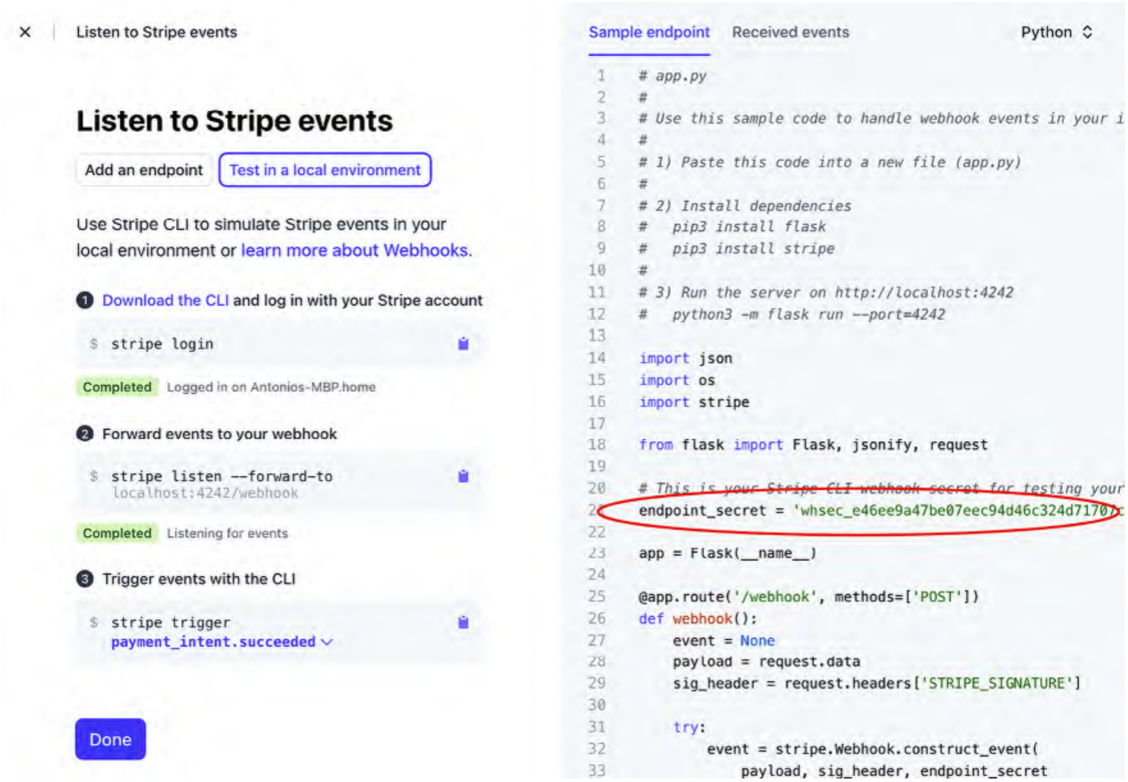


Figure 9.20: The Stripe webhook setup screen

This screen shows the steps to listen to Stripe events from your local environment. It also includes a sample Python webhook endpoint. Copy just the `endpoint_secret` value.

Edit the `.env` file of your project and add the following environment variable highlighted in bold:

```
STRIPE_PUBLISHABLE_KEY=pk_test_XXXX
STRIPE_SECRET_KEY=sk_test_XXXX
STRIPE_WEBHOOK_SECRET=whsec_XXXX
```

Replace the `STRIPE_WEBHOOK_SECRET` value with the `endpoint_secret` value provided by Stripe.

Edit the `settings.py` file of the `myshop` project and add the following setting to it:

```
# ...
STRIPE_PUBLISHABLE_KEY = config('STRIPE_PUBLISHABLE_KEY')
STRIPE_SECERT_KEY = config('STRIPE_SECRET_KEY')
STRIPE_API_VERSION = '2024-04-10'
STRIPE_WEBHOOK_SECRET = config('STRIPE_WEBHOOK_SECRET')
```

To build a webhook endpoint, we will create a view that receives a JSON payload with the event details. We will check the event details to identify when a checkout session is completed and mark the related order as paid.

Stripe signs the webhook events it sends to your endpoints by including a `Stripe-Signature` header, with a signature in each event. By checking the Stripe signature, you can verify that events were sent by Stripe and not by a third party. If you don't check the signature, an attacker could send fake events to your webhooks intentionally. The Stripe SDK provides a method to verify signatures. We will use it to create a webhook that verifies the signature.

Add a new file to the `payment/` application directory and name it `webhooks.py`. Add the following code to the new `webhooks.py` file:

```
import stripe
from django.conf import settings
from django.http import HttpResponse
from django.views.decorators.csrf import csrf_exempt
from orders.models import Order


@csrf_exempt
def stripe_webhook(request):
    payload = request.body
    sig_header = request.META['HTTP_STRIPE_SIGNATURE']
    event = None

    try:
        event = stripe.Webhook.construct_event(
            payload, sig_header, settings.STRIPE_WEBHOOK_SECRET
        )
    except ValueError as e:
        # Invalid payload
        return HttpResponse(status=400)
    except stripe.error.SignatureVerificationError as e:
        # Invalid signature
        return HttpResponse(status=400)

    return HttpResponse(status=200)
```

The `@csrf_exempt` decorator is used to prevent Django from performing the **cross-site request forgery** (**CSRF**) validation that is done by default for all `POST` requests. We use the method `stripe.Webhook.construct_event()` of the `stripe` library to verify the event's signature header. If the event's payload or the signature is invalid, we return an HTTP `400 Bad Request` response. Otherwise, we return an HTTP `200 OK` response.

This is the basic functionality required to verify the signature and construct the event from the JSON payload. Now, we can implement the actions of the webhook endpoint.

Add the following code highlighted in bold to the `stripe_webhook` view:

```
@csrf_exempt
def stripe_webhook(request):
    payload = request.body
    sig_header = request.META['HTTP_STRIPE_SIGNATURE']
    event = None
    try:
        event = stripe.Webhook.construct_event(
            payload, sig_header, settings.STRIPE_WEBHOOK_SECRET
        )
    except ValueError as e:
        # Invalid payload
        return HttpResponse(status=400)
    except stripe.error.SignatureVerificationError as e:
        # Invalid signature
        return HttpResponse(status=400)

    if event.type == 'checkout.session.completed':
        session = event.data.object
        if (
            session.mode == 'payment'
            and session.payment_status == 'paid'
        ):
            try:
                order = Order.objects.get(
                    id=session.client_reference_id
                )
            except Order.DoesNotExist:
                return HttpResponse(status=404)
            # mark order as paid
            order.paid = True
            order.save()

    return HttpResponse(status=200)
```

In the new code, we check whether the event received is `checkout.session.completed`. This event indicates that the checkout session has been successfully completed. If we receive this event, we retrieve the `session` object and check whether the session `mode` is `payment` because this is the expected mode for one-off payments.

Then, we get the `client_reference_id` attribute that we used when we created the checkout session and use the Django ORM to retrieve the `Order` object with the given `id`. If the order does not exist, we raise an HTTP `404` exception. Otherwise, we mark the order as paid with `order.paid = True`, and we save the order in the database.

Edit the `urls.py` file of the `payment` application and add the following code highlighted in bold:

```
from django.urls import path
from . import views, webhooks

app_name = 'payment'

urlpatterns = [
    path('process/', views.payment_process, name='process'),
    path('completed/', views.payment_completed, name='completed'),
    path('canceled/', views.payment_canceled, name='canceled'),
    path('webhook/', webhooks.stripe_webhook, name='stripe-webhook'),
]
```

We have imported the `webhooks` module and added the URL pattern for the Stripe webhook.

Testing webhook notifications

To test webhooks, you need to install the Stripe CLI. The Stripe CLI is a developer tool that allows you to test and manage your integration with Stripe directly from your shell. You will find installation instructions at `https://stripe.com/docs/stripe-cli#install`.

If you are using macOS or Linux, you can install the Stripe CLI with Homebrew using the following command:

```
brew install stripe/stripe-cli/stripe
```

If you are using Windows, or you are using macOS or Linux without Homebrew, download the latest Stripe CLI release for macOS, Linux, or Windows from `https://github.com/stripe/stripe-cli/releases/latest` and unzip the file. If you are using Windows, run the unzipped `.exe` file.

After installing the Stripe CLI, run the following command from a shell:

```
stripe login
```

You will see the following output:

```
Your pairing code is: xxxx-yyyy-zzzz-oooo This pairing code verifies your
authentication with Stripe.Press Enter to open the browser or visit https://
dashboard.stripe.com/stripecli/confirm_auth?t=....
```

Press *Enter* or open the URL in your browser. You will see the following screen:

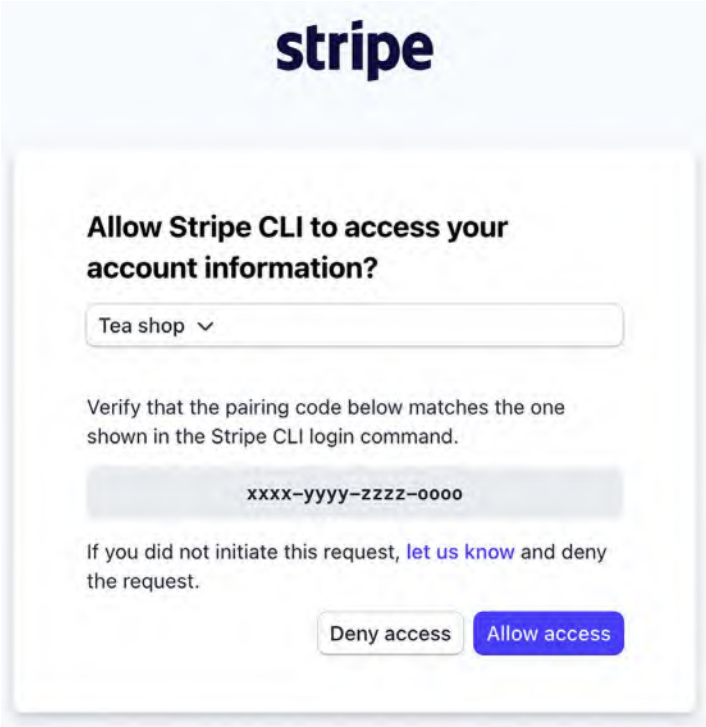


Figure 9.21: The Stripe CLI pairing screen

Verify that the pairing code in the Stripe CLI matches the one shown on the website and click on **Allow access**. You will see the following message:

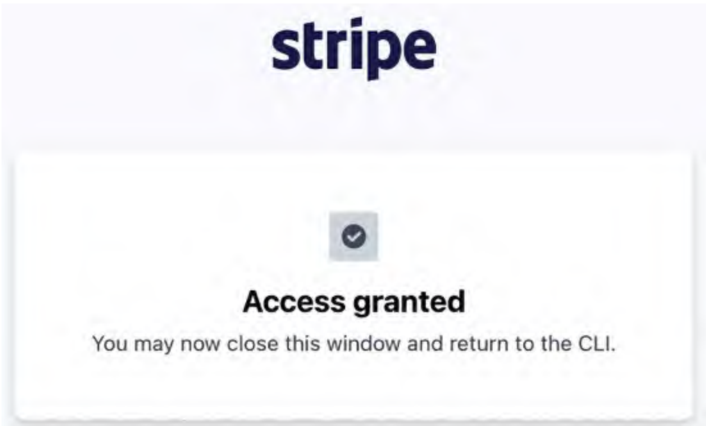


Figure 9.22: The Stripe CLI pairing confirmation

Now, run the following command from your shell:

```
stripe listen --forward-to 127.0.0.1:8000/payment/webhook/
```

We use this command to tell Stripe to listen to events and forward them to our localhost. We use port `8000`, where the Django development server is running, and the path `/payment/webhook/`, which matches the URL pattern of our webhook.

You will see the following output:

```
Getting ready... > Ready! You are using Stripe API Version [2024-04-10]. Your
webhook signing secret is xxxxxxxxxxxxxxxxxxx (^C to quit)
```

Here, you can see the webhook secret. Check that the webhook signing secret matches the `STRIPE_WEBHOOK_SECRET` setting in the `settings.py` file of your project.

Open `https://dashboard.stripe.com/test/webhooks` in your browser. You will see the following screen:

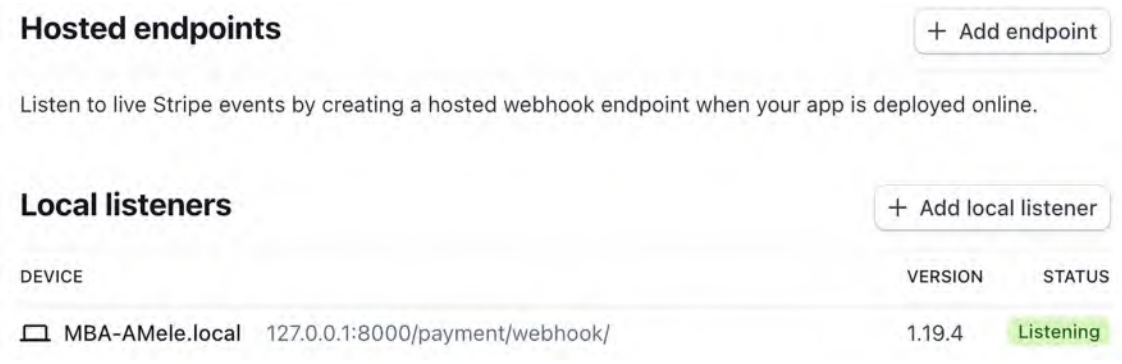


Figure 9.23: The Stripe Webhooks page

Under **Local listeners**, you will see the local listener that we created.

> In a production environment, the Stripe CLI is not needed. Instead, you would need to add a hosted webhook endpoint using the URL of your hosted application.

Open `http://127.0.0.1:8000/` in your browser, add some products to the shopping cart, and complete the checkout process.

Check the shell where you are running the Stripe CLI:

```
2024-01-03 18:06:13   --> payment_intent.created [evt_...]
2024-01-03 18:06:13  <--  [200] POST http://127.0.0.1:8000/payment/webhook/
[evt_...]
2024-01-03 18:06:13   --> payment_intent.succeeded [evt_...]
```

```
2024-01-03 18:06:13  <--  [200] POST http://127.0.0.1:8000/payment/webhook/
[evt_...]
2024-01-03 18:06:13   --> charge.succeeded [evt_...]
2024-01-03 18:06:13  <--  [200] POST http://127.0.0.1:8000/payment/webhook/
[evt_...]
2024-01-03 18:06:14   --> checkout.session.completed [evt_...]
2024-01-03 18:06:14  <--  [200] POST http://127.0.0.1:8000/payment/webhook/
[evt_...]
```

You can see the different events that have been sent by Stripe to the local webhook endpoint. The events might be in a different order than above. Stripe doesn't guarantee the delivery of events in the order in which they are generated. Let's review the events:

- `payment_intent.created`: The payment intent has been created.
- `payment_intent.succeeded`: The payment intent succeeded.
- `charge.succeeded`: The charge associated with the payment intent succeeded.
- `checkout.session.completed`: The checkout session has been completed. This is the event that we use to mark the order as paid.

The `stripe_webhook` webhook returns an HTTP `200 OK` response to all of the requests sent by Stripe. However, we only process the event `checkout.session.completed` to mark the order related to the payment as paid.

Next, open `http://127.0.0.1:8000/admin/orders/order/` in your browser. The order should now be marked as paid:

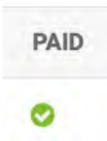


Figure 9.24: An order marked as paid in the order list of the administration site

Now, orders get automatically marked as paid with Stripe payment notifications. Next, you are going to learn how to reference Stripe payments in your shop orders.

Referencing Stripe payments in orders

Each Stripe payment has a unique identifier. We can use the payment ID to associate each order with its corresponding Stripe payment. We will add a new field to the `Order` model of the `orders` application so that we can reference the related payment by its ID. This will allow us to link each order with the related Stripe transaction.

Edit the `models.py` file of the `orders` application and add the following field to the `Order` model. The new field is highlighted in bold:

```
class Order(models.Model):
```

```
    # ...
    stripe_id = models.CharField(max_length=250, blank=True)
```

Let's sync this field with the database. Use the following command to generate the database migrations for the project:

```
python manage.py makemigrations
```

You will see the following output:

```
Migrations for 'orders':
  orders/migrations/0002_order_stripe_id.py
    - Add field stripe_id to order
```

Apply the migration to the database with the following command:

```
python manage.py migrate
```

You will see output that ends with the following line:

```
Applying orders.0002_order_stripe_id... OK
```

The model changes are now synced with the database. Now, you will be able to store the Stripe payment ID for each order.

Edit the `stripe_webhook` function in the `webhooks.py` file of the payment application and add the following lines highlighted in bold:

```
# ...
@csrf_exempt
def stripe_webhook(request):
    # ...

    if event.type == 'checkout.session.completed':
        session = event.data.object
        if (
            session.mode == 'payment'
            and session.payment_status == 'paid'
        ):
            try:
                order = Order.objects.get(
                    id=session.client_reference_id
                )
            except Order.DoesNotExist:
                return HttpResponse(status=404)
            # mark order as paid
            order.paid = True
```

```
            # store Stripe payment ID
            order.stripe_id = session.payment_intent
            order.save()
    return HttpResponse(status=200)
```

With this change, when receiving a webhook notification for a completed checkout session, the payment intent ID is stored in the `stripe_id` field of the `Order` object.

Open `http://127.0.0.1:8000/` in your browser, add some products to the shopping cart, and complete the checkout process. Then, access `http://127.0.0.1:8000/admin/orders/order/` in your browser and click on the latest order ID to edit it. The `stripe_id` field should contain the payment intent ID, as shown in *Figure 9.25*:

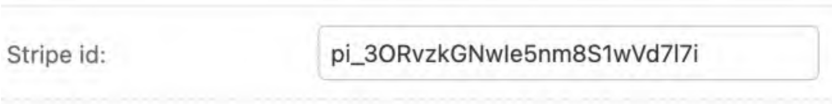


Figure 9.25: The Stripe id field with the payment intent ID

Great! We have successfully referenced Stripe payments in orders. Now, we can add Stripe payment IDs to the order list on the administration site. We can also include a link to each payment ID to see the payment details in the Stripe dashboard.

Edit the `models.py` file of the `orders` application and add the following code highlighted in bold:

```
from django.conf import settings
from django.db import models


class Order(models.Model):
    # ...
    class Meta:
        # ...

    def __str__(self):
        return f'Order {self.id}'

    def get_total_cost(self):
        return sum(item.get_cost() for item in self.items.all())

    def get_stripe_url(self):
        if not self.stripe_id:
            # no payment associated
            return ''
        if '_test_' in settings.STRIPE_SECRET_KEY:
```

```
            # Stripe path for test payments
            path = '/test/'
        else:
            # Stripe path for real payments
            path = '/'
        return f'https://dashboard.stripe.com{path}payments/{self.stripe_id}'
```

We have added the new `get_stripe_url()` method to the `Order` model. This method is used to return the Stripe dashboard's URL for the payment associated with the order. If no payment ID is stored in the `stripe_id` field of the `Order` object, an empty string is returned. Otherwise, the URL for the payment in the Stripe dashboard is returned. We check if the string `_test_` is present in the `STRIPE_SECRET_KEY` setting to discriminate the production environment from the test environment. Payments in the production environment follow the pattern `https://dashboard.stripe.com/payments/{id}`, whereas test payments follow the pattern `https://dashboard.stripe.com/payments/test/{id}`.

Let's add a link to each `Order` object on the list display page of the administration site.

Edit the `admin.py` file of the `orders` application and add the following code highlighted in bold:

```
# ...
from django.utils.safestring import mark_safe


def order_payment(obj):
    url = obj.get_stripe_url()
    if obj.stripe_id:
        html = f'<a href="{url}" target="_blank">{obj.stripe_id}</a>'
        return mark_safe(html)
    return ''
order_payment.short_description = 'Stripe payment'

@admin.register(Order)
class OrderAdmin(admin.ModelAdmin):
    list_display = [
        'id',
        'first_name',
        'last_name',
        'email',
        'address',
        'postal_code',
        'city',
        'paid',
        order_payment,
        'created',
```

```
            'updated'
        ]
        # ...
```

The `order_stripe_payment()` function takes an `Order` object as an argument and returns an HTML link with the payment URL in Stripe. Django escapes HTML output by default. We use the `mark_safe` function to avoid auto-escaping.

> Avoid using `mark_safe` on input that has come from the user to avoid **Cross-Site Scripting** (**XSS**). XSS enables attackers to inject client-side scripts into web content viewed by other users.

Open `http://127.0.0.1:8000/admin/orders/order/` in your browser. You will see a new column named **STRIPE PAYMENT**. You will see the related Stripe payment ID for the latest order. If you click on the payment ID, you will be taken to the payment URL in Stripe, where you can find the additional payment details.

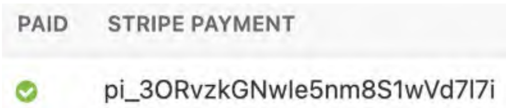


Figure 9.26: The Stripe payment ID for an Order object in the administration site

Now, you automatically store Stripe payment IDs in orders when receiving payment notifications. You have successfully integrated Stripe into your project.

Going live

Once you have tested your integration, you can apply for a production Stripe account. When you are ready to move into production, remember to replace your test Stripe credentials with the live ones in the `settings.py` file. You will also need to add a webhook endpoint for your hosted website at `https://dashboard.stripe.com/webhooks` instead of using the Stripe CLI. *Chapter 17*, *Going Live*, will teach you how to configure project settings for multiple environments.

Exporting orders to CSV files

Sometimes, you might want to export the information contained in a model to a file so that you can import it into another system. One of the most widely used formats to export/import data is the **Comma-Separated Values** (**CSV**) format. A CSV file is a plain text file consisting of a number of records. There is usually one record per line and some delimiter character, usually a literal comma, separating the record fields. We are going to customize the administration site to be able to export orders to CSV files.

Adding custom actions to the administration site

Django offers a wide range of options to customize the administration site. You are going to modify the object list view to include a custom administration action. You can implement custom administration actions to allow staff users to apply actions to multiple elements at once in the change list view.

An administration action works as follows: a user selects objects from the administration object list page with checkboxes, selects an action to perform on all of the selected items, and then executes the actions. *Figure 9.27* shows where the actions are located on the administration site:

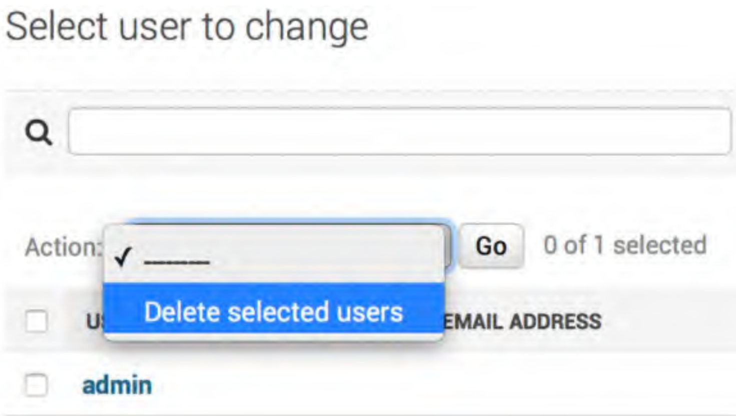


Figure 9.27: The drop-down menu for Django administration actions

You can create a custom action by writing a regular function that receives the following parameters:

- The current `ModelAdmin` being displayed
- The current request object as an `HttpRequest` instance
- A QuerySet for the objects selected by the user

This function will be executed when the action is triggered from the administration site.

You are going to create a custom administration action to download a list of orders as a CSV file.

Edit the `admin.py` file of the `orders` application and add the following code before the `OrderAdmin` class:

```
import csv
import datetime
from django.http import HttpResponse


def export_to_csv(modeladmin, request, queryset):
    opts = modeladmin.model._meta
    content_disposition = (
        f'attachment; filename={opts.verbose_name}.csv'
```

```
    )
    response = HttpResponse(content_type='text/csv')
    response['Content-Disposition'] = content_disposition
    writer = csv.writer(response)
    fields = [
        field
        for field in opts.get_fields()
        if not field.many_to_many and not field.one_to_many
    ]
    # Write a first row with header information
    writer.writerow([field.verbose_name for field in fields])
    # Write data rows
    for obj in queryset:
        data_row = []
        for field in fields:
            value = getattr(obj, field.name)
            if isinstance(value, datetime.datetime):
                value = value.strftime('%d/%m/%Y')
            data_row.append(value)
        writer.writerow(data_row)
    return response
export_to_csv.short_description = 'Export to CSV'
```

In this code, you perform the following tasks:

1. You create an instance of `HttpResponse`, specifying the `text/csv` content type, to tell the browser that the response has to be treated as a CSV file. You also add a `Content-Disposition` header to indicate that the HTTP response contains an attached file.
2. You create a CSV `writer` object that will write to the `response` object.
3. You get the `model` fields dynamically using the `get_fields()` method of the model's `_meta` options. You exclude many-to-many and one-to-many relationships.
4. You write a header row, including the field names.
5. You iterate over the given QuerySet and write a row for each object returned by the QuerySet. You take care of formatting `datetime` objects because the output value for CSV has to be a string.
6. You customize the display name for the action in the action's drop-down element of the administration site by setting a `short_description` attribute on the function.

You have created a generic administration action that can be added to any `ModelAdmin` class.

Finally, add the new `export_to_csv` administration action to the `OrderAdmin` class, as follows. The new code is highlighted in bold:

```
@admin.register(Order)
class OrderAdmin(admin.ModelAdmin):
```

```
    # ...
    actions = [export_to_csv]
```

Start the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/orders/order/` in your browser. The resulting administration action should look like this:

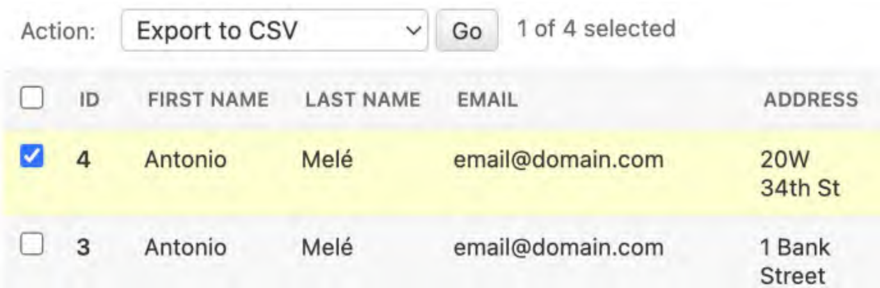


Figure 9.28: Using the custom Export to CSV administration action

Select some orders, choose the **Export to CSV** action from the select box, and then click the **Go** button. Your browser will download the generated CSV file named `order.csv`. Open the downloaded file using a text editor. You should see content with the following format, including a header row and a row for each `Order` object you selected:

```
ID,first name,last name,email,address,postal
code,city,created,updated,paid,stripe id
4,Antonio,Melé,email@domain.com,20 W 34th St,10001,New
York,03/01/2024,03/01/2024,True,pi_3ORvzkGNwIe5nm8S1wVd7l7i
...
```

As you can see, creating administration actions is pretty straightforward. You can learn more about generating CSV files with Django at `https://docs.djangoproject.com/en/5.0/howto/outputting-csv/`.

If you want to add more advanced import/export functionalities to your administration site, you can use the third-party application `django-import-export`. You can find its documentation at `https://django-import-export.readthedocs.io/en/latest/`.

The example we have implemented works well for small to medium datasets. Given that the export occurs within an HTTP request, very large datasets could lead to server timeouts if the server closes the connection before the export process concludes. To circumvent this, you can generate exports asynchronously using Celery, with the `django-import-export-celery` application. This project is available at `https://github.com/auto-mat/django-import-export-celery`.

Next, you are going to customize the administration site further by creating a custom administration view.

Extending the administration site with custom views

Sometimes, you may want to customize the administration site beyond what is possible by configuring `ModelAdmin`, creating administration actions, and overriding administration templates. You might want to implement additional functionalities that are not available in existing administration views or templates. If this is the case, you need to create a custom administration view. With a custom view, you can build any functionality you want; you just have to make sure that only staff users can access your view and that you maintain the administration look and feel by making your template extend an administration template.

Let's create a custom view to display information about an order. Edit the `views.py` file of the `orders` application and add the following code highlighted in bold:

```
from django.contrib.admin.views.decorators import staff_member_required
from django.shortcuts import get_object_or_404, redirect, render
from cart.cart import Cart
from .forms import OrderCreateForm
from .models import Order, OrderItem
from .tasks import order_created


def order_create(request):
    # ...

@staff_member_required
def admin_order_detail(request, order_id):
    order = get_object_or_404(Order, id=order_id)
    return render(
        request, 'admin/orders/order/detail.html', {'order': order}
    )
```

The `staff_member_required` decorator checks that both the `is_active` and `is_staff` fields of the user requesting the page are set to `True`. In this view, you get the `Order` object with the given ID and render a template to display the order.

Next, edit the `urls.py` file of the `orders` application and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    path('create/', views.order_create, name='order_create'),
    path(
        'admin/order/<int:order_id>/',
        views.admin_order_detail,
        name='admin_order_detail'
```

```
    ),
]
```

Create the following file structure inside the `templates/` directory of the `orders` application:

```
admin/
    orders/
        order/
            detail.html
```

Edit the `detail.html` template and add the following content to it:

```
{% extends "admin/base_site.html" %}

{% block title %}
  Order {{ order.id }} {{ block.super }}
{% endblock %}

{% block breadcrumbs %}
  <div class="breadcrumbs">
    <a href="{% url "admin:index" %}">Home</a> &rsaquo;
    <a href="{% url "admin:orders_order_changelist" %}">Orders</a>
    &rsaquo;
    <a href="{% url "admin:orders_order_change" order.id %}">Order {{ order.id
}}</a>
    &rsaquo; Detail
  </div>
{% endblock %}

{% block content %}
<div class="module">
  <h1>Order {{ order.id }}</h1>
  <ul class="object-tools">
    <li>
      <a href="#" onclick="window.print();">
        Print order
      </a>
    </li>
  </ul>
  <table>
    <tr>
      <th>Created</th>
      <td>{{ order.created }}</td>
```

```
      </tr>
      <tr>
        <th>Customer</th>
        <td>{{ order.first_name }} {{ order.last_name }}</td>
      </tr>
      <tr>
        <th>E-mail</th>
        <td><a href="mailto:{{ order.email }}">{{ order.email }}</a></td>
      </tr>
      <tr>
        <th>Address</th>
      <td>
        {{ order.address }},
        {{ order.postal_code }} {{ order.city }}
      </td>
      </tr>
      <tr>
        <th>Total amount</th>
        <td>${{ order.get_total_cost }}</td>
      </tr>
      <tr>
        <th>Status</th>
        <td>{% if order.paid %}Paid{% else %}Pending payment{% endif %}</td>
      </tr>
      <tr>
        <th>Stripe payment</th>
        <td>
          {% if order.stripe_id %}
            <a href="{{ order.get_stripe_url }}" target="_blank">
              {{ order.stripe_id }}
            </a>
          {% endif %}
        </td>
      </tr>
    </table>
  </div>
  <div class="module">
    <h2>Items bought</h2>
    <table style="width:100%">
      <thead>
        <tr>
          <th>Product</th>
```

```
          <th>Price</th>
          <th>Quantity</th>
          <th>Total</th>
        </tr>
      </thead>
      <tbody>
        {% for item in order.items.all %}
          <tr class="row{% cycle "1" "2" %}">
            <td>{{ item.product.name }}</td>
            <td class="num">${{ item.price }}</td>
            <td class="num">{{ item.quantity }}</td>
            <td class="num">${{ item.get_cost }}</td>
          </tr>
        {% endfor %}
        <tr class="total">
          <td colspan="3">Total</td>
          <td class="num">${{ order.get_total_cost }}</td>
        </tr>
      </tbody>
    </table>
  </div>
{% endblock %}
```

Make sure that no template tag is split across multiple lines.

This is the template to display the details of an order on the administration site. This template extends the `admin/base_site.html` template of Django's administration site, which contains the main HTML structure and CSS styles. You use the blocks defined in the parent template to include your own content. You display information about the order and the items bought.

When you want to extend an administration template, you need to know its structure and identify existing blocks. You can find all administration templates at `https://github.com/django/django/tree/5.0/django/contrib/admin/templates/admin`.

You can also override an administration template if you need to. To do so, copy a template into your `templates/` directory, keeping the same relative path and filename. Django's administration site will use your custom template instead of the default one.

Finally, let's add a link to each `Order` object on the list display page of the administration site. Edit the `admin.py` file of the `orders` application and add the following code to it, above the `OrderAdmin` class:

```
from django.urls import reverse


def order_detail(obj):
```

```
    url = reverse('orders:admin_order_detail', args=[obj.id])
    return mark_safe(f'<a href="{url}">View</a>')
```

This is a function that takes an `Order` object as an argument and returns an HTML link for the `admin_order_detail` URL. Django escapes HTML output by default. You have to use the `mark_safe` function to avoid auto-escaping.

Then, edit the `OrderAdmin` class to display the link, as follows. The new code is highlighted in bold:

```
class OrderAdmin(admin.ModelAdmin):
    list_display = [
        'id',
        'first_name',
        'last_name',
        'email',
        'address',
        'postal_code',
        'city',
        'paid',
        order_payment,
        'created',
        'updated',
        order_detail,
    ]
    # ...
```

Start the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/orders/order/` in your browser. Each row includes a **View** link, as follows:

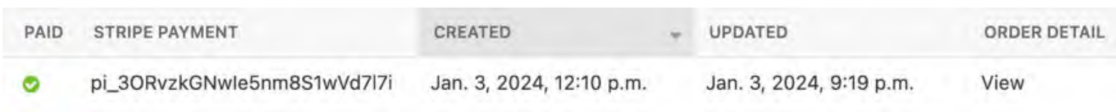


Figure 9.29: The View link included in each order row

Click on the **View** link for any order to load the custom order detail page. You should see a page like the following one:

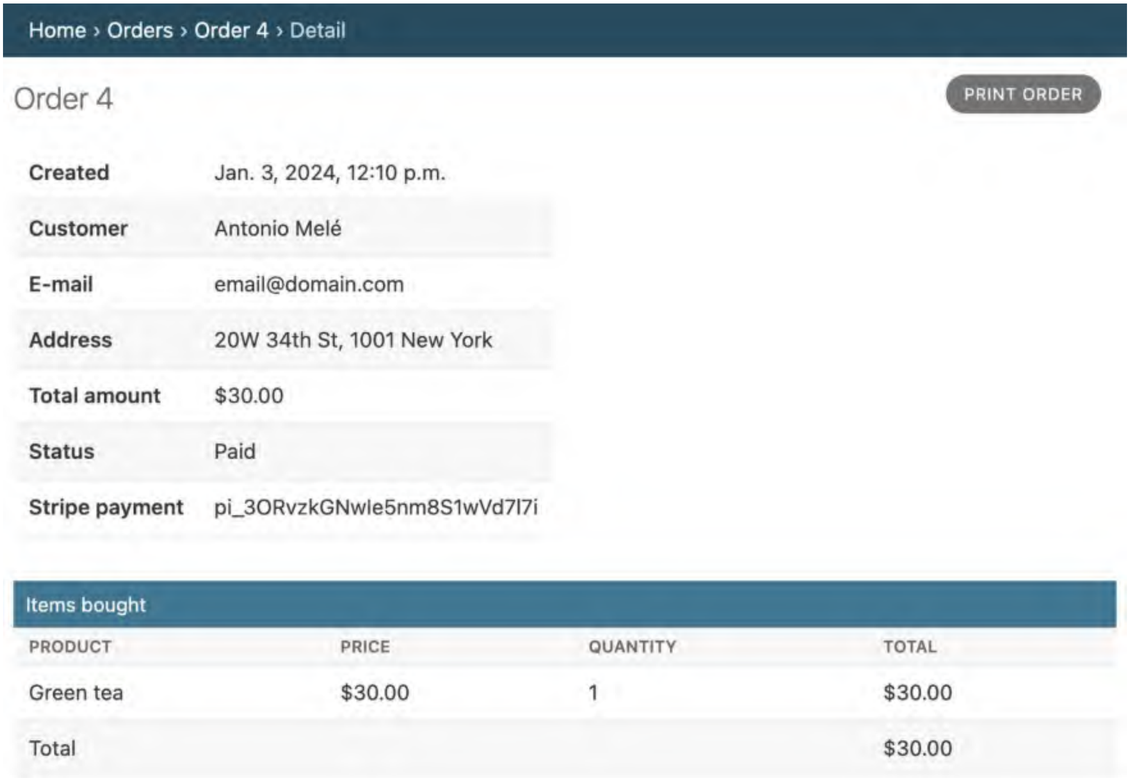


Figure 9.30: The custom order detail page on the administration site

Now that you have created the product detail page, you will learn how to generate order invoices in the PDF format dynamically.

Generating PDF invoices dynamically

Now that you have a complete checkout and payment system, you can generate a PDF invoice for each order. There are several Python libraries to generate PDF files. One popular library to generate PDFs with Python code is ReportLab. You can find information about how to output PDF files with ReportLab at `https://docs.djangoproject.com/en/5.0/howto/outputting-pdf/`.

In most cases, you will have to add custom styles and formatting to your PDF files. You will find it more convenient to render an HTML template and convert it into a PDF file, keeping Python away from the presentation layer. You are going to follow this approach and use a module to generate PDF files with Django. You will use WeasyPrint, which is a Python library that can generate PDF files from HTML templates.

Installing WeasyPrint

First, install WeasyPrint's dependencies for your operating system from `https://doc.courtbouillon.org/weasyprint/stable/first_steps.html`. Then, install WeasyPrint via `pip` using the following command:

```
python -m pip install WeasyPrint==61.2
```

Creating a PDF template

You need an HTML document as input for WeasyPrint. You are going to create an HTML template, render it using Django, and pass it to WeasyPrint to generate the PDF file.

Create a new template file inside the `templates/orders/order/` directory of the `orders` application and name it `pdf.html`. Add the following code to it:

```
<html>
<body>
  <h1>My Shop</h1>
  <p>
    Invoice no. {{ order.id }}<br>
    <span class="secondary">
      {{ order.created|date:"M d, Y" }}
    </span>
  </p>
  <h3>Bill to</h3>
  <p>
    {{ order.first_name }} {{ order.last_name }}<br>
    {{ order.email }}<br>
    {{ order.address }}<br>
    {{ order.postal_code }}, {{ order.city }}
  </p>
  <h3>Items bought</h3>
  <table>
    <thead>
      <tr>
        <th>Product</th>
        <th>Price</th>
        <th>Quantity</th>
        <th>Cost</th>
      </tr>
    </thead>
    <tbody>
      {% for item in order.items.all %}
```

```
          <tr class="row{% cycle "1" "2" %}">
            <td>{{ item.product.name }}</td>
            <td class="num">${{ item.price }}</td>
            <td class="num">{{ item.quantity }}</td>
            <td class="num">${{ item.get_cost }}</td>
          </tr>
        {% endfor %}
        <tr class="total">
          <td colspan="3">Total</td>
          <td class="num">${{ order.get_total_cost }}</td>
        </tr>
      </tbody>
    </table>

    <span class="{% if order.paid %}paid{% else %}pending{% endif %}">
      {% if order.paid %}Paid{% else %}Pending payment{% endif %}
    </span>
  </body>
  </html>
```

This is the template for the PDF invoice. In this template, you display all order details and an HTML `<table>` element, including the products. You also include a message to display whether the order has been paid.

Rendering PDF files

You are going to create a view to generate PDF invoices for existing orders using the administration site. Edit the `views.py` file inside the `orders` application directory and add the following code to it:

```
import weasyprint
from django.contrib.staticfiles import finders
from django.http import HttpResponse
from django.template.loader import render_to_string


@staff_member_required
def admin_order_pdf(request, order_id):
    order = get_object_or_404(Order, id=order_id)
    html = render_to_string('orders/order/pdf.html', {'order': order})
    response = HttpResponse(content_type='application/pdf')
    response['Content-Disposition'] = f'filename=order_{order.id}.pdf'
    weasyprint.HTML(string=html).write_pdf(
        response,
```

```
            stylesheets=[weasyprint.CSS(finders.find('css/pdf.css'))]
        )
        return response
```

This is the view to generate a PDF invoice for an order. You use the `staff_member_required` decorator to make sure only staff users can access this view.

You get the `Order` object with the given ID and use the `render_to_string()` function provided by Django to render `orders/order/pdf.html`. The rendered HTML is saved in the `html` variable.

Then, you generate a new `HttpResponse` object, specifying the `application/pdf` content type and including the `Content-Disposition` header to specify the filename. You use WeasyPrint to generate a PDF file from the rendered HTML code and write the file to the `HttpResponse` object.

You use the static file `css/pdf.css` to add CSS styles to the generated PDF file. To locate the file, you use the `finders()` function of the `staticfiles` module. Finally, you return the generated response.

If you are missing the CSS styles, remember to copy the static files located in the `static/` directory of the `shop` application to the same location of your project.

You can find the contents of the directory at `https://github.com/PacktPublishing/Django-5-by-Example/tree/main/Chapter09/myshop/shop/static`.

Since you need to use the `STATIC_ROOT` setting, you have to add it to your project. This is the project's path where static files reside. Edit the `settings.py` file of the `myshop` project and add the following setting:

```
STATIC_ROOT = BASE_DIR / 'static'
```

Then, run the following command:

```
python manage.py collectstatic
```

You should see output that ends like this:

```
131 static files copied to 'code/myshop/static'.
```

The `collectstatic` command copies all static files from your applications into the directory defined in the `STATIC_ROOT` setting. This allows each application to provide its own static files using a `static/` directory containing them. You can also provide additional static file sources in the `STATICFILES_DIRS` setting. All of the directories specified in the `STATICFILES_DIRS` list will also be copied to the `STATIC_ROOT` directory when `collectstatic` is executed. Whenever you execute `collectstatic` again, you will be asked if you want to override the existing static files.

Edit the `urls.py` file inside the `orders` application directory and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    # ...
    path('admin/order/<int:order_id>/pdf/',
```

```
        views.admin_order_pdf,
        name='admin_order_pdf'
    ),
]
```

Now, you can edit the administration list display page for the `Order` model to add a link to the PDF file for each result. Edit the `admin.py` file inside the `orders` application and add the following code above the `OrderAdmin` class:

```
def order_pdf(obj):
    url = reverse('orders:admin_order_pdf', args=[obj.id])
    return mark_safe(f'<a href="{url}">PDF</a>')
order_pdf.short_description = 'Invoice'
```

If you specify a `short_description` attribute for your callable, Django will use it for the name of the column.

Add `order_pdf` to the `list_display` attribute of the `OrderAdmin` class, as follows:

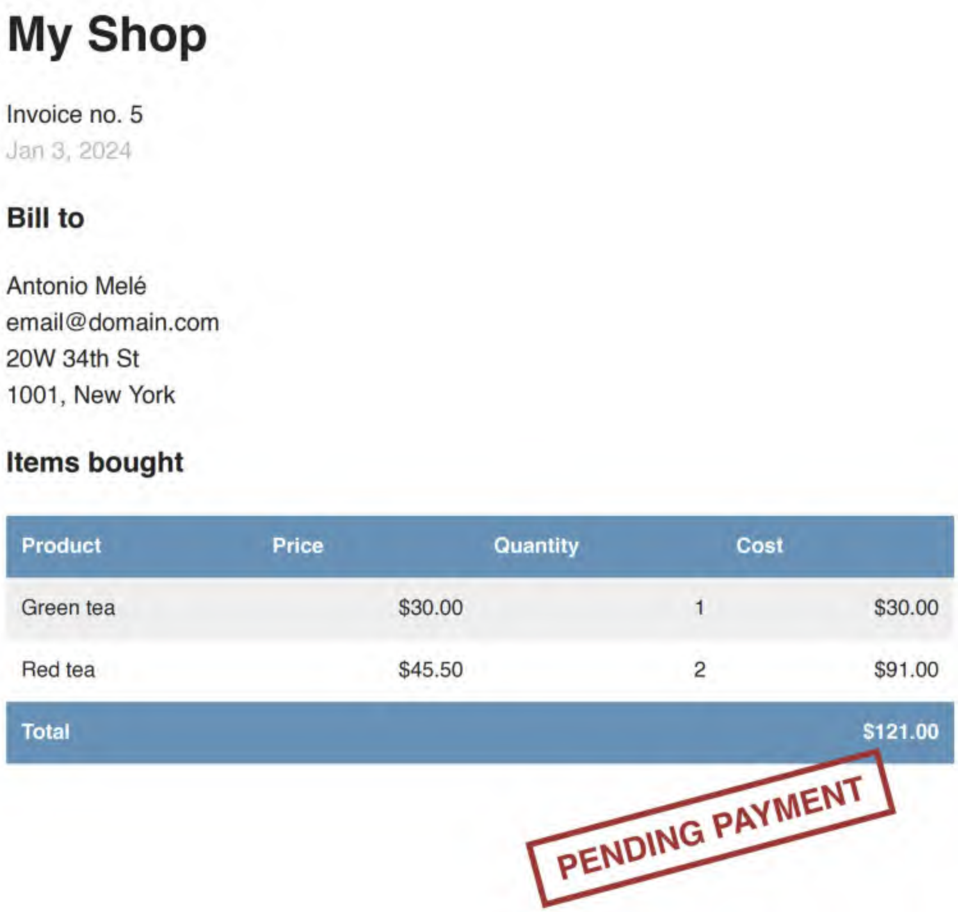
```
class OrderAdmin(admin.ModelAdmin):
    list_display = [
        'id',
        'first_name',
        'last_name',
        'email',
        'address',
        'postal_code',
        'city',
        'paid',
        order_payment,
        'created',
        'updated',
        order_detail,
        order_pdf,
    ]
```

Make sure the development server is running. Open `http://127.0.0.1:8000/admin/orders/order/` in your browser. Each row should now include a **PDF** link, like this:

CREATED	UPDATED	ORDER DETAIL	INVOICE
Jan. 3, 2024, 12:10 p.m.	Jan. 3, 2024, 9:19 p.m.	View	PDF

Figure 9.31: The PDF link included in each order row

Click on the **PDF** link for any order. You should see a generated PDF file like the following one for orders that have not been paid yet:



My Shop

Invoice no. 5
Jan 3, 2024

Bill to

Antonio Melé
email@domain.com
20W 34th St
1001, New York

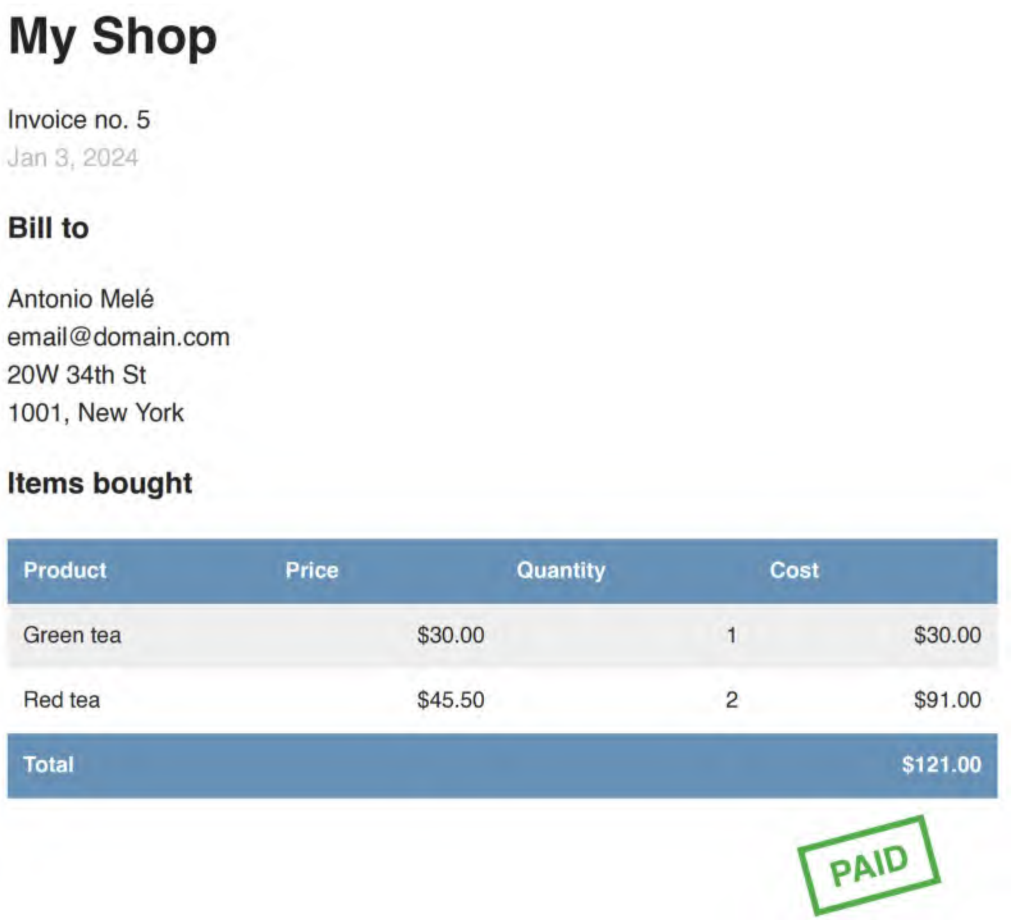
Items bought

Product	Price	Quantity	Cost
Green tea	$30.00	1	$30.00
Red tea	$45.50	2	$91.00
Total			**$121.00**

PENDING PAYMENT

Figure 9.32: The PDF invoice for an unpaid order

For paid orders, you will see the following PDF file:



My Shop

Invoice no. 5
Jan 3, 2024

Bill to

Antonio Melé
email@domain.com
20W 34th St
1001, New York

Items bought

Product	Price	Quantity	Cost
Green tea	$30.00	1	$30.00
Red tea	$45.50	2	$91.00
Total			$121.00

PAID

Figure 9.33: The PDF invoice for a paid order

Sending PDF files by email

When a payment is successful, you will send an automatic email to your customer including the generated PDF invoice. You will create an asynchronous task to perform this action.

Create a new file inside the `payment` application directory and name it `tasks.py`. Add the following code to it:

```
from io import BytesIO
import weasyprint
from celery import shared_task
from django.contrib.staticfiles import finders
from django.core.mail import EmailMessage
from django.template.loader import render_to_string
from orders.models import Order


@shared_task
def payment_completed(order_id):
    """
    Task to send an e-mail notification when an order is
    successfully paid.
    """
    order = Order.objects.get(id=order_id)
    # create invoice e-mail
    subject = f'My Shop - Invoice no. {order.id}'
    message = (
        'Please, find attached the invoice for your recent purchase.'
    )
    email = EmailMessage(
        subject, message, 'admin@myshop.com', [order.email]
    )
    # generate PDF
    html = render_to_string('orders/order/pdf.html', {'order': order})
    out = BytesIO()
    stylesheets=[weasyprint.CSS(finders.find('css/pdf.css'))]
    weasyprint.HTML(string=html).write_pdf(out, stylesheets=stylesheets)
    # attach PDF file
    email.attach(
        f'order_{order.id}.pdf', out.getvalue(), 'application/pdf'
    )
    # send e-mail
    email.send()
```

You define the `payment_completed` task by using the `@shared_task` decorator. In this task, you use the `EmailMessage` class provided by Django to create an `email` object. Then, you render the template in the `html` variable. You generate the PDF file from the rendered template and output it to a `BytesIO` instance, which is an in-memory bytes buffer. Then, you attach the generated PDF file to the `EmailMessage` object using the `attach()` method, including the contents of the `out` buffer. Finally, you send the email.

Remember to set up your **Simple Mail Transfer Protocol** (**SMTP**) settings in the `settings.py` file of the project to send emails. You can refer to *Chapter 2*, *Enhancing Your Blog with Advanced Features*, to see a working example of an SMTP configuration. If you don't want to set up email settings, you can tell Django to write emails to the console by adding the following setting to the `settings.py` file:

```
EMAIL_BACKEND = 'django.core.mail.backends.console.EmailBackend'
```

Let's add the `payment_completed` task to the webhook endpoint that handles payment completion events.

Edit the `webhooks.py` file of the `payment` application and modify it to make it look like this:

```
import stripe
from django.conf import settings
from django.http import HttpResponse
from django.views.decorators.csrf import csrf_exempt
from orders.models import Order
from .tasks import payment_completed


@csrf_exempt
def stripe_webhook(request):
    payload = request.body
    sig_header = request.META['HTTP_STRIPE_SIGNATURE']
    event = None
    try:
        event = stripe.Webhook.construct_event(
            payload, sig_header, settings.STRIPE_WEBHOOK_SECRET
        )
    except ValueError as e:
        # Invalid payload
        return HttpResponse(status=400)
    except stripe.error.SignatureVerificationError as e:
        # Invalid signature
        return HttpResponse(status=400)
    if event.type == 'checkout.session.completed':
        session = event.data.object
        if (
```

```
                session.mode == 'payment'
                and session.payment_status == 'paid'
            ):
                try:
                    order = Order.objects.get(
                        id=session.client_reference_id
                    )
                except Order.DoesNotExist:
                    return HttpResponse(status=404)
                # mark order as paid
                order.paid = True
                # store Stripe payment ID
                order.stripe_id = session.payment_intent
                order.save()
                # launch asynchronous task
                payment_completed.delay(order.id)

        return HttpResponse(status=200)
```

The `payment_completed` task is queued by calling its `delay()` method. The task will be added to the queue and executed asynchronously by a Celery worker as soon as possible.

Now, you can complete a new checkout process in order to receive the PDF invoice in your email. If you are using the `console.EmailBackend` for your email backend, in the shell where you are running Celery, you will be able to see the following output:

```
MIME-Version: 1.0
Subject: My Shop - Invoice no. 7
From: admin@myshop.com
To: email@domain.com
Date: Wed, 3 Jan 2024 20:15:24 -0000
Message-ID: <164841212458.94972.10344068999595916799@amele-mbp.home>
--===============8908668108717577350==
Content-Type: text/plain; charset="utf-8"
MIME-Version: 1.0
Content-Transfer-Encoding: 7bit
Please, find attached the invoice for your recent purchase.
--===============8908668108717577350==
Content-Type: application/pdf
MIME-Version: 1.0
Content-Transfer-Encoding: base64
Content-Disposition: attachment; filename="order_7.pdf"
JVBERi0xLjcKJfCflqQKMSAwIG9iago8PAovVHlwZSA...
```

This output shows that the email contains an attachment. You have learned how to attach files to emails and send them programmatically.

Congratulations! You have completed the Stripe integration and have added valuable functionality to your shop.

Summary

In this chapter, you integrated the Stripe payment gateway into your project and created a webhook endpoint to receive payment notifications. You built a custom administration action to export orders to CSV. You also customized the Django administration site using custom views and templates. Finally, you learned how to generate PDF files with WeasyPrint and how to attach them to emails.

The next chapter will teach you how to create a coupon system using Django sessions, and you will build a product recommendation engine with Redis.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter09`
- Stripe website: `https://www.stripe.com/`
- Stripe Checkout documentation: `https://stripe.com/docs/payments/checkout`
- Creating a Stripe account: `https://dashboard.stripe.com/register`
- Stripe account settings: `https://dashboard.stripe.com/settings/account`
- Stripe Python library: `https://github.com/stripe/stripe-python`
- Stripe test API keys: `https://dashboard.stripe.com/test/apikeys`
- Stripe API keys documentation: `https://stripe.com/docs/keys`
- Stripe API version 2024-04-10 release: `https://stripe.com/docs/upgrades#2024-04-10`
- Stripe checkout session modes: `https://stripe.com/docs/api/checkout/sessions/object#checkout_session_object-mode`
- Building absolute URIs with Django: `https://docs.djangoproject.com/en/5.0/ref/request-response/#django.http.HttpRequest.build_absolute_uri`
- Creating Stripe sessions: `https://stripe.com/docs/api/checkout/sessions/create`
- Stripe-supported currencies: `https://stripe.com/docs/currencies`
- Stripe Payments dashboard: `https://dashboard.stripe.com/test/payments`
- Credit cards for testing payments with Stripe: `https://stripe.com/docs/testing`
- Stripe webhooks: `https://dashboard.stripe.com/test/webhooks`
- Types of events sent by Stripe: `https://stripe.com/docs/api/events/types`
- Installing the Stripe CLI: `https://stripe.com/docs/stripe-cli#install`

- Latest Stripe CLI release: `https://github.com/stripe/stripe-cli/releases/latest`
- Generating CSV files with Django: `https://docs.djangoproject.com/en/5.0/howto/outputting-csv/`
- `django-import-export` application: `https://django-import-export.readthedocs.io/en/latest/`
- `django-import-export-celery` application: `https://github.com/auto-mat/django-import-export-celery`
- Django administration templates: `https://github.com/django/django/tree/5.0/django/contrib/admin/templates/admin`
- Outputting PDF files with ReportLab: `https://docs.djangoproject.com/en/5.0/howto/outputting-pdf/`
- Installing WeasyPrint: `https://doc.courtbouillon.org/weasyprint/stable/first_steps.html`
- Static files for this chapter: `https://github.com/PacktPublishing/Django-5-by-Example/tree/main/Chapter09/myshop/shop/static`

10

Extending Your Shop

In the previous chapter, you learned how to integrate a payment gateway into your shop. You also learned how to generate CSV and PDF files.

In this chapter, you will add a coupon system to your shop and create a product recommendation engine.

This chapter will cover the following points:

- Creating a coupon system
- Applying coupons to the shopping cart
- Applying coupons to orders
- Creating coupons for Stripe Checkout
- Storing products that are usually bought together
- Building a product recommendation engine with Redis

Functional overview

Figure 10.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

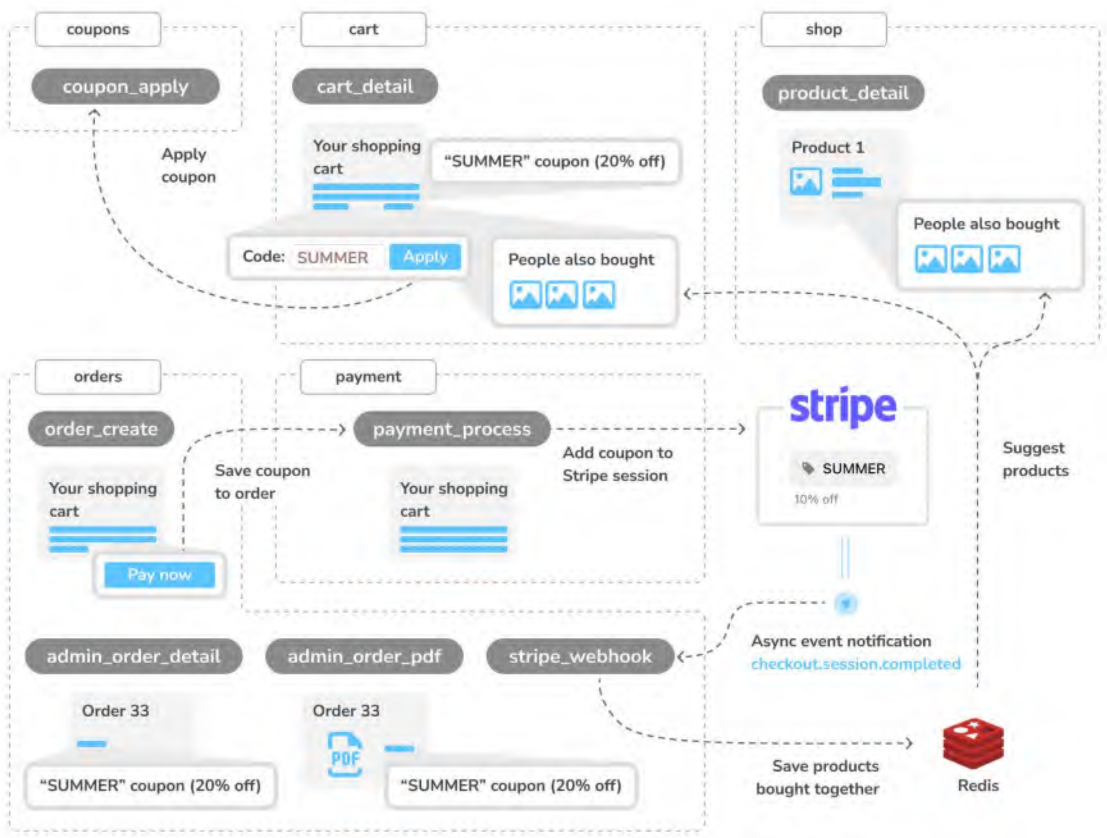


Figure 10.1: Diagram of functionalities built in Chapter 10

In this chapter, you will build a new `coupons` application and create the `coupon_apply` view to apply discount coupons to the cart session. You will add the discount applied to the template of the `cart_detail` view of the `cart` application. When an order is created with the `order_create` view of the `orders` application, you will save the coupon to the order created. Then, when you create the Stripe session in the `payment_process` view of the `payment` application, you will add the coupon to the Stripe checkout session before redirecting the user to Stripe to complete the payment. You will add the discount applied to the templates of the admin views `admin_order_detail` and `admin_order_pdf` of the `order` application. In addition to the coupon system, you will also implement a recommendation system. When the `checkout.session.completed` Stripe event is received by the `stripe_webhook` view, you will save the products that have been bought together in Redis. You will add product recommendations to the `product_detail` and `cart_detail` views by retrieving from Redis the items that are frequently bought together.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter10`.

All the Python packages used in this chapter are included in the `requirements.txt` file in the source code for the chapter. You can follow the instructions to install each Python package in the following sections, or you can install all the requirements at once with the command `python -m pip install -r requirements.txt`.

Creating a coupon system

Many online shops give out coupons to customers that can be redeemed for discounts on their purchases. An online coupon usually consists of a code that is given to users and is valid for a specific time frame.

You are going to create a coupon system for your shop. Your coupons will be valid for customers during a certain time frame. The coupons will not have any limitations in terms of the number of times they can be redeemed, and they will be applied to the total value of the shopping cart.

For this functionality, you will need to create a model to store the coupon code, a valid time frame, and the discount to apply.

Create a new application inside the `myshop` project using the following command:

```
python manage.py startapp coupons
```

Edit the `settings.py` file of `myshop` and add the application to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'coupons.apps.CouponsConfig',
]
```

The new application is now active in your Django project.

Building the coupon model

Let's start by creating the `Coupon` model. Edit the `models.py` file of the `coupons` application and add the following code to it:

```
from django.core.validators import MaxValueValidator, MinValueValidator
from django.db import models


class Coupon(models.Model):
    code = models.CharField(max_length=50, unique=True)
    valid_from = models.DateTimeField()
    valid_to = models.DateTimeField()
    discount = models.IntegerField(
```

```
        validators=[MinValueValidator(0), MaxValueValidator(100)],
        help_text='Percentage value (0 to 100)'
    )
    active = models.BooleanField()

    def __str__(self):
        return self.code
```

This is the model that you are going to use to store coupons. The `Coupon` model contains the following fields:

- `code`: The code that users have to enter in order to apply the coupon to their purchase.
- `valid_from`: The datetime value that indicates when the coupon becomes valid.
- `valid_to`: The datetime value that indicates when the coupon becomes invalid.
- `discount`: The discount rate to apply (this is a percentage, so it takes values from `0` to `100`). You use validators for this field to limit the minimum and maximum accepted values.
- `active`: A Boolean that indicates whether the coupon is active.

Run the following command to generate the initial migration for the `coupons` application:

```
python manage.py makemigrations
```

The output should include the following lines:

```
Migrations for 'coupons':
  coupons/migrations/0001_initial.py
    - Create model Coupon
```

Then, execute the next command to apply migrations:

```
python manage.py migrate
```

You should see an output that includes the following line:

```
Applying coupons.0001_initial... OK
```

The migrations have now been applied to the database. Let's add the `Coupon` model to the administration site. Edit the `admin.py` file of the `coupons` application and add the following code to it:

```
from django.contrib import admin
from .models import Coupon


@admin.register(Coupon)
class CouponAdmin(admin.ModelAdmin):
    list_display = [
        'code',
```

```
            'valid_from',
            'valid_to',
            'discount',
            'active'
        ]
        list_filter = ['active', 'valid_from', 'valid_to']
        search_fields = ['code']
```

The `Coupon` model is now registered on the administration site. Ensure that your local server is running with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/coupons/coupon/add/` in your browser.

You should see the following form:

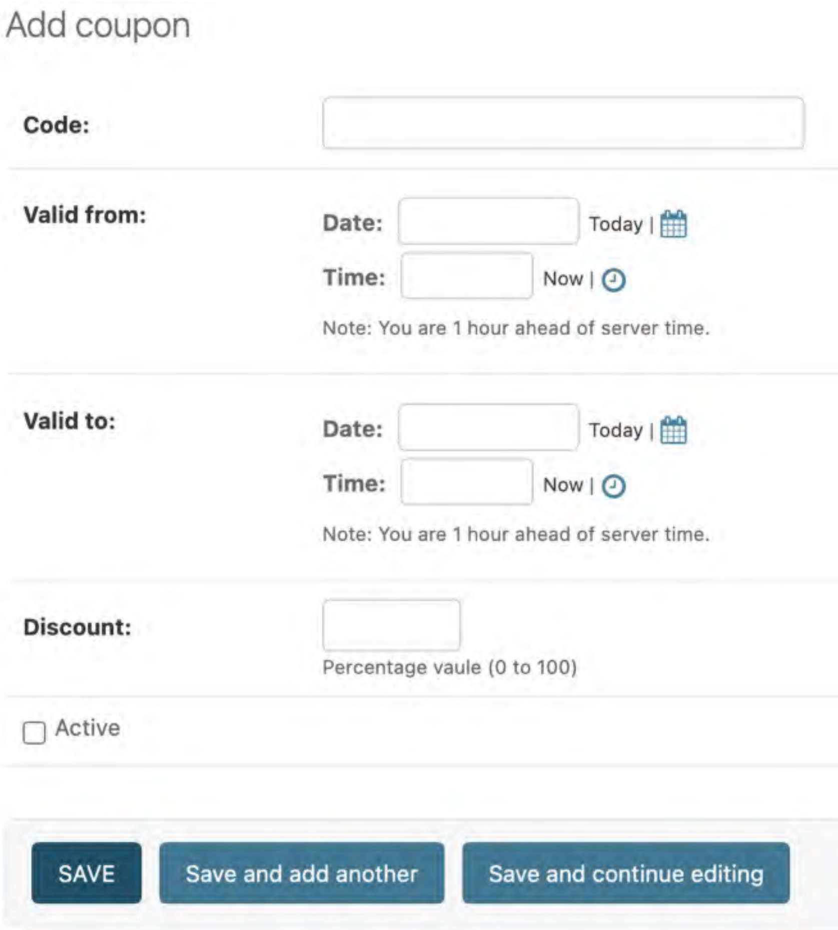


Figure 10.2: The Add coupon form on the Django administration site

Fill in the form to create a new coupon that is valid for the current date. Make sure that you check the **Active** checkbox, and click the **SAVE** button. *Figure 10.3* shows an example of creating a coupon:

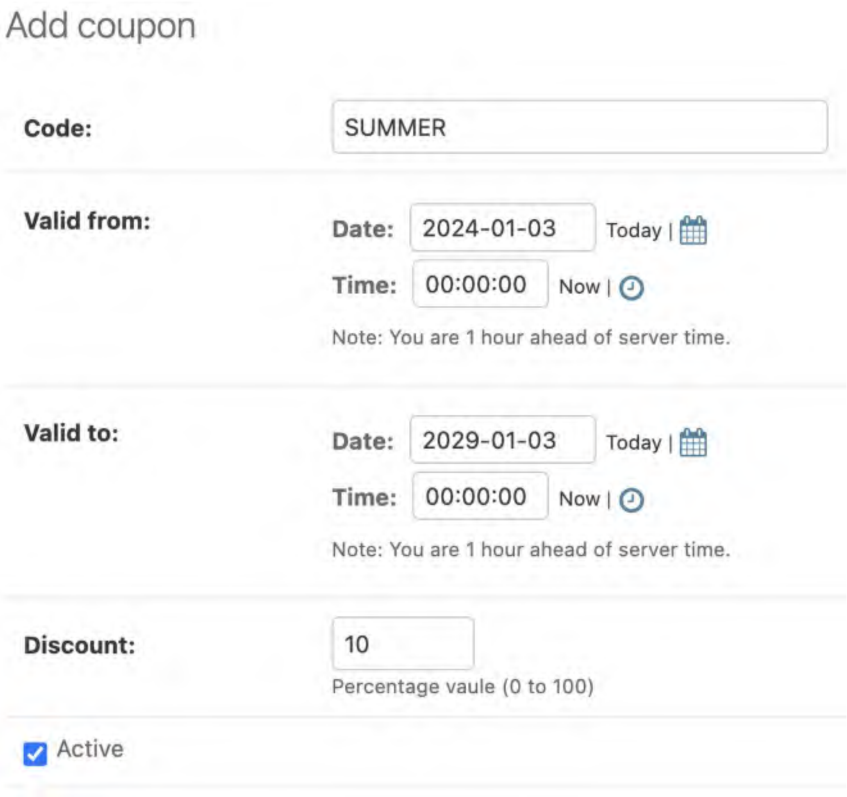


Figure 10.3: The Add coupon form with sample data

After creating the coupon, the coupon change list page on the administration site will look similar to *Figure 10.4*:

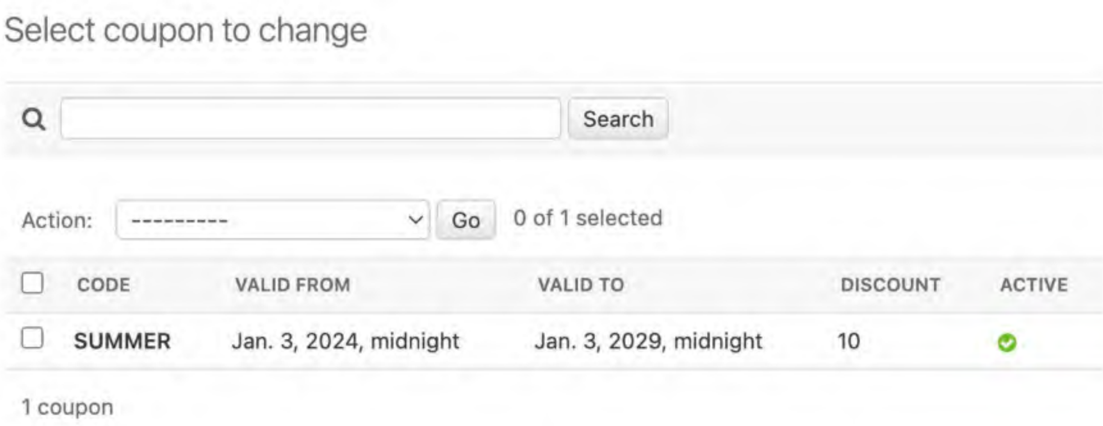


Figure 10.4: The coupon change list page on the Django administration site

Next, we will implement the functionality to apply coupons to the shopping cart.

Applying a coupon to the shopping cart

You can store new coupons and make queries to retrieve existing coupons. Now you need a way for customers to apply coupons to their purchases. The functionality to apply a coupon would be as follows:

1. The user adds products to the shopping cart.
2. The user can enter a coupon code in a form displayed on the shopping cart details page.
3. When the user enters a coupon code and submits the form, you look for an existing coupon with the given code that is currently valid. You have to check that the coupon code matches the one entered by the user, that the `active` attribute is `True`, and that the current datetime is between the `valid_from` and `valid_to` values.
4. If a coupon is found, you save it in the user's session and display the cart, including the discount applied to it and the updated total amount.
5. When the user places an order, you save the coupon to the given order.

Create a new file inside the `coupons` application directory and name it `forms.py`. Add the following code to it:

```
from django import forms


class CouponApplyForm(forms.Form):
    code = forms.CharField()
```

This is the form that you are going to use for the user to enter a coupon code. Edit the `views.py` file inside the `coupons` application and add the following code to it:

```
from django.shortcuts import redirect
from django.utils import timezone
from django.views.decorators.http import require_POST
from .forms import CouponApplyForm
from .models import Coupon


@require_POST
def coupon_apply(request):
    now = timezone.now()
    form = CouponApplyForm(request.POST)
    if form.is_valid():
        code = form.cleaned_data['code']
        try:
            coupon = Coupon.objects.get(
                code__iexact=code,
```

```
                valid_from__lte=now,
                valid_to__gte=now,
                active=True
            )
            request.session['coupon_id'] = coupon.id
        except Coupon.DoesNotExist:
            request.session['coupon_id'] = None
    return redirect('cart:cart_detail')
```

The `coupon_apply` view validates the coupon and stores it in the user's session. You apply the `require_POST` decorator to this view to restrict it to `POST` requests. In the view, you perform the following tasks:

1. You instantiate the `CouponApplyForm` form using the posted data and check that the form is valid.
2. If the form is valid, you get the `code` entered by the user from the form's `cleaned_data` dictionary. You try to retrieve the `Coupon` object with the given code. You use the `iexact` field lookup to perform a case-insensitive exact match. The coupon has to be currently active (`active=True`) and valid for the current datetime. You use Django's `timezone.now()` function to get the current timezone-aware datetime, and you compare it with the `valid_from` and `valid_to` fields by performing the `lte` (less than or equal to) and `gte` (greater than or equal to) field lookups, respectively.
3. You store the coupon ID in the user's session.
4. You redirect the user to the `cart_detail` URL to display the cart with the coupon applied.

You need a URL pattern for the `coupon_apply` view. Create a new file inside the `coupons` application directory and name it `urls.py`. Add the following code to it:

```
from django.urls import path
from . import views


app_name = 'coupons'

urlpatterns = [
    path('apply/', views.coupon_apply, name='apply'),
]
```

Then, edit the main `urls.py` of the `myshop` project and include the `coupons` URL patterns with the following line highlighted in bold:

```
urlpatterns = [
    path('admin/', admin.site.urls),
    path('cart/', include('cart.urls', namespace='cart')),
    path('orders/', include('orders.urls', namespace='orders')),
    path('payment/', include('payment.urls', namespace='payment')),
    path('coupons/', include('coupons.urls', namespace='coupons')),
```

```
    path('', include('shop.urls', namespace='shop')),
]
```

Remember to place this pattern before the `shop.urls` pattern.

Now, edit the `cart.py` file of the `cart` application. Include the following import:

```
from coupons.models import Coupon
```

Add the following code highlighted in bold to the end of the `__init__()` method of the `Cart` class to initialize the coupon from the current session:

```
class Cart:
    def __init__(self, request):
        """
        Initialize the cart.
        """
        self.session = request.session
        cart = self.session.get(settings.CART_SESSION_ID)
        if not cart:
            # save an empty cart in the session
            cart = self.session[settings.CART_SESSION_ID] = {}
        self.cart = cart
        # store current applied coupon
        self.coupon_id = self.session.get('coupon_id')
```

In this code, you try to get the `coupon_id` session key from the current session and store its value in the `Cart` object. Add the following methods highlighted in bold to the `Cart` object:

```
class Cart:
    # ...

    @property
    def coupon(self):
        if self.coupon_id:
            try:
                return Coupon.objects.get(id=self.coupon_id)
            except Coupon.DoesNotExist:
                pass
        return None

    def get_discount(self):
        if self.coupon:
            return (
                self.coupon.discount / Decimal(100)
```

```
            ) * self.get_total_price()
        return Decimal(0)

    def get_total_price_after_discount(self):
        return self.get_total_price() - self.get_discount()
```

These methods are as follows:

- `coupon()`: You define this method as a `property`. If the cart contains a `coupon_id` attribute, the `Coupon` object with the given ID is returned.
- `get_discount()`: If the cart contains a coupon, you retrieve its discount rate and return the amount to be deducted from the total amount of the cart.
- `get_total_price_after_discount()`: You return the total amount of the cart after deducting the amount returned by the `get_discount()` method.

The `Cart` class is now prepared to handle a coupon applied to the current session and apply the corresponding discount.

Let's include the coupon system in the cart's detail view. Edit the `views.py` file of the `cart` application and add the following import to the top of the file:

```
from coupons.forms import CouponApplyForm
```

Further down, edit the `cart_detail` view and add the new form to it, as follows:

```
def cart_detail(request):
    cart = Cart(request)
    for item in cart:
        item['update_quantity_form'] = CartAddProductForm(
            initial={'quantity': item['quantity'], 'override': True}
        )
    coupon_apply_form = CouponApplyForm()
    return render(
        request,
        'cart/detail.html',
        {
            'cart': cart,
            'coupon_apply_form': coupon_apply_form
        }
    )
```

Edit the `cart/detail.html` template of the `cart` application and locate the following lines:

```
<tr class="total">
  <td>Total</td>
  <td colspan="4"></td>
  <td class="num">${{ cart.get_total_price }}</td>
</tr>
```

Replace them with the following code:

```
{% if cart.coupon %}
  <tr class="subtotal">
    <td>Subtotal</td>
    <td colspan="4"></td>
    <td class="num">${{ cart.get_total_price|floatformat:2 }}</td>
  </tr>
  <tr>
    <td>
      "{{ cart.coupon.code }}" coupon
      ({{ cart.coupon.discount }}% off)
    </td>
    <td colspan="4"></td>
    <td class="num neg">
      - ${{ cart.get_discount|floatformat:2 }}
    </td>
  </tr>
{% endif %}
<tr class="total">
  <td>Total</td>
  <td colspan="4"></td>
  <td class="num">
    ${{ cart.get_total_price_after_discount|floatformat:2 }}
  </td>
</tr>
```

This is the code for displaying an optional coupon and its discount rate. If the cart contains a coupon, you display the first row, including the total amount of the cart as the subtotal. Then, you use a second row to display the current coupon applied to the cart. Finally, you display the total price, including any discount, by calling the `get_total_price_after_discount()` method of the `cart` object.

In the same file, include the following code after the `</table>` HTML tag:

```
<p>Apply a coupon:</p>
<form action="{% url "coupons:apply" %}" method="post">
  {{ coupon_apply_form }}
  <input type="submit" value="Apply">
  {% csrf_token %}
</form>
```

This will display the form to enter a coupon code and apply it to the current cart.

Open `http://127.0.0.1:8000/` in your browser and add a product to the cart. You will see that the shopping cart page now includes a form to apply a coupon:

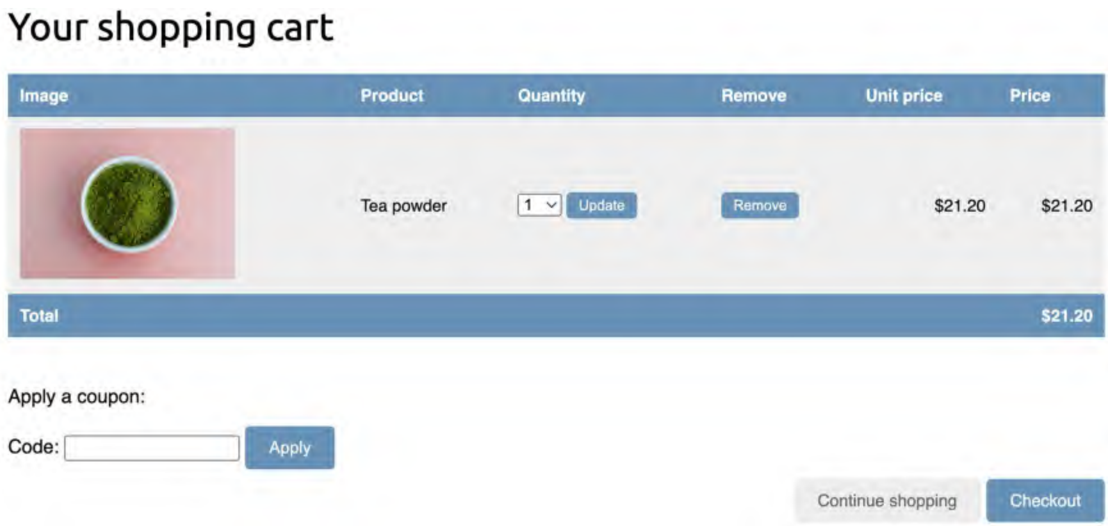


Figure 10.5: The cart detail page, including a form to apply a coupon

Image of *Tea powder*: Photo by Phuong Nguyen on Unsplash

In the **Code** field, enter the coupon code you created using the administration site:

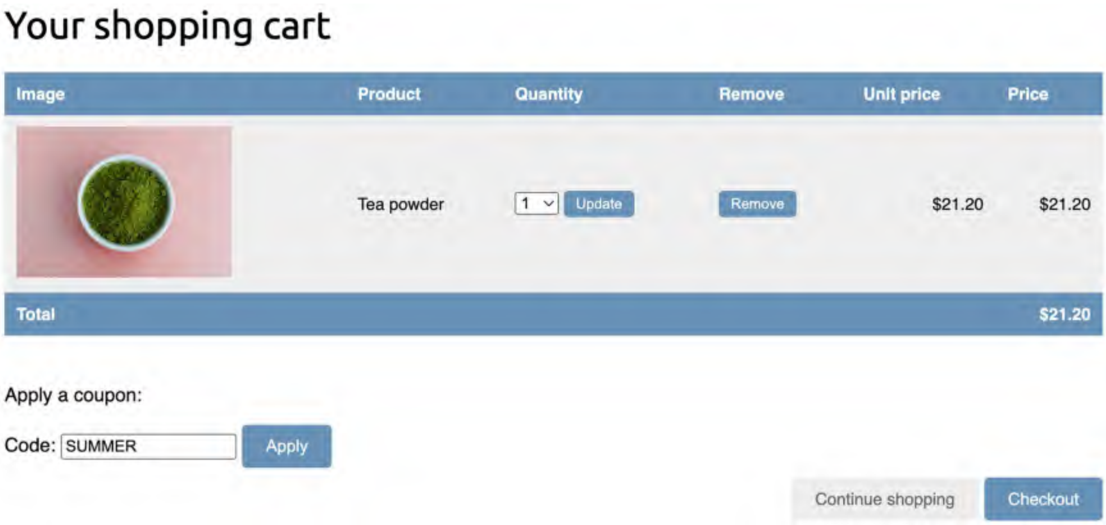


Figure 10.6: The cart detail page, including a coupon code on the form

Click the **Apply** button. The coupon will be applied, and the cart will display the coupon discount as follows:

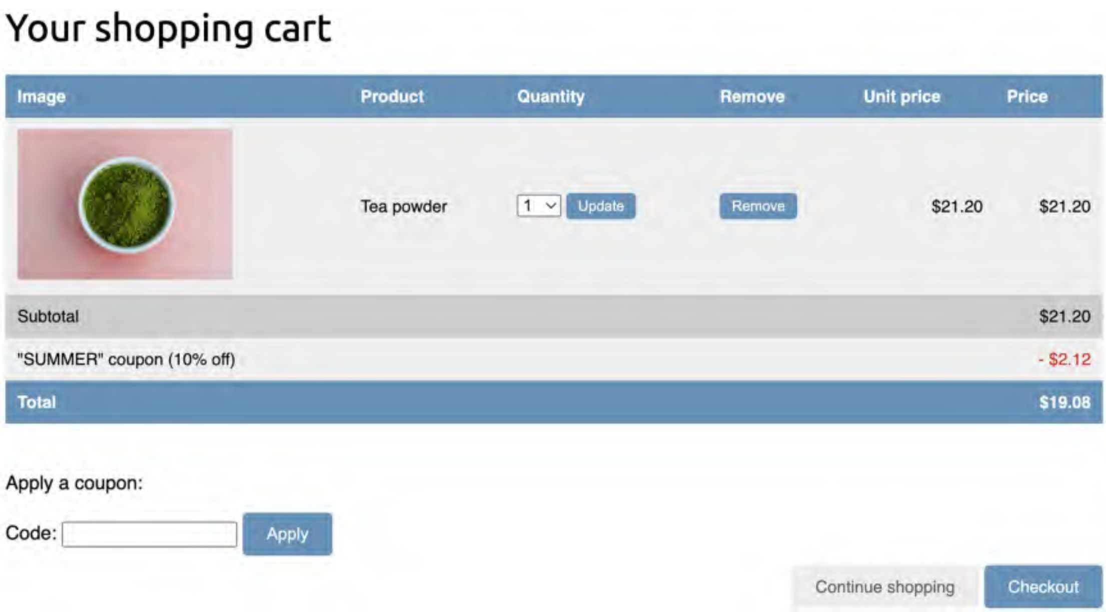


Figure 10.7: The cart detail page, including the coupon applied

Let's add the coupon to the next step of the purchase process. Edit the `orders/order/create.html` template of the `orders` application and locate the following lines:

```
<ul>
  {% for item in cart %}
    <li>
      {{ item.quantity }}x {{ item.product.name }}
      <span>${{ item.total_price }}</span>
    </li>
  {% endfor %}
</ul>
```

Replace them with the following code:

```
<ul>
  {% for item in cart %}
    <li>
      {{ item.quantity }}x {{ item.product.name }}
      <span>${{ item.total_price|floatformat:2 }}</span>
    </li>
  {% endfor %}
  {% if cart.coupon %}
    <li>
      "{{ cart.coupon.code }}" ({{ cart.coupon.discount }}% off)
      <span class="neg">- ${{ cart.get_discount|floatformat:2 }}</span>
    </li>
  {% endif %}
</ul>
```

The order summary should now include the coupon applied, if there is one. Now find the following line:

```
<p>Total: ${{ cart.get_total_price }}</p>
```

Replace it with the following:

```
<p>Total: ${{ cart.get_total_price_after_discount|floatformat:2 }}</p>
```

By doing this, the total price will also be calculated by applying the discount of the coupon.

Open `http://127.0.0.1:8000/orders/create/` in your browser. You should see that the order summary includes the applied coupon, as follows:

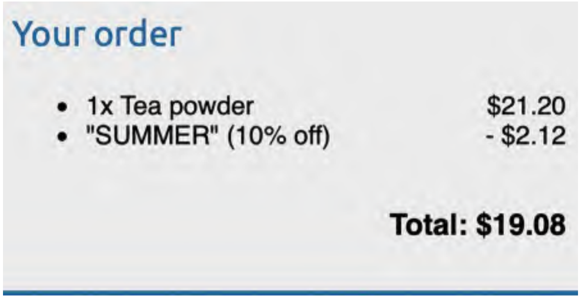


Figure 10.8: The order summary, including the coupon applied to the cart

Users can now apply coupons to their shopping carts. However, you still need to store coupon information in the order that it is created when users check out the cart.

Applying coupons to orders

You are going to store the coupon that was applied to each order. First, you need to modify the `Order` model to store the related `Coupon` object, if there is one.

Edit the `models.py` file of the `orders` application and add the following imports to it:

```
from decimal import Decimal
from django.core.validators import MaxValueValidator, MinValueValidator
from coupons.models import Coupon
```

Then, add the following fields to the `Order` model:

```
class Order(models.Model):
    # ...
    coupon = models.ForeignKey(
        Coupon,
        related_name='orders',
        null=True,
        blank=True,
        on_delete=models.SET_NULL
    )
    discount = models.IntegerField(
        default=0,
        validators=[MinValueValidator(0), MaxValueValidator(100)]
    )
```

These fields allow you to store an optional coupon for the order and the discount percentage applied with the coupon. The discount is stored in the related `Coupon` object, but you can include it in the `Order` model to preserve it if the coupon has been modified or deleted. You set `on_delete` to `models.SET_NULL` so that if the coupon gets deleted, the `coupon` field is set to `Null`, but the discount is preserved.

You need to create a migration to include the new fields of the `Order` model. Run the following command from the command line:

```
python manage.py makemigrations
```

You should see an output like the following:

```
Migrations for 'orders':
  orders/migrations/0003_order_coupon_order_discount.py
    - Add field coupon to order
    - Add field discount to order
```

Apply the new migration with the following command:

```
python manage.py migrate orders
```

You should see the following confirmation indicating that the new migration has been applied:

```
Applying orders.0003_order_coupon_order_discount... OK
```

The `Order` model field changes are now synced with the database.

Edit the `models.py` file, and add two new methods, `get_total_cost_before_discount()` and `get_discount()`, to the `Order` model like this. The new code is highlighted in bold:

```
class Order(models.Model):
    # ...
    def get_total_cost_before_discount(self):
        return sum(item.get_cost() for item in self.items.all())

    def get_discount(self):
        total_cost = self.get_total_cost_before_discount()
        if self.discount:
            return total_cost * (self.discount / Decimal(100))
        return Decimal(0)
```

Then, edit the `get_total_cost()` method of the `Order` model as follows. The new code is highlighted in bold:

```
    def get_total_cost(self):
        total_cost = self.get_total_cost_before_discount()
        return total_cost - self.get_discount()
```

The `get_total_cost()` method of the `Order` model will now take into account the discount applied, if there is one.

Edit the `views.py` file of the `orders` application and modify the `order_create` view to save the related coupon and its discount when creating a new order. Add the following code highlighted in bold to the `order_create` view:

```
def order_create(request):
    cart = Cart(request)
    if request.method == 'POST':
        form = OrderCreateForm(request.POST)
        if form.is_valid():
            order = form.save(commit=False)
            if cart.coupon:
                order.coupon = cart.coupon
                order.discount = cart.coupon.discount
            order.save()
            for item in cart:
                OrderItem.objects.create(
                    order=order,
                    product=item['product'],
                    price=item['price'],
                    quantity=item['quantity']
                )
            # clear the cart
            cart.clear()
            # launch asynchronous task
            order_created.delay(order.id)
            # set the order in the session
            request.session['order_id'] = order.id
            # redirect for payment
            return redirect('payment:process')
    else:
        form = OrderCreateForm()
    return render(
        request,
        'orders/order/create.html',
        {'cart': cart, 'form': form}
    )
```

In the new code, you create an `Order` object using the `save()` method of the `OrderCreateForm` form. You avoid saving it to the database yet by using `commit=False`. If the cart contains a coupon, you store the related coupon and the discount that was applied. Then, you save the `order` object to the database.

Edit the `payment/process.html` template of the `payment` application and locate the following lines:

```
<tr class="total">
  <td>Total</td>
  <td colspan="4"></td>
  <td class="num">${{ order.get_total_cost }}</td>
</tr>
```

Replace them with the following code. New lines are highlighted in bold:

```
{% if order.coupon %}
  <tr class="subtotal">
    <td>Subtotal</td>
    <td colspan="3"></td>
    <td class="num">
      ${{ order.get_total_cost_before_discount|floatformat:2 }}
    </td>
  </tr>
  <tr>
    <td>
      "{{ order.coupon.code }}" coupon
      ({{ order.discount }}% off)
    </td>
    <td colspan="3"></td>
    <td class="num neg">
      - ${{ order.get_discount|floatformat:2 }}
    </td>
  </tr>
{% endif %}
<tr class="total">
  <td>Total</td>
  <td colspan="3"></td>
  <td class="num">
    ${{ order.get_total_cost|floatformat:2 }}
  </td>
</tr>
```

We have updated the order summary before payment.

Make sure that the development server is running with the following command:

```
python manage.py runserver
```

Make sure Docker is running, and execute the following command in another shell to start the RabbitMQ server with Docker:

```
docker run -it --rm --name rabbitmq -p 5672:5672 -p 15672:15672
rabbitmq:3.13.1-management
```

Open another shell and start the Celery worker from your project directory with the following command:

```
celery -A myshop worker -l info
```

Open an additional shell and execute the following command to forward Stripe events to your local webhook URL:

```
stripe listen --forward-to localhost:8000/payment/webhook/
```

Open `http://127.0.0.1:8000/` in your browser and create an order using the coupon you created. After validating the items in the shopping cart, on the **Order summary** page, you will see the coupon applied to the order:

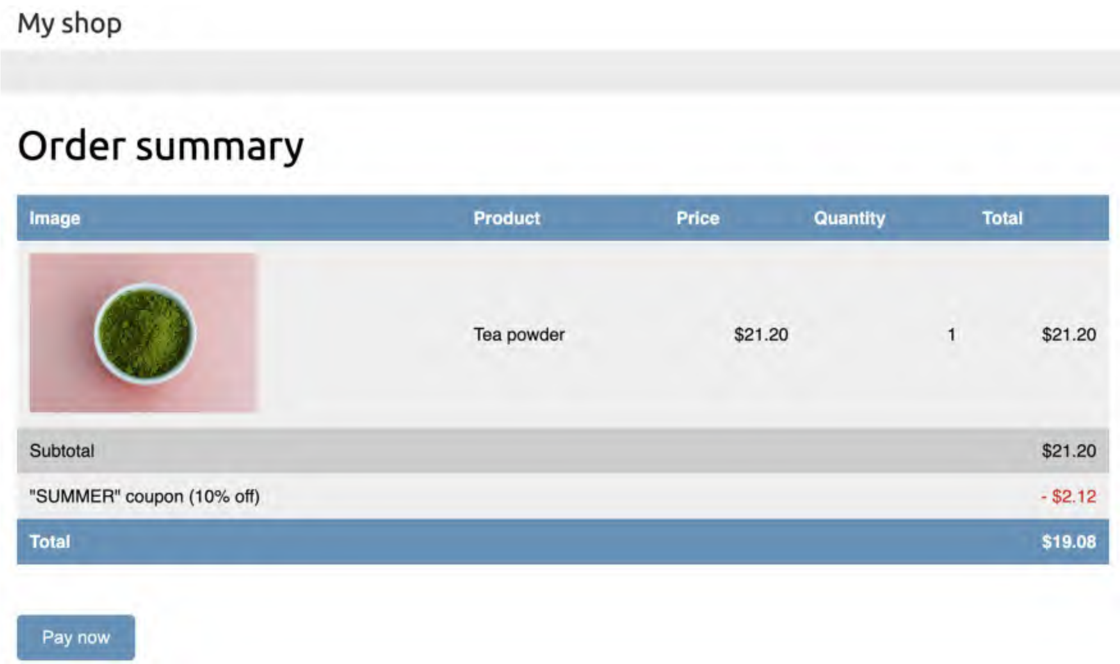


Figure 10.9: The Order summary page, including the coupon applied to the order

If you click on **Pay now**, you will see that Stripe is not aware of the discount applied, as displayed in *Figure 10.10*:

Figure 10.10: The item details of the Stripe Checkout page, including no discount coupon

Stripe shows the full amount to be paid without any deduction. This is because we are not passing on the discount to Stripe. Remember that in the `payment_process` view, we pass the order items as `line_items` to Stripe, including the cost and quantity of each order item.

Creating coupons for Stripe Checkout

Stripe allows you to define discount coupons and link them to one-time payments. You can find more information about creating discounts for Stripe Checkout at `https://stripe.com/docs/payments/checkout/discounts`.

Let's edit the `payment_process` view to create a coupon for Stripe Checkout. Edit the `views.py` file of the `payment` application and add the following code highlighted in bold to the `payment_process` view:

```
def payment_process(request):
    order_id = request.session.get('order_id')
    order = get_object_or_404(Order, id=order_id)

    if request.method == 'POST':
        success_url = request.build_absolute_uri(
            reverse('payment:completed')
        )
        cancel_url = request.build_absolute_uri(
            reverse('payment:canceled')
        )

        # Stripe checkout session data
        session_data = {
            'mode': 'payment',
            'client_reference_id': order.id,
            'success_url': success_url,
            'cancel_url': cancel_url,
            'line_items': []
        }
```

```
        # add order items to the Stripe checkout session
        for item in order.items.all():
            session_data['line_items'].append(
                {
                    'price_data': {
                        'unit_amount': int(item.price * Decimal('100')),
                        'currency': 'usd',
                        'product_data': {
                            'name': item.product.name,
                        },
                    },
                    'quantity': item.quantity,
                }
            )

        # Stripe coupon
        if order.coupon:
            stripe_coupon = stripe.Coupon.create(
                name=order.coupon.code,
                percent_off=order.discount,
                duration='once'
            )
            session_data['discounts'] = [{'coupon': stripe_coupon.id}]
        # create Stripe checkout session
        session = stripe.checkout.Session.create(**session_data)
        # redirect to Stripe payment form
        return redirect(session.url, code=303)
    else:
        return render(request, 'payment/process.html', locals())
```

In the new code, you check if the order has a related coupon. In that case, you use the Stripe SDK to create a Stripe coupon using `stripe.Coupon.create()`. You use the following attributes for the coupon:

- `name`: The `code` of the coupon related to the `order` object is used.
- `percent_off`: The `discount` of the `order` object is issued.
- `duration`: The value `once` is used. This indicates to Stripe that this is a coupon for a one-time payment.

After creating the coupon, its `id` is added to the `session_data` dictionary used to create the Stripe Checkout session. This links the coupon to the checkout session.

Open `http://127.0.0.1:8000/` in your browser and complete a purchase using the coupon you created. When redirected to the Stripe Checkout page, you will see the coupon applied:

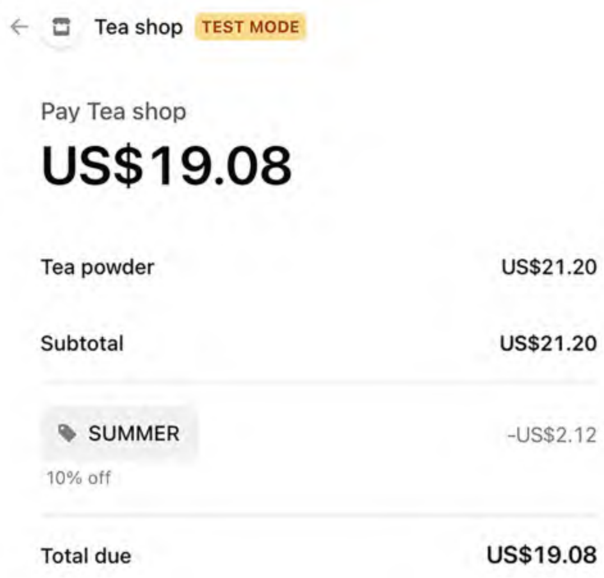


Figure 10.11: The item details of the Stripe Checkout page, including a discount coupon named SUMMER

The Stripe Checkout page now includes the order coupon, and the total amount to pay now includes the amount deducted using the coupon.

Complete the purchase and then open `http://127.0.0.1:8000/admin/orders/order/` in your browser. Click on the `order` object for which the coupon was used. The edit form will display the discount applied, as shown in *Figure 10.12*:

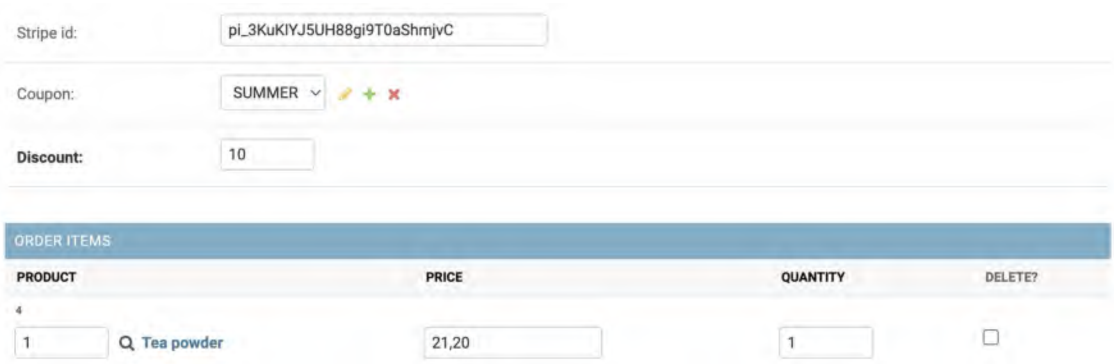


Figure 10.12: The order edit form, including the coupon and discount applied

You have successfully stored coupons for orders and processed payments with discounts. Next, you will add coupons to the order detail view of the administration site and to PDF invoices for orders.

Adding coupons to orders on the administration site and to PDF invoices

Let's add the coupon to the order detail page on the administration site. Edit the `admin/orders/order/detail.html` template of the `orders` application and add the following code highlighted in bold:

```
...
<table style="width:100%">
  ...
  <tbody>
    {% for item in order.items.all %}
      <tr class="row{% cycle "1" "2" %}">
        <td>{{ item.product.name }}</td>
        <td class="num">${{ item.price }}</td>
        <td class="num">{{ item.quantity }}</td>
        <td class="num">${{ item.get_cost }}</td>
      </tr>
    {% endfor %}

    {% if order.coupon %}
      <tr class="subtotal">
        <td colspan="3">Subtotal</td>
        <td class="num">
          ${{ order.get_total_cost_before_discount|floatformat:2 }}
        </td>
      </tr>
      <tr>
        <td colspan="3">
          "{{ order.coupon.code }}" coupon
          ({{ order.discount }}% off)
        </td>
        <td class="num neg">
          - ${{ order.get_discount|floatformat:2 }}
        </td>
      </tr>
    {% endif %}

    <tr class="total">
      <td colspan="3">Total</td>
      <td class="num">
        ${{ order.get_total_cost|floatformat:2 }}
      </td>
    </tr>
```

```
    </tbody>
  </table>
  ...
```

Access `http://127.0.0.1:8000/admin/orders/order/` with your browser, and click on the **View** link of the latest order. The **Items bought** table will now include the coupon used, as shown in *Figure 10.13*:

Items bought			
PRODUCT	PRICE	QUANTITY	TOTAL
Tea powder	$21.20	2	$42.40
Subtotal			$42.40
"SUMMER" coupon (10% off)			- $4.24
Total			$38.16

Figure 10.13: The product detail page on the administration site, including the coupon used

Now, let's modify the order invoice template to include the coupon used for the order. Edit the `orders/order/pdf.html` template of the `orders` application and add the following code highlighted in bold:

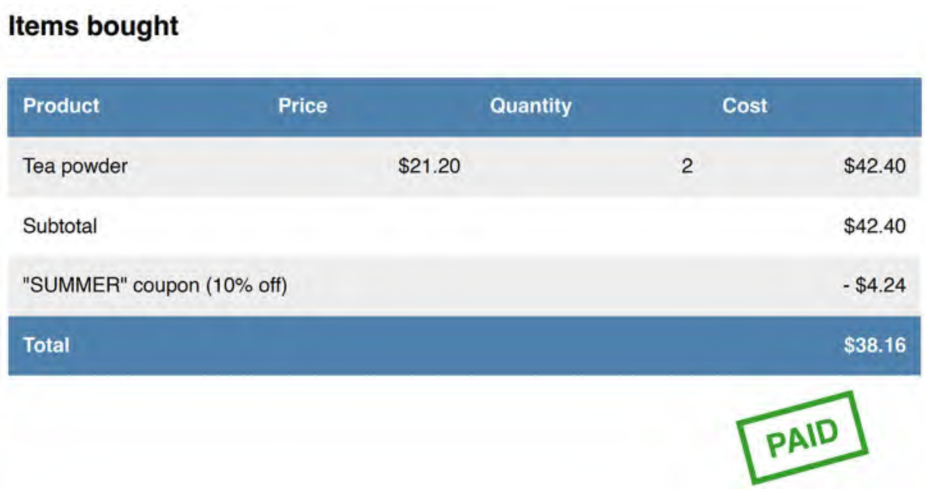
```
...
<table>
  <thead>
    <tr>
      <th>Product</th>
      <th>Price</th>
      <th>Quantity</th>
      <th>Cost</th>
    </tr>
  </thead>
  <tbody>
    {% for item in order.items.all %}
      <tr class="row{% cycle "1" "2" %}">
        <td>{{ item.product.name }}</td>
        <td class="num">${{ item.price }}</td>
        <td class="num">{{ item.quantity }}</td>
        <td class="num">${{ item.get_cost }}</td>
      </tr>
    {% endfor %}

    {% if order.coupon %}
      <tr class="subtotal">
        <td colspan="3">Subtotal</td>
```

```
        <td class="num">
          ${{ order.get_total_cost_before_discount|floatformat:2 }}
        </td>
      </tr>
      <tr>
        <td colspan="3">
          "{{ order.coupon.code }}" coupon
          ({{ order.discount }}% off)
        </td>
        <td class="num neg">
          - ${{ order.get_discount|floatformat:2 }}
        </td>
      </tr>
    {% endif %}

    <tr class="total">
      <td colspan="3">Total</td>
      <td class="num">${{ order.get_total_cost|floatformat:2 }}</td>
    </tr>
  </tbody>
</table>
...
```

Access `http://127.0.0.1:8000/admin/orders/order/` with your browser, and click on the **PDF** link of the latest order. The **Items bought** table will now include the coupon used, as shown in *Figure 10.14*:



Items bought

Product	Price	Quantity	Cost
Tea powder	$21.20	2	$42.40
Subtotal			$42.40
"SUMMER" coupon (10% off)			- $4.24
Total			$38.16

Figure 10.14: The PDF order invoice, including the coupon used

You successfully added a coupon system to your shop. Next, you are going to build a product recommendation engine.

Building a recommendation engine

A recommendation engine is a system that predicts the preference or rating that a user would give to an item. The system selects relevant items for a user based on their behavior and the knowledge it has about them. Nowadays, recommendation systems are used in many online services. They help users by selecting the stuff they might be interested in from the vast amount of available data that is irrelevant to them. Offering good recommendations enhances user engagement. E-commerce sites also benefit from offering relevant product recommendations by increasing their average revenue per user.

You are going to create a simple yet powerful recommendation engine that suggests products that are usually bought together. You will suggest products based on historical sales, thus identifying products that are usually bought together. You are going to suggest complementary products in two different scenarios:

- **Product detail page**: You will display a list of products that are usually bought with the given product. This will be displayed as *users who bought this also bought X, Y, and Z*. You need a data structure that allows you to store the number of times each product has been bought together with the product being displayed.
- **Cart detail page**: Based on the products that users add to the cart, you are going to suggest products that are usually bought together with these ones. In this case, the score you calculate to obtain related products has to be aggregated.

You are going to use Redis to store products that are usually purchased together. Remember that you already used Redis in *Chapter 7*, *Tracking User Actions*. If you haven't installed Redis yet, you can find installation instructions in that chapter.

Recommending products based on previous purchases

We will recommend products to users based on items that are frequently bought together. For that, we are going to use Redis sorted sets. Remember that you used sorted sets in *Chapter 7*, *Tracking User Actions*, to create a ranking of the most viewed images on your site.

Figure 10.15 shows a representation of a sorted set, where set members are strings associated with a score:

Figure 10.15: Redis sorted set representation

We are going to store a key in Redis for each product bought on the site. The product key will contain a Redis sorted set with scores. Every time a new purchase is completed, we will increment the score by 1 for each product bought together. The sorted set will allow you to give scores to products that are bought together. We will use the number of times the product is bought with another product as the score for that item.

Remember to install `redis-py` in your environment using the following command:

```
python -m pip install redis==5.0.4
```

Edit the `settings.py` file of your project and add the following settings to it:

```
# Redis settings
REDIS_HOST = 'localhost'
REDIS_PORT = 6379
REDIS_DB = 1
```

These are the settings required to establish a connection with the Redis server. Create a new file inside the `shop` application directory and name it `recommender.py`. Add the following code to it:

```
import redis
from django.conf import settings
from .models import Product


# connect to redis
r = redis.Redis(
    host=settings.REDIS_HOST,
    port=settings.REDIS_PORT,
    db=settings.REDIS_DB
)

class Recommender:
    def get_product_key(self, id):
        return f'product:{id}:purchased_with'

    def products_bought(self, products):
        product_ids = [p.id for p in products]
        for product_id in product_ids:
            for with_id in product_ids:
                # get the other products bought with each product
                if product_id != with_id:
                    # increment score for product purchased together
                    r.zincrby(
                        self.get_product_key(product_id), 1, with_id
                    )
```

This is the `Recommender` class, which will allow you to store product purchases and retrieve product suggestions for a given product or products.

The `get_product_key()` method receives the ID of a `Product` object and builds the Redis key for the sorted set where related products are stored, which looks like `product:[id]:purchased_with`.

The `products_bought()` method receives a list of `Product` objects that have been bought together (that is, belong to the same order).

In this method, you perform the following tasks:

1. You get the product IDs for the given `Product` objects.
2. You iterate over the product IDs. For each ID, you iterate again over the product IDs and skip the same product so that you get the products that are bought together with each product.
3. You get the Redis product key for each product bought using the `get_product_id()` method. For a product with an ID of `33`, this method returns the key `product:33:purchased_with`. This is the key for the sorted set that contains the product IDs of products that were bought together with this one.
4. You increment the score of each product ID contained in the sorted set by 1 using the Redis `ZINCRBY` operation. The score represents the number of times another product has been bought together with the given product.

Figure 10.16 shows an example of five different products with IDs 1 to 5 and five purchase orders of different combinations of products:

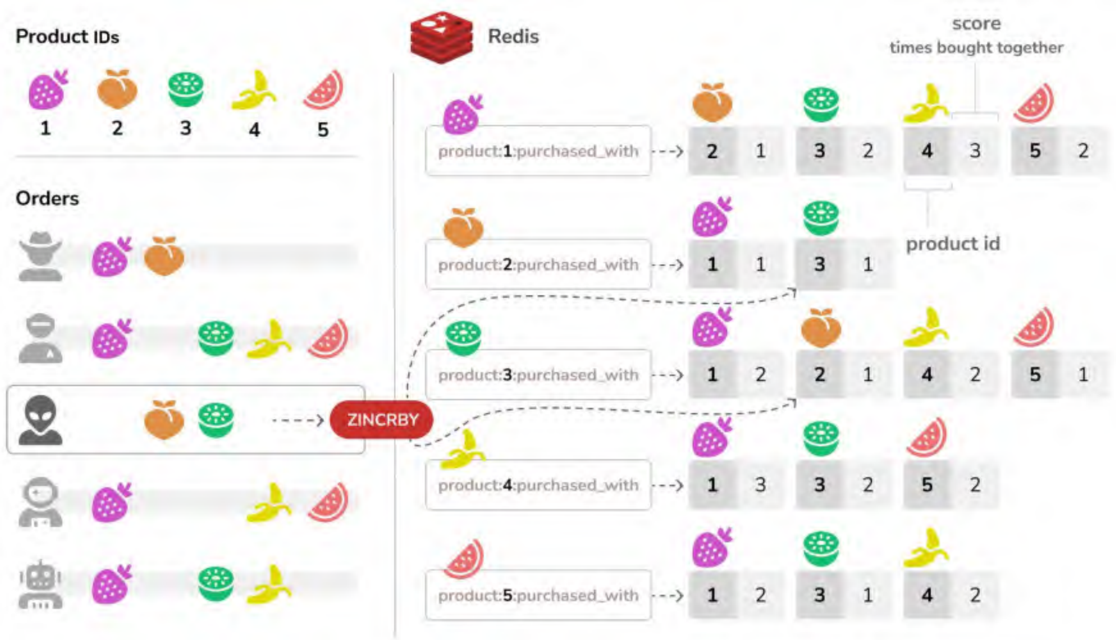


Figure 10.16: Five products with respective IDs and purchase order combinations

In the figure, you can see a sorted set created in Redis for each product, with the key `product:<id>:purchased_with`, where `<id>` is the product's unique identifier. The sorted set members are the IDs of the products that have been purchased alongside the principal product. The score for each member reflects the cumulative count of joint purchases. The figure shows the `ZINCRBY` Redis operation to increment by 1 the score of products purchased together in one order.

You now have a method to store and score the products that were bought together. Next, you need a method to retrieve the products that were bought together for a list of given products. Add the following `suggest_products_for()` method to the `Recommender` class:

```
def suggest_products_for(self, products, max_results=6):
    product_ids = [p.id for p in products]
    if len(products) == 1:
        # only 1 product
        suggestions = r.zrange(
            self.get_product_key(product_ids[0]), 0, -1, desc=True
        )[:max_results]
    else:
        # generate a temporary key
        flat_ids = ''.join([str(id) for id in product_ids])
        tmp_key = f'tmp_{flat_ids}'
        # multiple products, combine scores of all products
        # store the resulting sorted set in a temporary key
        keys = [self.get_product_key(id) for id in product_ids]
        r.zunionstore(tmp_key, keys)
        # remove ids for the products the recommendation is for
        r.zrem(tmp_key, *product_ids)
        # get the product ids by their score, descendant sort
        suggestions = r.zrange(
            tmp_key, 0, -1, desc=True
        )[:max_results]
        # remove the temporary key
        r.delete(tmp_key)
    suggested_products_ids = [int(id) for id in suggestions]
    # get suggested products and sort by order of appearance
    suggested_products = list(
        Product.objects.filter(id__in=suggested_products_ids)
    )
    suggested_products.sort(
        key=lambda x: suggested_products_ids.index(x.id)
    )
    return suggested_products
```

The `suggest_products_for()` method receives the following parameters:

- `products`: This is a list of `Product` objects to get recommendations for. It can contain one or more products.
- `max_results`: This is an integer that represents the maximum number of recommendations to return.

In this method, you perform the following actions:

1. You get the product IDs for the given `Product` objects.
2. If only one product is given, you retrieve the ID of the products that were bought together with the given product, ordered by the total number of times that they were bought together. To do so, you use Redis' `ZRANGE` command. You limit the number of results to the number specified in the `max_results` attribute (`6` by default). You can read more about the `ZRANGE` command at `https://redis.io/commands/zrange/`.
3. If more than one product is given, you generate a temporary Redis key built with the IDs of the products.
4. Combine and sum all scores for the items contained in the sorted set of each of the given products. This is done using the Redis `ZUNIONSTORE` command. The `ZUNIONSTORE` command performs a union of the sorted sets with the given keys and stores the aggregated sum of scores of the elements in a new Redis key. You can read more about this command at `https://redis.io/commands/zunionstore/`. You save the aggregated scores in the temporary key.
5. Since you are aggregating scores, you might obtain the same products you are getting recommendations for. You remove them from the generated sorted set using the `ZREM` command. You can read more about the `ZREM` command at `https://redis.io/commands/zrem/`.
6. You retrieve the IDs of the products from the temporary key, ordered by their scores using the `ZRANGE` command. You limit the number of results to the number specified in the `max_results` attribute.
7. Then, you remove the temporary key using the `redis-py delete()` method that executes the Redis `DEL` command. You can read more about the `DEL` command at `https://redis.io/commands/del/`.
8. Finally, you get the `Product` objects with the given IDs, and you order the products in the same order as the sorted set members.

Figure 10.17 shows an example of a session where two products have been added to the shopping cart and the Redis operations performed to obtain related product recommendations:

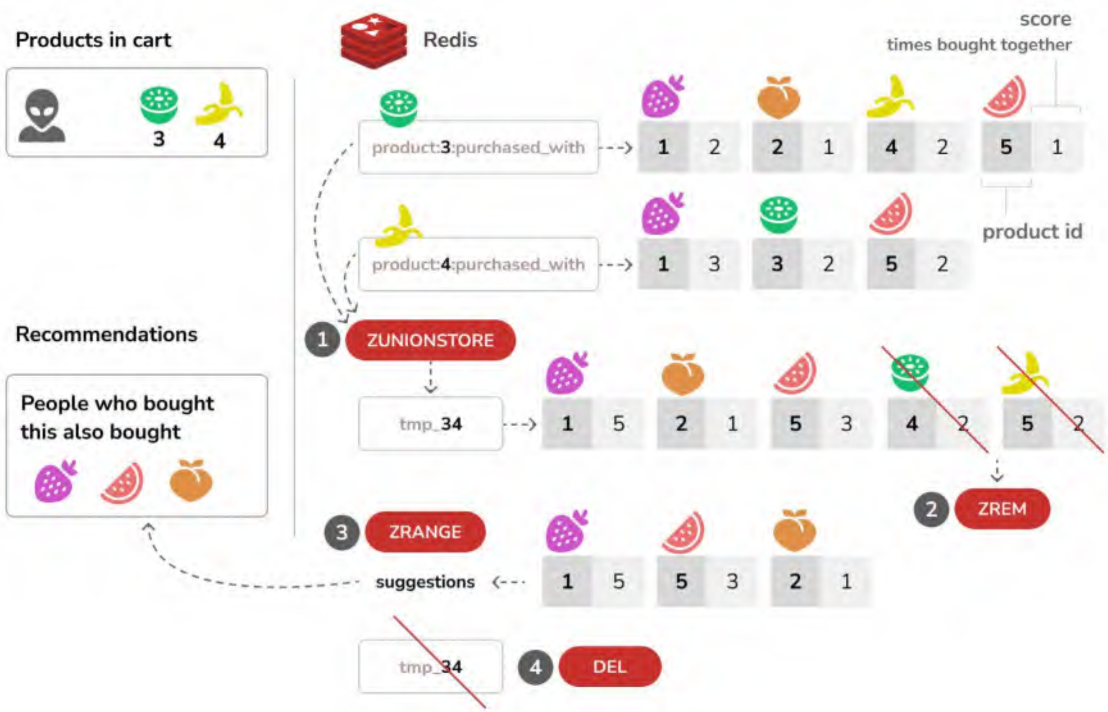


Figure 10.17: Product recommendation system

In the figure, you can see the four steps to generate product recommendations for the items in the cart:

1. The `ZUNIONSTORE` Redis command is used to aggregate the scores of products purchased frequently with the products in the shopping cart. The resulting sorted set of this operation is stored in a new Redis key named after the IDs of the products in the shopping cart, `tmp_34` for IDs 3 and 4.
2. The `ZREM` command is used to remove the products being purchased from the sorted set, to avoid recommending products that are already in the shopping cart.
3. The `ZRANGE` command is used to return the `tmp_34` sorted set members ordered by score.
4. Finally, the `DEL` command is used to delete the Redis key `tmp_34`.

For practical purposes, let's also add a method to clear the recommendations. Add the following method to the `Recommender` class:

```
def clear_purchases(self):
    for id in Product.objects.values_list('id', flat=True):
        r.delete(self.get_product_key(id))
```

Let's try the recommendation engine. Make sure you include several `Product` objects in the database and initialize the Redis Docker container using the following command:

```
docker run -it --rm --name redis -p 6379:6379 redis:7.2.4
```

Open another shell and run the following command to open the Python shell:

```
python manage.py shell
```

Make sure that you have at least four different products in your database. Retrieve four different products by their names:

```
>>> from shop.models import Product
>>> black_tea = Product.objects.get(name='Black tea')
>>> red_tea = Product.objects.get(name='Red tea')
>>> green_tea = Product.objects.get(name='Green tea')
>>> tea_powder = Product.objects.get(name='Tea powder')
```

Then, add some test purchases to the recommendation engine:

```
>>> from shop.recommender import Recommender
>>> r = Recommender()
>>> r.products_bought([black_tea, red_tea])
>>> r.products_bought([black_tea, green_tea])
>>> r.products_bought([red_tea, black_tea, tea_powder])
>>> r.products_bought([green_tea, tea_powder])
>>> r.products_bought([black_tea, tea_powder])
>>> r.products_bought([red_tea, green_tea])
```

You have stored the following scores:

```
black_tea:  red_tea (2), tea_powder (2), green_tea (1)
red_tea:    black_tea (2), tea_powder (1), green_tea (1)
green_tea:  black_tea (1), tea_powder (1), red_tea(1)
tea_powder: black_tea (2), red_tea (1), green_tea (1)
```

This is a representation of products that have been bought together with each of the products, including how many times they have been bought together.

Let's retrieve product recommendations for a single product:

```
>>> r.suggest_products_for([black_tea])
[<Product: Tea powder>, <Product: Red tea>, <Product: Green tea>]
>>> r.suggest_products_for([red_tea])
[<Product: Black tea>, <Product: Tea powder>, <Product: Green tea>]
>>> r.suggest_products_for([green_tea])
[<Product: Black tea>, <Product: Tea powder>, <Product: Red tea>]
```

```
>>> r.suggest_products_for([tea_powder])
[<Product: Black tea>, <Product: Red tea>, <Product: Green tea>]
```

You can see that the order for recommended products is based on their score. Let's get recommendations for multiple products with aggregated scores:

```
>>> r.suggest_products_for([black_tea, red_tea])
[<Product: Tea powder>, <Product: Green tea>]
>>> r.suggest_products_for([green_tea, red_tea])
[<Product: Black tea>, <Product: Tea powder>]
>>> r.suggest_products_for([tea_powder, black_tea])
[<Product: Red tea>, <Product: Green tea>]
```

You can see that the order of the suggested products matches the aggregated scores. For example, products suggested for `black_tea` and `red_tea` are `tea_powder` (`2+1`) and `green_tea` (`1+1`).

You have verified that your recommendation algorithm works as expected.

Let's store the products that are bought together every time a payment is confirmed. Edit the `webhooks.py` file of the `payment` application and add the following code highlighted in bold:

```
# ...
from shop.models import Product
from shop.recommender import Recommender


@csrf_exempt
def stripe_webhook(request):
    # ...
    if event.type == 'checkout.session.completed':
        session = event.data.object
        if (
            session.mode == 'payment'
            and session.payment_status == 'paid'
        ):
            try:
                order = Order.objects.get(
                    id=session.client_reference_id
                )
            except Order.DoesNotExist:
                return HttpResponse(status=404)

            # mark order as paid
            order.paid = True

            # store Stripe payment ID
```

```
            order.stripe_id = session.payment_intent
            order.save()

            # save items bought for product recommendations
            product_ids = order.items.values_list('product_id')
            products = Product.objects.filter(id__in=product_ids)
            r = Recommender()
            r.products_bought(products)

            # launch asynchronous task
            payment_completed.delay(order.id)

    return HttpResponse(status=200)
```

In the new code, when a new order payment is confirmed, you retrieve the `Product` objects associated with the order items. Then, you create an instance of the `Recommender` class and call the `products_bought()` method to store the products bought together in Redis.

You are now storing the related products that are bought together when orders are paid. Let's now display recommendations for products on your site.

Edit the `views.py` file of the `shop` application. Add the functionality to retrieve a maximum of four recommended products into the `product_detail` view, as follows:

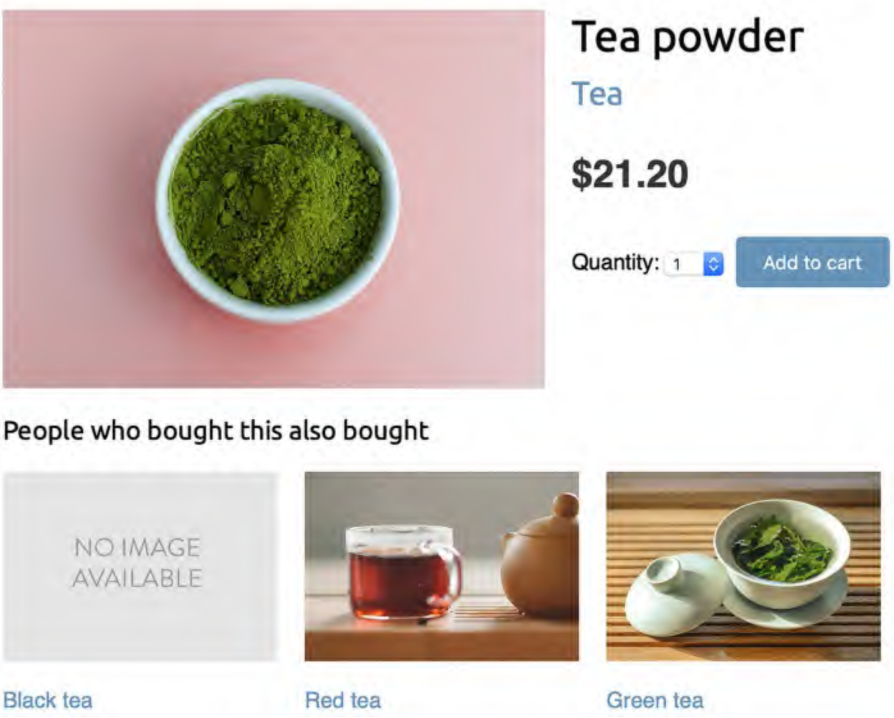
```
from .recommender import Recommender


def product_detail(request, id, slug):
    product = get_object_or_404(
        Product, id=id, slug=slug, available=True
    )
    cart_product_form = CartAddProductForm()
    r = Recommender()
    recommended_products = r.suggest_products_for([product], 4)
    return render(
        request,
        'shop/product/detail.html',
        {
            'product': product,
            'cart_product_form': cart_product_form,
           'recommended_products': recommended_products
        }
    )
```

Edit the shop/product/detail.html template of the shop application and add the following code after {{ product.description|linebreaks }}:

```
{% if recommended_products %}
  <div class="recommendations">
    <h3>People who bought this also bought</h3>
    {% for p in recommended_products %}
      <div class="item">
        <a href="{{ p.get_absolute_url }}">
          <img src="{% if p.image %}{{ p.image.url }}{% else %}
          {% static  "img/no_image.png" %}{% endif %}">
        </a>
        <p><a href="{{ p.get_absolute_url }}">{{ p.name }}</a></p>
      </div>
    {% endfor %}
  </div>
{% endif %}
```

Run the development server, and open http://127.0.0.1:8000/ in your browser. Click on any product to view its details. You should see that recommended products are displayed below the product, as shown in *Figure 10.18*:



Images in this chapter:

- *Green tea*: Photo by Jia Ye on Unsplash
- *Red tea*: Photo by Manki Kim on Unsplash
- *Tea powder*: Photo by Phuong Nguyen on Unsplash

You are also going to include product recommendations in the cart. The recommendations will be based on the products that the user has added to the cart.

Edit `views.py` inside the `cart` application, import the `Recommender` class, and edit the `cart_detail` view to make it look like the following:

```
from shop.recommender import Recommender

def cart_detail(request):
    cart = Cart(request)
    for item in cart:
        item['update_quantity_form'] = CartAddProductForm(
            initial={'quantity': item['quantity'], 'override': True}
        )
    coupon_apply_form = CouponApplyForm()

    r = Recommender()
    cart_products = [item['product'] for item in cart]
    if(cart_products):
        recommended_products = r.suggest_products_for(
            cart_products, max_results=4
        )
    else:
        recommended_products = []
    return render(
        request,
        'cart/detail.html',
        {
            'cart': cart,
            'coupon_apply_form': coupon_apply_form,
           'recommended_products': recommended_products})
        }
    )
```

Edit the `cart/detail.html` template of the `cart` application and add the following code just after the `</table>` HTML tag:

```
{% if recommended_products %}
  <div class="recommendations cart">
    <h3>People who bought this also bought</h3>
    {% for p in recommended_products %}
      <div class="item">
        <a href="{{ p.get_absolute_url }}">
          <img src="{% if p.image %}{{ p.image.url }}{% else %}
          {% static "img/no_image.png" %}{% endif %}">
        </a>
        <p><a href="{{ p.get_absolute_url }}">{{ p.name }}</a></p>
      </div>
    {% endfor %}
  </div>
{% endif %}
```

Open `http://127.0.0.1:8000/en/` in your browser and add a couple of products to your cart. When you navigate to `http://127.0.0.1:8000/en/cart/`, you should see the aggregated product recommendations for the items in the cart, as follows:

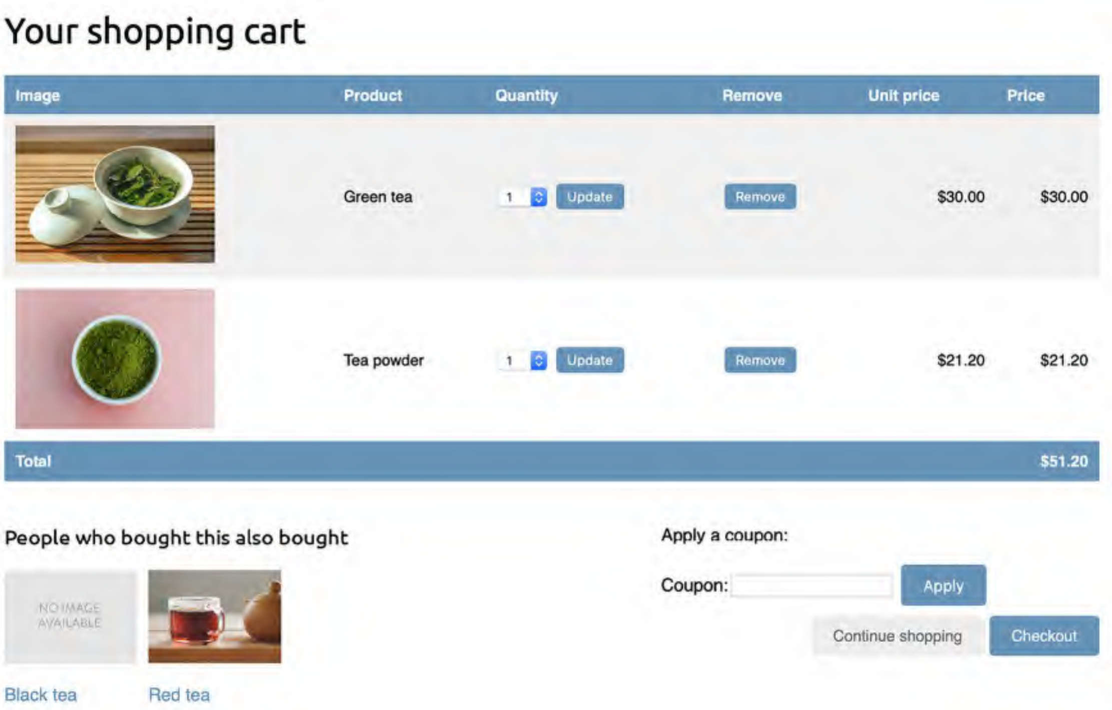


Figure 10.19: The shopping cart details page, including recommended products

Congratulations! You have built a complete recommendation engine using Django and Redis.

Summary

In this chapter, you created a coupon system using Django sessions and integrated it with Stripe. You also built a recommendation engine using Redis to recommend products that are usually purchased together.

The next chapter will give you an insight into the internationalization and localization of Django projects. You will learn how to translate code and manage translations with Rosetta. You will implement URLs for translations and build a language selector. You will also implement model translations using `django-parler` and you will validate localized form fields using `django-localflavor`.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter10`
- Discounts for Stripe Checkout: `https://stripe.com/docs/payments/checkout/discounts`
- The Redis `ZRANGE` command: `https://redis.io/commands/zrange/`
- The Redis `ZUNIONSTORE` command: `https://redis.io/commands/zunionstore/`
- The Redis `ZREM` command: `https://redis.io/commands/zrem/`
- The Redis `DEL` command: `https://redis.io/commands/del/`

11

Adding Internationalization to Your Shop

In the previous chapter, you added a coupon system to your shop and built a product recommendation engine.

In this chapter, you will learn how internationalization and localization work. By making your application accessible in multiple languages, you can serve a wider range of users. Additionally, by adapting your application to local formatting conventions such as date or number formatting, you improve its usability. By translating and localizing your application, you will make it more intuitive for users from different cultural backgrounds and increase user engagement.

This chapter will cover the following topics:

- Preparing your project for internationalization
- Managing translation files
- Translating Python code
- Translating templates
- Using Rosetta to manage translations
- Translating URL patterns and using a language prefix in URLs
- Allowing users to switch language
- Translating models using `django-parler`
- Using model translations with the ORM
- Adapting views to use translations
- Using the localized form fields of `django-localflavor`

Functional overview

Figure 11.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

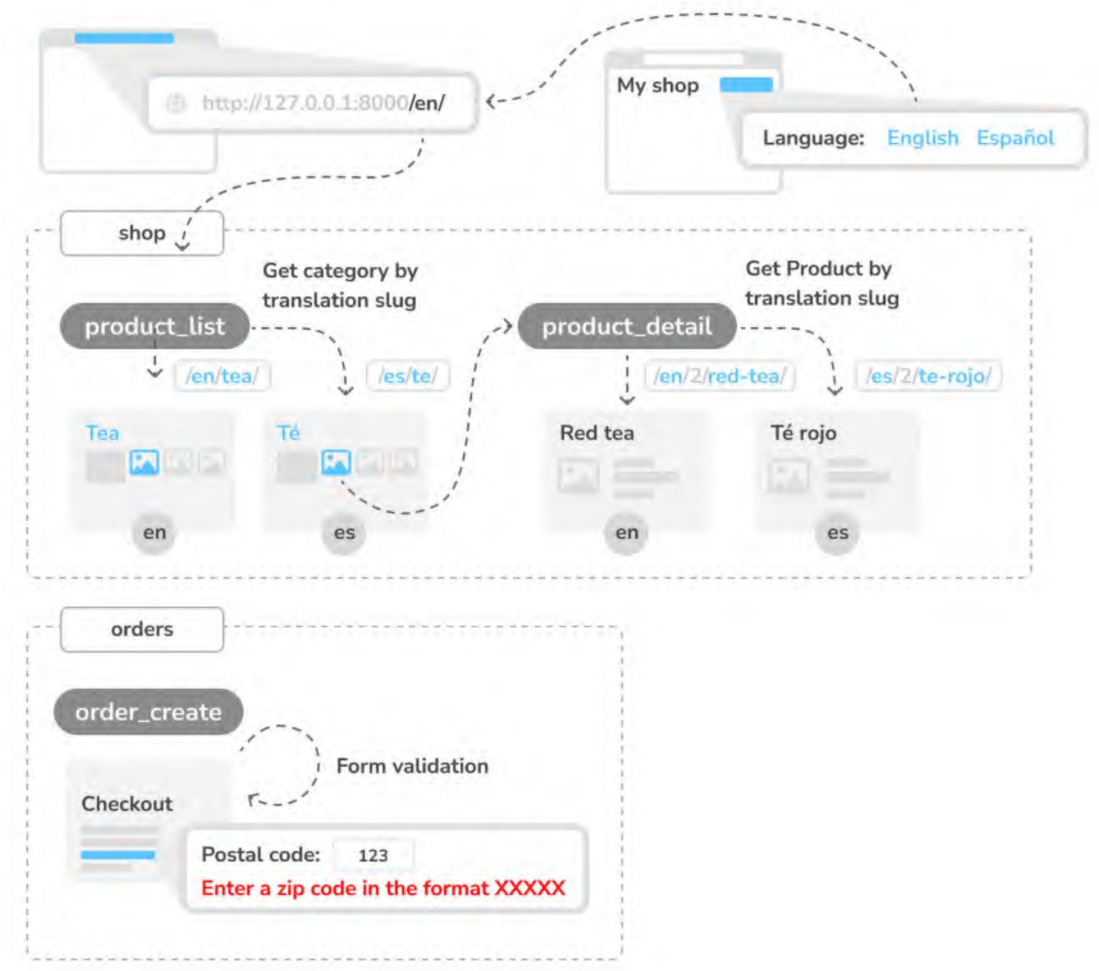


Figure 11.1: Diagram of the functionalities built in Chapter 11

In this chapter, you will implement internationalization in your project and translate templates, URLs, and models. You will add language selection links to the header of your site and create language-specific URLs. You will modify the `product_list` and `product_detail` views of the `shop` application to retrieve `Category` and `Product` objects by their translated slugs. You will also add a localized postal code field to the form used in the `order_create` view.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter11`.

All the Python modules used in this chapter are included in the `requirements.txt` file in the source code that comes with this chapter. You can follow the instructions to install each Python module below, or you can install all the requirements at once with the command `python -m pip install -r requirements.txt`.

Internationalization with Django

Django offers full internationalization and localization support. It allows you to translate your application into multiple languages, and it handles locale-specific formatting for dates, times, numbers, and time zones. Let's clarify the difference between internationalization and localization:

- **Internationalization** (frequently abbreviated to **i18n**) is the process of adapting software for the potential use of different languages and locales so that it isn't hardwired to a specific language or locale.
- **Localization** (abbreviated to **l10n**) is the process of actually translating the software and adapting it to a particular locale. Django itself is translated into more than 50 languages using its internationalization framework.

The internationalization framework allows you to easily mark strings for translation, both in Python code and in your templates. It relies on the GNU `gettext` toolset to generate and manage message files. A **message file** is a plain text file that represents a language. It contains a part, or all, of the translation strings found in your application and their respective translations for a single language. Message files have the `.po` extension. Once the translation is done, message files are compiled to offer rapid access to translated strings. The compiled translation files have the `.mo` extension.

Let's review the settings that Django provides for internationalization and localization.

Internationalization and localization settings

Django provides several settings for internationalization. The following settings are the most relevant ones:

- `USE_I18N`: A Boolean that specifies whether Django's translation system is enabled. This is `True` by default.
- `USE_TZ`: A Boolean that specifies whether datetimes are time-zone-aware. When you create a project with the `startproject` command, this is set to `True`.
- `LANGUAGE_CODE`: The default language code for the project. This is in the standard language ID format, for example, `en-us` for American English or `en-gb` for British English. This setting requires `USE_I18N` to be set to `True` in order to take effect. You can find a list of valid language IDs at `http://www.i18nguy.com/unicode/language-identifiers.html`.
- `LANGUAGES`: A tuple that contains available languages for the project. They come in two tuples with a **language code** and a **language name**. You can see the list of available languages at `django.conf.global_settings`. When you choose which languages your site will be available in, you set `LANGUAGES` to a subset of that list.
- `LOCALE_PATHS`: A list of directories where Django looks for message files containing translations for the project.

- `TIME_ZONE`: A string that represents the time zone for the project. This is set to `'UTC'` when you create a new project using the `startproject` command. You can set it to any other time zone, such as `'Europe/Madrid'`.

These are some of the internationalization and localization settings available. You can find the full list at `https://docs.djangoproject.com/en/5.0/ref/settings/#globalization-i18n-l10n`.

After reviewing the most important settings for internationalization and localization, let's learn how we can create translations for our application.

Internationalization management commands

Django includes the following management commands to manage translations:

- `makemessages`: This runs over the source tree to find all the strings marked for translation and creates or updates the `.po` message files in the `locale` directory. A single `.po` file is created for each language.
- `compilemessages`: This compiles the existing `.po` message files to `.mo` files, which are used to retrieve translations.

Django relies on the `gettext` toolkit to generate and compile translation files. Let's review how to install it.

Installing the gettext toolkit

You will need the `gettext` toolkit to be able to create, update, and compile message files. Most Linux distributions include the `gettext` toolkit. If you are using macOS, the simplest way to install it is via Homebrew, at `https://brew.sh/`, with the following command:

```
brew install gettext
```

You might also need to force-link it with the following command:

```
brew link --force gettext
```

If you are using Windows, follow the steps at `https://docs.djangoproject.com/en/5.0/topics/i18n/translation/#gettext-on-windows`. You can download a precompiled `gettext` binary installer for Windows from `https://mlocati.github.io/articles/gettext-iconv-windows.html`.

Once you have installed the `gettext` toolkit, you are all set to start translating your project. First, you need to understand the steps needed to translate your project and how Django determines the user's language.

How to add translations to a Django project

Let's explore the process of internationalizing your project. Here are the steps needed to translate a Django project:

1. Mark the strings for translation in your Python code and your templates.

2. Run the `makemessages` command to create or update message files that include all the translation strings from your code.
3. Translate the strings contained in the message files.
4. Compile the message files using the `compilemessages` management command.

We will follow this process to add translations to our project throughout this chapter.

Next, you are going to learn how Django determines the language of the current user.

How Django determines the current language

Django comes with a middleware that determines the current language based on the request data. This is the `LocaleMiddleware` middleware that resides in `django.middleware.locale.LocaleMiddleware`, which performs the following tasks:

1. If you are using `i18n_patterns`, that is, you are using translated URL patterns, it looks for a language prefix in the requested URL to determine the current language. You will learn to translate URL patterns in the *Translating URL patterns section*.
2. If no language prefix is found, it looks for an existing `LANGUAGE_SESSION_KEY` in the current user's session.
3. If the language is not set in the session, it looks for an existing cookie with the current language. A custom name for this cookie can be provided in the `LANGUAGE_COOKIE_NAME` setting. By default, the name for this cookie is `django_language`.
4. If no cookie is found, it looks for the `Accept-Language` HTTP header of the request.
5. If the `Accept-Language` header does not specify a language, Django uses the language defined in the `LANGUAGE_CODE` setting.

By default, Django will use the language defined in the `LANGUAGE_CODE` setting unless you are using `LocaleMiddleware`. The process described here only applies when using this middleware.

We can also let users change their language. You will learn about how to implement a language selector in the section *Allowing users to switch language*.

Let's start by configuring our project for internationalization.

Preparing your project for internationalization

We will prepare our project to use different languages. We are going to create an English and a Spanish version for the online shop:

Edit the `settings.py` file of your project and add the following `LANGUAGES` setting to it. Place it next to the `LANGUAGE_CODE` setting:

```
LANGUAGES = [
    ('en', 'English'),
    ('es', 'Spanish'),
]
```

The LANGUAGES setting contains two tuples that consist of a language code and a name. Language codes can be locale-specific, such as en-us or en-gb, or generic, such as en. With this setting, you specify that your application will only be available in English and Spanish. If you don't define a custom LANGUAGES setting, the site will be available in all the languages that Django is translated into.

Make your LANGUAGE_CODE setting look like the following:

```
LANGUAGE_CODE = 'en'
```

Add 'django.middleware.locale.LocaleMiddleware' to the MIDDLEWARE setting. Make sure that this middleware comes after SessionMiddleware because LocaleMiddleware needs to use session data. It also has to be placed before CommonMiddleware because the latter needs an active language to resolve the requested URL. The MIDDLEWARE setting should now look like the following:

```
MIDDLEWARE = [
    'django.middleware.security.SecurityMiddleware',
    'django.contrib.sessions.middleware.SessionMiddleware',
    'django.middleware.locale.LocaleMiddleware',
    'django.middleware.common.CommonMiddleware',
    'django.middleware.csrf.CsrfViewMiddleware',
    'django.contrib.auth.middleware.AuthenticationMiddleware',
    'django.contrib.messages.middleware.MessageMiddleware',
    'django.middleware.clickjacking.XFrameOptionsMiddleware',
]
```

The order of middleware classes is very important because each middleware can depend on data set by another middleware that was executed previously. Middleware is applied for requests in order of appearance in MIDDLEWARE, and in reverse order for responses.

Create the following directory structure inside the main project directory, next to the manage.py file:

```
locale/
    en/
    es/
```

The locale directory is the place where message files for your application will reside.

Edit the settings.py file again and add the following setting to it:

```
LOCALE_PATHS = [
    BASE_DIR / 'locale',
]
```

The LOCALE_PATHS setting specifies the directories where Django has to look for translation files. Locale paths that appear first have the highest precedence.

When you use the `makemessages` command from your project directory, message files will be generated in the `locale/` path you created. However, for applications that contain a `locale/` directory, message files will be generated in that directory.

Your project is now configured for internationalization. Next, you will learn how to translate strings in your Python code.

Translating Python code

We will explore various methods to handle translations within Python code. We will cover the following methods:

- **Standard translations**
- **Lazy translations**: Executed when the value is accessed rather than when the function is called.
- **Translations including variables:** Used to interpolate variables within strings that are to be translated.
- **Plural forms in translations**: Techniques to manage translations that depend on numerical quantities that might affect the string being translated.

For translating literals in your Python code, you can mark strings for translation using the `gettext()` function included in `django.utils.translation`. This function translates the message and returns a string. The convention is to import this function as a shorter alias named _ (the underscore character).

You can find all the documentation about translations at `https://docs.djangoproject.com/en/5.0/topics/i18n/translation/`.

Let's review the different translation methods for Python strings.

Standard translations

The following code shows how to mark a string for translation:

```
from django.utils.translation import gettext as _
output = _('Text to be translated.')
```

This method allows you to apply translations to most strings within your Python code by using the `gettext()` function, aliased as _ for convenience.

Lazy translations

Django includes **lazy** versions for all of its translation functions, which have the suffix `_lazy()`. When using the lazy functions, strings are translated when the value is accessed, rather than when the function is called (this is why they are translated **lazily**). The lazy translation functions come in handy when the strings marked for translation are in paths that are executed when modules are loaded.

A common example where lazy translations are beneficial is in the `settings.py` file of your project, where immediate translation is not practical because the settings must be defined before the translation system is fully ready.

> Using `gettext_lazy()` instead of `gettext()` means that strings are translated when the value is accessed. Django offers a lazy version for all translation functions.

Translations including variables

The strings marked for translation can include placeholders to include variables in the translations. The following code is an example of a translation string with a placeholder:

```
from django.utils.translation import gettext as _
month = _('April')
day = '14'
output = _('Today is %(month)s %(day)s') % {'month': month, 'day': day}
```

By using placeholders, you can reorder the text variables. For example, an English translation of the previous example might be *today is April 14*, while the Spanish one might be *hoy es 14 de Abril*. Always use string interpolation instead of positional interpolation when you have more than one parameter for the translation string. By doing so, you will be able to reorder the placeholder text.

Plural forms in translations

For plural forms, Django provides `ngettext()` and `ngettext_lazy()`. These functions translate singular and plural forms, depending on an argument that indicates the number of objects. The following example shows how to use them:

```
output = ngettext(
    'there is %(count)d product',    # Singular form
    'there are %(count)d products',  # Plural form
    count                            # Numeric value to determine form
) % {'count': count}
```

In this example, if `count` is `1`, `ngettext()` will use the first string and output `there is 1 product`. For any other number, it will use the second string, appropriately outputting, for example, `there are 5 products`. This allows for more accurate and grammatically correct translations in languages where pluralization rules are essential.

Now that you know the basics of translating literals in your Python code, it's time to apply translations to your project.

Translating your own code

First, we will translate the language names. To do this, you can follow these instructions:

Edit the `settings.py` file of your project, import the `gettext_lazy()` function, and change the `LANGUAGES` setting, as follows:

```
from django.utils.translation import gettext_lazy as _
# ...

LANGUAGES = [
    ('en', _('English')),
    ('es', _('Spanish')),
]
```

Here, you use the `gettext_lazy()` function instead of `gettext()` to avoid a circular import, thus translating the languages' names when they are accessed.

Open the shell and run the following command from your project directory:

```
django-admin makemessages --all
```

You should see the following output:

```
processing locale es
processing locale en
```

Take a look at the `locale/` directory. You should see a file structure like the following:

```
en/
    LC_MESSAGES/
        django.po
es/
    LC_MESSAGES/
        django.po
```

A `.po` message file has been created for each language.

Open `es/LC_MESSAGES/django.po` with a text editor. At the end of the file, you should be able to see the following:

```
#: myshop/settings.py:118
msgid "English"
msgstr ""
#: myshop/settings.py:119
msgid "Spanish"
msgstr ""
```

Each translation string is preceded by a comment showing details about the file and the line where it was found. Each translation includes two strings:

- `msgid`: The translation string as it appears in the source code.
- `msgstr`: The language translation, which is empty by default. This is where you have to enter the actual translation for the given string.

Fill in the `msgstr` translations for the given `msgid` string, as follows:

```
#: myshop/settings.py:118
msgid "English"
msgstr "Inglés"
#: myshop/settings.py:119
msgid "Spanish"
msgstr "Español"
```

Save the modified message file, open the shell, and run the following command:

```
django-admin compilemessages
```

If everything goes well, you should see an output like the following:

```
processing file django.po in myshop/locale/en/LC_MESSAGES
processing file django.po in myshop/locale/es/LC_MESSAGES
```

The output gives you information about the message files that are being compiled. Take a look at the `locale` directory of the `myshop` project again. You should see the following files:

```
en/
    LC_MESSAGES/
        django.mo
        django.po
es/
    LC_MESSAGES/
        django.mo
        django.po
```

You can see that a `.mo` compiled message file has been generated for each language.

Now that you have translated the language names, let's translate the model field names that are displayed on the site:

Edit the `models.py` file of the `orders` application, and add names marked for translation to the `Order` model fields, as follows:

```
from django.utils.translation import gettext_lazy as _


class Order(models.Model):
```

```
    first_name = models.CharField(_('first name'), max_length=50)
    last_name = models.CharField(_('last name'), max_length=50)
    email = models.EmailField(_('e-mail'))
    address = models.CharField(_('address'), max_length=250)
    postal_code = models.CharField(_('postal code'), max_length=20)
    city = models.CharField(_('city'), max_length=100)
    # ...
```

You have added names for the fields that are displayed when a user places a new order. These are `first_name`, `last_name`, `email`, `address`, `postal_code`, and `city`. Remember that you can also use the `verbose_name` attribute to name the fields.

Create the following directory structure inside the `orders` application directory:

```
locale/
    en/
    es/
```

By creating a `locale` directory, the translation strings of this application will be stored in a message file in this directory instead of the main messages file. In this way, you can generate separate translation files for each application.

Open the shell from the project directory and run the following command:

```
django-admin makemessages --all
```

You should see the following output:

```
processing locale es
processing locale en
```

Open the `locale/es/LC_MESSAGES/django.po` file of the `order` application using a text editor. You will see the translation strings for the `Order` model. Fill in the following `msgstr` translations for the given `msgid` strings:

```
#: orders/models.py:12
msgid "first name"
msgstr "nombre"
#: orders/models.py:14
msgid "last name"
msgstr "apellidos"
#: orders/models.py:16
msgid "e-mail"
msgstr "e-mail"
#: orders/models.py:17
msgid "address"
```

```
msgstr "dirección"
#: orders/models.py:19
msgid "postal code"
msgstr "código postal"
#: orders/models.py:21
msgid "city"
msgstr "ciudad"
```

After you have finished adding the translations, save the file.

Besides a text editor, you can use Poedit to edit translations. Poedit is a piece of software for editing translations that uses `gettext`. It is available for Linux, Windows, and macOS. You can download Poedit from `https://poedit.net/`.

Let's also translate the forms of your project. The `OrderCreateForm` of the `orders` application does not have to be translated. That's because it is a `ModelForm` and uses the `verbose_name` attribute of the `Order` model fields for the form field labels. You are going to translate the forms of the `cart` and `coupons` applications:

Edit the `forms.py` file inside the `cart` application directory and add a `label` attribute to the `quantity` field of the `CartAddProductForm`. Then, mark this field for translation, as follows:

```
from django import forms
from django.utils.translation import gettext_lazy as _

PRODUCT_QUANTITY_CHOICES = [(i, str(i)) for i in range(1, 21)]

class CartAddProductForm(forms.Form):
    quantity = forms.TypedChoiceField(
        choices=PRODUCT_QUANTITY_CHOICES,
        coerce=int,
        label=_('Quantity')
    )
    override = forms.BooleanField(
        required=False,
        initial=False,
        widget=forms.HiddenInput
    )
```

Edit the `forms.py` file of the `coupons` application and translate the `CouponApplyForm` form, as follows:

```
from django import forms
from django.utils.translation import gettext_lazy as _

class CouponApplyForm(forms.Form):
```

```
    code = forms.CharField(label=_('Coupon'))
```

You have added a label to the `code` field and marked it for translation.

You have finished marking Python strings for translation. Next, you will learn how to mark text for translation in templates.

Translating templates

Django offers the `{% translate %}` and `{% blocktranslate %}` template tags to translate the strings using templates. In order to use the translation template tags, you have to add `{% load i18n %}` to the top of your template to load them.

The {% translate %} template tag

The `{% translate %}` template tag allows you to mark a literal for translation. Internally, Django executes `gettext()` on the given text. This is how to mark a string for translation in a template:

```
{% translate "Text to be translated" %}
```

You can use `as` to store the translated content in a variable that you can use throughout your template. The following example stores the translated text in a variable called `greeting`:

```
{% translate "Hello!" as greeting %}
<h1>{{ greeting }}</h1>
```

The `{% translate %}` tag is useful for simple translation strings, but it can't handle content for translation that includes variables.

The {% blocktranslate %} template tag

The `{% blocktranslate %}` template tag allows you to mark content that includes literals and variable content, using placeholders. The following example shows you how to use the `{% blocktranslate %}` tag, including a `name` variable in the content for translation:

```
{% blocktranslate %}Hello {{ name }}!{% endblocktranslate %}
```

You can use `with` to include template expressions, such as accessing object attributes or applying template filters to variables. You always have to use placeholders for these. You can't access expressions or object attributes inside the `blocktrans` block. The following example shows you how to use `with` to include an object attribute to which the `capfirst` filter has been applied:

```
{% blocktranslate with name=user.name|capfirst %}
  Hello {{ name }}!
{% endblocktranslate %}
```

Use the `{% blocktranslate %}` tag instead of `{% translate %}` when you need to include variable content in your translation string.

Now that you are familiar with the translation template tags, let's put them to use.

Translating the shop templates

Edit the `shop/base.html` template of the `shop` application. Make sure that you load the `i18n` tag at the top of the template and mark the strings for translation, as follows. The new code is highlighted in bold:

```
{% load i18n static %}
<!DOCTYPE html>
<html>
<head>
  <meta charset="utf-8" />
  <title>
    {% block title %}{% translate "My shop" %}{% endblock %}
  </title>
  <link href="{% static "css/base.css" %}" rel="stylesheet">
</head>
<body>
  <div id="header">
    <a href="/" class="logo">{% translate "My shop" %}</a>
  </div>
  <div id="subheader">
    <div class="cart">
      {% with total_items=cart|length %}
        {% if total_items > 0 %}
          {% translate "Your cart" %}:
          <a href="{% url "cart:cart_detail" %}">
            {% blocktranslate with total=cart.get_total_price count
items=total_items %}
              {{ items }} item, ${{ total }}
            {% plural %}
              {{ items }} items, ${{ total }}
            {% endblocktranslate %}
          </a>
        {% elif not order %}
          {% translate "Your cart is empty." %}
        {% endif %}
      {% endwith %}
    </div>
  </div>
  <div id="content">
    {% block content %}
    {% endblock %}
```

```
  </div>
</body>
</html>
```

Make sure that no template tag is split across multiple lines.

Notice the `{% blocktranslate %}` tag to display the cart's summary. The cart's summary was previously as follows:

```
{{ total_items }} item{{ total_items|pluralize }},
${{ cart.get_total_price }}
```

You changed it, and now you use `{% blocktranslate with ... %}` to set up the placeholder `total` with the value of `cart.get_total_price` (the object method called here). You also use `count`, which allows you to set a variable for counting objects for Django to select the right plural form. You set the `items` variable to count objects with the value of `total_items`.

This allows you to set a translation for the singular and plural forms, which you separate with the `{% plural %}` tag within the `{% blocktranslate %}` block. The resulting code is:

```
{% blocktranslate with total=cart.get_total_price count items=total_items %}
  {{ items }} item, ${{ total }}
{% plural %}
  {{ items }} items, ${{ total }}
{% endblocktranslate %}
```

Next, edit the `shop/product/detail.html` template of the `shop` application and add `i18n` to the `{% load %}` tag:

```
{% extends "shop/base.html" %}
{% load i18n static %}
...
```

Note that `{% load %}` allows you to load all template tags at once by including the modules separated by spaces. In this case, we load the `i18n` and `static` modules that contain template tags.

Then, find the following line:

```
<input type="submit" value="Add to cart">
```

Replace it with the following:

```
<input type="submit" value="{% translate "Add to cart" %}">
```

Then, find the following line:

```
<h3>People who bought this also bought</h3>
```

Replace it with the following:

```
<h3>{% translate "People who bought this also bought" %}</h3>
```

Now, translate the `orders` application template. Edit the `orders/order/create.html` template of the `orders` application and mark the text for translation, as follows:

```
{% extends "shop/base.html" %}
{% load i18n %}

{% block title %}
  {% translate "Checkout" %}
{% endblock %}

{% block content %}
  <h1>{% translate "Checkout" %}</h1>
  <div class="order-info">
    <h3>{% translate "Your order" %}</h3>
    <ul>
      {% for item in cart %}
        <li>
          {{ item.quantity }}x {{ item.product.name }}
          <span>${{ item.total_price }}</span>
        </li>
      {% endfor %}
      {% if cart.coupon %}
        <li>
          {% blocktranslate with code=cart.coupon.code discount=cart.coupon.
discount %}
            "{{ code }}" ({{ discount }}% off)
          {% endblocktranslate %}
          <span class="neg">- ${{ cart.get_discount|floatformat:2 }}</span>
        </li>
      {% endif %}
    </ul>
    <p>{% translate "Total" %}: ${{
    cart.get_total_price_after_discount|floatformat:2 }}</p>
  </div>
  <form method="post" class="order-form">
    {{ form.as_p }}
    <p><input type="submit" value="{% translate "Place order" %}"></p>
    {% csrf_token %}
  </form>
{% endblock %}
```

Make sure that no template tag is split across multiple lines. Take a look at the following files in the code that accompanies this chapter to see how the strings have been marked for translation:

- The `shop` application: Template `shop/product/list.html`
- The `orders` application: Template `orders/order/pdf.html`
- The `cart` application: Template `cart/detail.html`
- The `payments` application: Templates `payment/process.html`, `payment/completed.html`, and `payment/canceled.html`

Remember that you can find the source code for this chapter at `https://github.com/PacktPublishing/Django-5-by-Example/tree/master/Chapter11`.

Let's update the message files to include the new translation strings:

Open the shell and run the following command:

```
django-admin makemessages --all
```

The `.po` files are inside the `locale` directory of the `myshop` project, and you'll see that the `orders` application now contains all the strings that you marked for translation.

Edit the `.po` translation files of the project and the `orders` application, and include Spanish translations in `msgstr`. You can also use the translated `.po` files in the source code that accompanies this chapter.

Run the following command to compile the translation files:

```
django-admin compilemessages
```

You will see the following output:

```
processing file django.po in myshop/locale/en/LC_MESSAGES
processing file django.po in myshop/locale/es/LC_MESSAGES
processing file django.po in myshop/orders/locale/en/LC_MESSAGES
processing file django.po in myshop/orders/locale/es/LC_MESSAGES
```

A `.mo` file containing compiled translations has been generated for each `.po` translation file.

Now, you have edited `.po` files with a text editor or by using Poedit. Next, we are going to use a Django application to edit translations directly within the browser.

Using the Rosetta translation interface

Rosetta is a third-party application that allows you to edit translations directly in the browser, using the same interface as the Django administration site. Rosetta makes it easy to edit `.po` files, and it updates compiled translation files. This eliminates the need to download and upload translation files, and it supports collaborative editing by multiple users.

Let's integrate Rosetta into your project:

Install Rosetta via `pip` using this command:

```
python -m pip install django-rosetta==0.10.0
```

Then, add `'rosetta'` to the `INSTALLED_APPS` setting in your project's `settings.py` file, as follows:

```
INSTALLED_APPS = [
    # ...
    'rosetta',
]
```

You need to add Rosetta's URLs to your main URL configuration. Edit the main `urls.py` file of your project and add the following URL pattern highlighted in bold:

```
urlpatterns = [
    path('admin/', admin.site.urls),
    path('cart/', include('cart.urls', namespace='cart')),
    path('orders/', include('orders.urls', namespace='orders')),
    path('payment/', include('payment.urls', namespace='payment')),
    path('coupons/', include('coupons.urls', namespace='coupons')),
    path('rosetta/', include('rosetta.urls')),
    path('', include('shop.urls', namespace='shop')),
]
```

Make sure you place it before the `shop.urls` pattern to prevent an undesired pattern match.

Open `http://127.0.0.1:8000/admin/` and log in as a superuser. Then, navigate to `http://127.0.0.1:8000/rosetta/` in your browser. In the **Filter** menu, click **THIRD PARTY** to display all the available message files, including those that belong to the `orders` application.

You should see a list of existing languages, as follows:

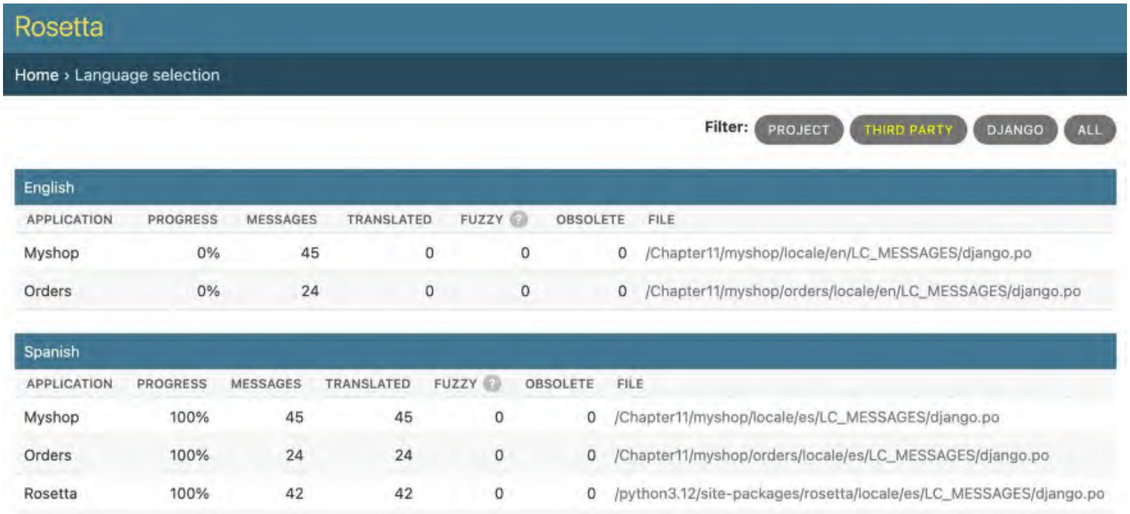


Figure 11.2: The Rosetta administration interface

Click the **Myshop** link in the **Spanish** section to edit the Spanish translations. You should see a list of translation strings, as follows:

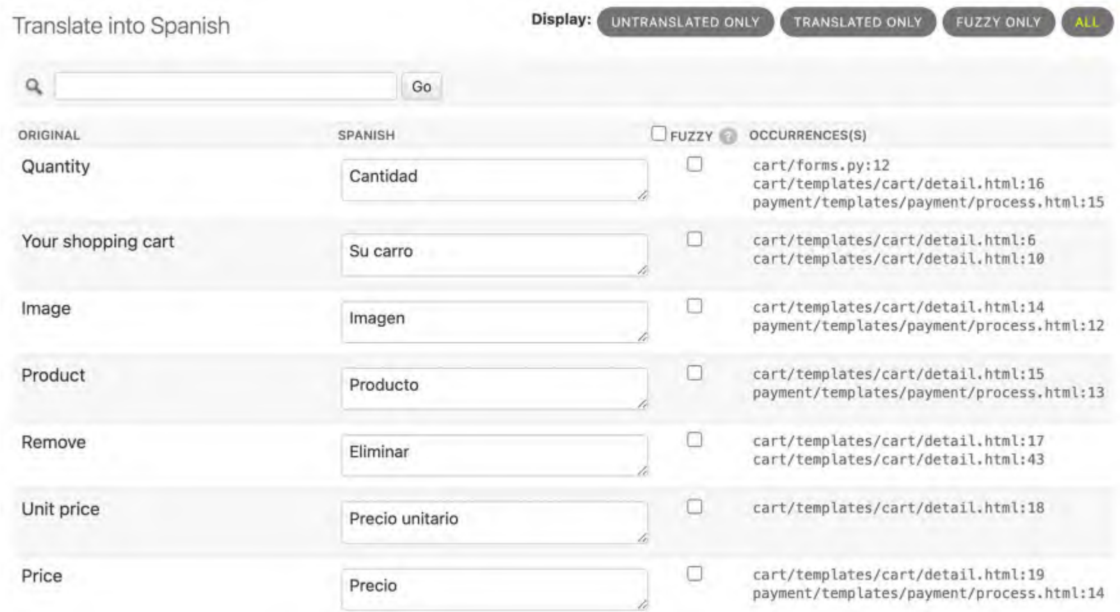


Figure 11.3: Editing Spanish translations using Rosetta

You can enter the translations in the **SPANISH** column. The **OCCURRENCE(S)** column displays the files and lines of code where each translation string was found.

Translations that include placeholders will appear as follows:

Figure 11.4: Translations including placeholders

Rosetta uses a different background color to display placeholders. When you translate content, make sure that you keep placeholders untranslated. For example, take the following string:

```
%(items)s items, $%(total)s
```

It can be translated into Spanish as follows:

```
%(items)s productos, $%(total)s
```

You can take a look at the source code that comes with this chapter to use the same Spanish translations for your project.

When you finish editing translations, click the **Save and translate next block** button to save the translations to the `.po` file. Rosetta compiles the message file when you save translations, so there is no need for you to run the `compilemessages` command. However, Rosetta requires write access to the `locale` directories to write the message files. Make sure that the directories have valid permissions.

If you want other users to be able to edit translations, open `http://127.0.0.1:8000/admin/auth/group/add/` in your browser and create a new group named `translators`. Then, access `http://127.0.0.1:8000/admin/auth/user/` to edit the users to whom you want to grant permissions so that they can edit translations. When editing a user, under the **Permissions** section, add the `translators` group to the **Chosen Groups** for each user. Rosetta is only available to superusers or users who belong to the `translators` group.

You can read Rosetta's documentation at `https://django-rosetta.readthedocs.io/`.

> When you add new translations to your production environment, if you serve Django with a real web server, you will have to reload your server after running the `compilemessages` command, or after saving the translations with Rosetta, for any changes to take effect.

When editing translations, a translation can be marked as *fuzzy*. Let's review what fuzzy translations are.

Fuzzy translations

When editing translations in Rosetta, you can see a **FUZZY** column. This is not a Rosetta feature; it is provided by `gettext`. If the **FUZZY** flag is active for a translation, it will not be included in the compiled message files. This flag marks translation strings that need to be reviewed by a translator. When `.po` files are updated with new translation strings, it is possible that some translation strings will automatically be flagged as fuzzy. This happens when `gettext` finds some `msgid` that has been slightly modified. `gettext` pairs it with what it thinks was the old translation and flags it as fuzzy for review. The translator should then review the fuzzy translations, remove the **FUZZY** flag, and compile the translation file again.

You have translated your project's interface, but internationalization doesn't stop there. You can also translate URL patterns, offering custom URLs tailored for each supported language.

URL patterns for internationalization

Django offers internationalization capabilities for URLs. It includes two main features for internationalized URLs:

- **A language prefix in URL patterns**: Adding a language prefix to URLs to serve each language version under a different base URL
- **Translated URL patterns**: Translating URL patterns so that every URL is different for each language

One reason for translating URLs is to optimize your site for search engines. By adding a language prefix to your patterns, you will be able to index a URL for each language instead of a single URL for all of them. Furthermore, by translating URLs into each language, you will provide search engines with URLs that will rank better for each language.

Adding a language prefix to URL patterns

Django allows you to add a language prefix to your URL patterns. For example, the English version of your site can be served by a path starting with `/en/`, and the Spanish version under `/es/`. To use languages in URL patterns, you have to use the `LocaleMiddleware` provided by Django. The framework will use it to identify the current language from the requested URL. Previously, you added it to the `MIDDLEWARE` setting of your project, so you don't need to do it now.

Let's add a language prefix to your URL patterns:

Edit the main `urls.py` file of the `myshop` project and add `i18n_patterns()`, as follows:

```
from django.conf.urls.i18n import i18n_patterns

urlpatterns = i18n_patterns(
    path('admin/', admin.site.urls),
    path('cart/', include('cart.urls', namespace='cart')),
    path('orders/', include('orders.urls', namespace='orders')),
    path('payment/', include('payment.urls', namespace='payment')),
```

```
    path('coupons/', include('coupons.urls', namespace='coupons')),
    path('rosetta/', include('rosetta.urls')),
    path('', include('shop.urls', namespace='shop')),
)
```

You can combine non-translatable standard URL patterns and patterns under `i18n_patterns` so that some patterns include a language prefix and others don't. However, it's better to use translated URLs only to avoid the possibility that a carelessly translated URL matches a non-translated URL pattern.

Run the development server and open `http://127.0.0.1:8000/` in your browser. Django will perform the steps described in the *How Django determines the current language* section to determine the current language, and it will redirect you to the requested URL, including the language prefix. Take a look at the URL in your browser; it should now look like `http://127.0.0.1:8000/en/`. The current language is the one set by the `Accept-Language` header of your browser if it is Spanish or English; otherwise, it is the default `LANGUAGE_CODE` (English) defined in your settings.

You have added a language prefix to your URLs, generating a different URL for each language available. This helps you to index different versions in search engines.

Next, we are going to translate URL patterns so that we can add fully translated URLs to our site.

Translating URL patterns

Django supports translated strings in URL patterns. You can use a different translation for each language for a single URL pattern. You can mark URL patterns for translation in the same way you would with literals, using the `gettext_lazy()` function. To do this, follow these steps:

Edit the main `urls.py` file of the `myshop` project and add translation strings to the regular expressions of the URL patterns for the `cart`, `orders`, `payment`, and `coupons` applications, as follows:

```
from django.utils.translation import gettext_lazy as _

urlpatterns = i18n_patterns(
    path('admin/', admin.site.urls),
    path(_('cart/'), include('cart.urls', namespace='cart')),
    path(_('orders/'), include('orders.urls', namespace='orders')),
    path(_('payment/'), include('payment.urls', namespace='payment')),
    path(_('coupons/'), include('coupons.urls', namespace='coupons')),
    path('rosetta/', include('rosetta.urls')),
    path('', include('shop.urls', namespace='shop')),
)
```

Edit the `urls.py` file of the `orders` application and mark the `order_create` URL pattern for translation, as follows:

```
from django.utils.translation import gettext_lazy as _
```

```
urlpatterns = [
    path(_('create/'), views.order_create, name='order_create'),
    # ...
]
```

Edit the `urls.py` file of the `payment` application and change the code to the following:

```
from django.utils.translation import gettext_lazy as _

urlpatterns = [
    path(_('process/'), views.payment_process, name='process'),
    path(_('completed/'), views.payment_completed, name='completed'),
    path(_('canceled/'), views.payment_canceled, name='canceled'),
    path('webhook/', webhooks.stripe_webhook, name='stripe-webhook'),
]
```

Note that these URL patterns will include a language prefix because they are included under `i18n_patterns()` in the main `urls.py` file of the project. This will make each URL pattern have a different URI for each available language, one starting with `/en/`, another one with `/es/`, and so on. However, we need a single URL for Stripe to notify events, and we need to avoid language prefixes in the `webhook` URL.

Remove the `webhook` URL pattern from the `urls.py` file of the `payment` application. The file should now look like the following:

```
from django.utils.translation import gettext_lazy as _

urlpatterns = [
    path(_('process/'), views.payment_process, name='process'),
    path(_('completed/'), views.payment_completed, name='completed'),
    path(_('canceled/'), views.payment_canceled, name='canceled'),
]
```

Then, add the following `webhook` URL pattern to the main `urls.py` file of the `myshop` project. The new code is highlighted in bold:

```
from django.utils.translation import gettext_lazy as _
from payment import webhooks

urlpatterns = i18n_patterns(
    path('admin/', admin.site.urls),
    path(_('cart/'), include('cart.urls', namespace='cart')),
    path(_('orders/'), include('orders.urls', namespace='orders')),
    path(_('payment/'), include('payment.urls', namespace='payment')),
    path(_('coupons/'), include('coupons.urls', namespace='coupons')),
```

```
    path('rosetta/', include('rosetta.urls')),
    path('', include('shop.urls', namespace='shop')),
)

urlpatterns += [
    path(
        'payment/webhook/',
        webhooks.stripe_webhook,
        name='stripe-webhook'
    ),
]
if settings.DEBUG:
    urlpatterns += static(
        settings.MEDIA_URL, document_root=settings.MEDIA_ROOT
    )
```

We have added the `webhook` URL pattern to `urlpatterns` outside of `i18n_patterns()` to ensure we maintain a single URL for Stripe event notifications.

You don't need to translate the URL patterns of the `shop` application, as they are built with variables and do not include any other literals.

Open the shell and run the next command to update the message files with the new translations:

```
django-admin makemessages --all
```

Make sure the development server is running with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/en/rosetta/` in your browser and click the **Myshop** link under the **Spanish** section. Click on **UNTRANSLATED ONLY** to only see the strings that have not been translated yet. Now, you will see the URL patterns for translation, as shown in *Figure 11.5*:

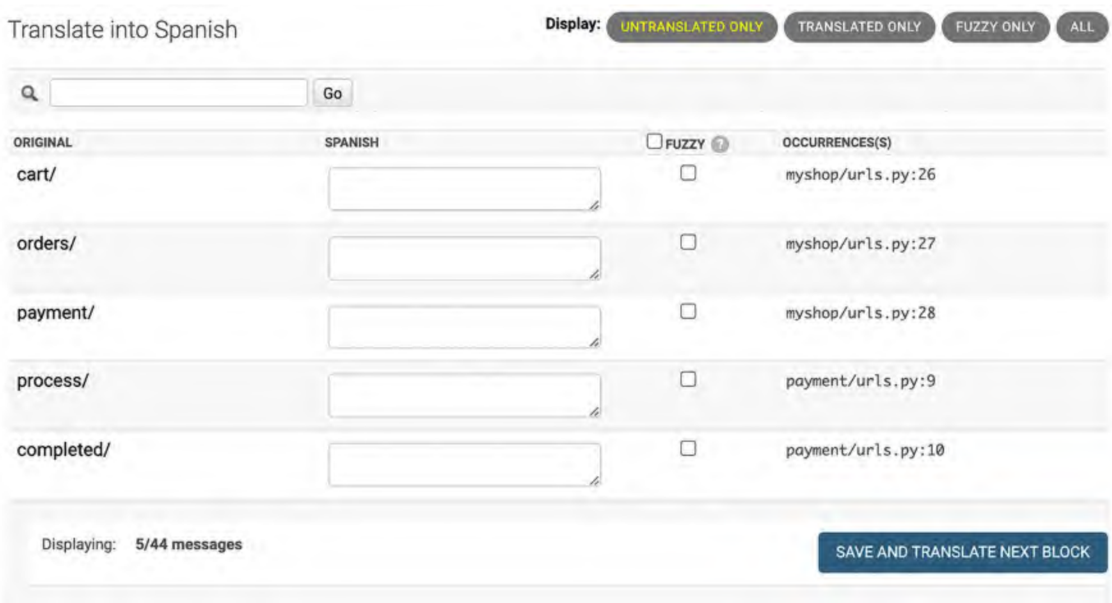


Figure 11.5: URL patterns for translation in the Rosetta interface

Add a different translation string for each URL. Don't forget to include a slash character, `/`, at the end of each URL, as shown in *Figure 11.6*:

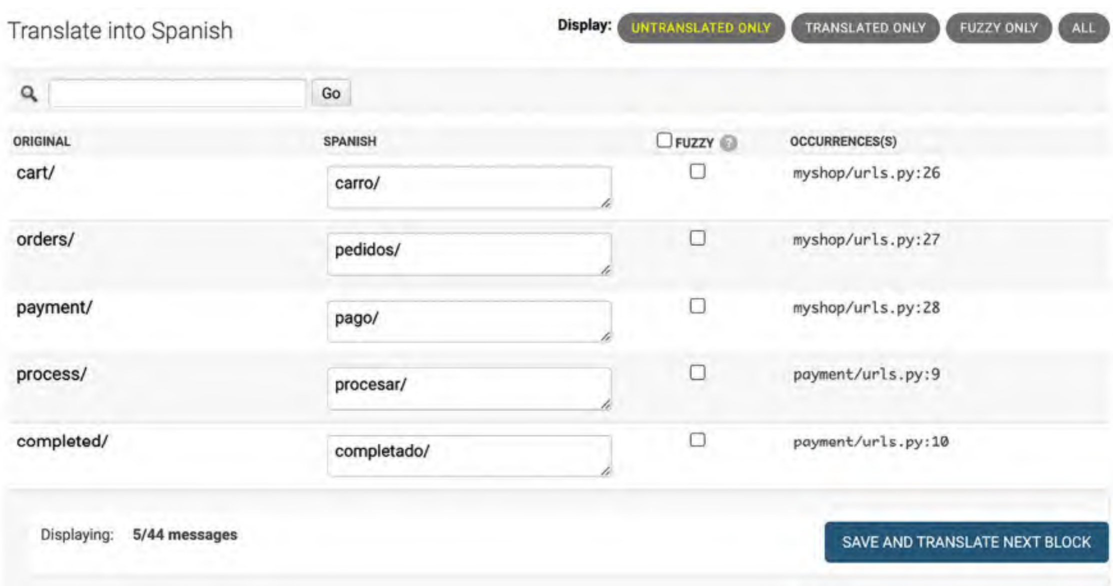


Figure 11.6: Spanish translations for URL patterns in the Rosetta interface

When you have finished, click **SAVE AND TRANSLATE NEXT BLOCK**.

Then, click on **FUZZY ONLY**. You will see translations that have been flagged as fuzzy because they were paired with the old translation of a similar original string. In the case displayed in *Figure 11.7*, the translations are incorrect and need to be corrected:

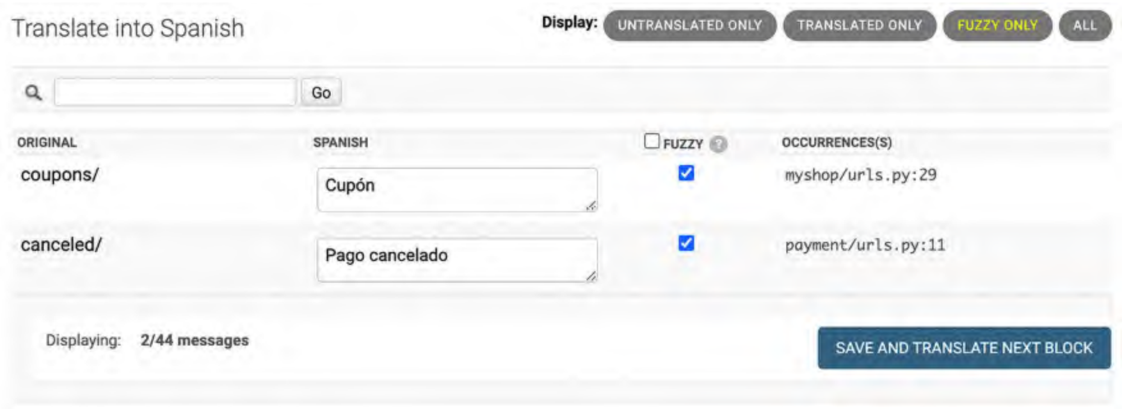


Figure 11.7: Fuzzy translations in the Rosetta interface

Enter the correct text for the fuzzy translations. Rosetta will automatically uncheck the **FUZZY** select box when you enter new text for a translation. When you have finished, click **SAVE AND TRANSLATE NEXT BLOCK**:

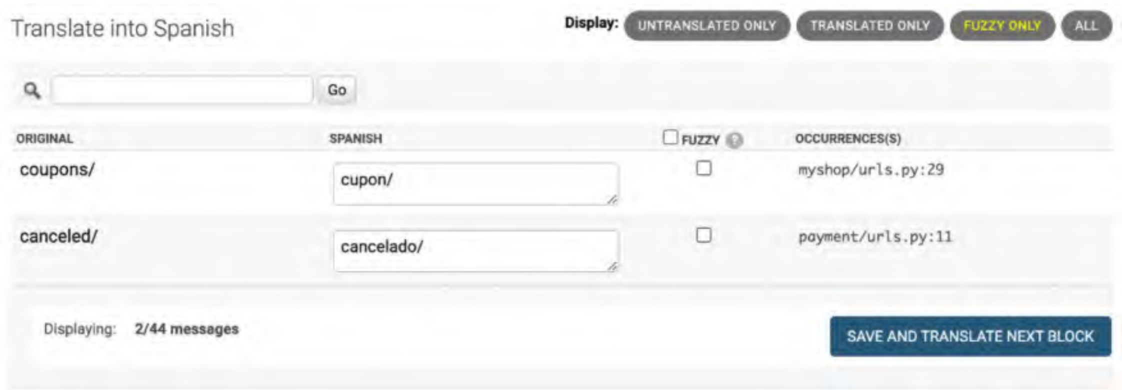


Figure 11.8: Correcting fuzzy translations in the Rosetta interface

You can now go back to `http://127.0.0.1:8000/en/rosetta/files/third-party/` and edit the Spanish translation for the `orders` application as well.

After translating the strings into Spanish, our site will be available in two languages. You have already learned how Django determines the current language. However, users may wish to switch languages. Let's create the functionality that allows users to change their language preference.

Allowing users to switch language

Since you are serving content that is available in multiple languages, you should let your users switch the site's language. You are going to add a language selector to your site. The language selector will consist of a list of available languages displayed using links.

Edit the `shop/base.html` template of the `shop` application and locate the following lines:

```
<div id="header">
  <a href="/" class="logo">{% translate "My shop" %}</a>
</div>
```

Replace them with the following code:

```
<div id="header">
  <a href="/" class="logo">{% translate "My shop" %}</a>
  {% get_current_language as LANGUAGE_CODE %}
  {% get_available_languages as LANGUAGES %}
  {% get_language_info_list for LANGUAGES as languages %}
  <div class="languages">
    <p>{% translate "Language" %}:</p>
    <ul class="languages">
      {% for language in languages %}
        <li>
          <a href="/{{ language.code }}/"
          {% if language.code == LANGUAGE_CODE %} class="selected"{% endif %}>
            {{ language.name_local }}
          </a>
        </li>
      {% endfor %}
    </ul>
  </div>
</div>
```

Make sure that no template tag is split into multiple lines.

This is how you build your language selector:

1. You load the internationalization tags using `{% load i18n %}`.
2. You use the `{% get_current_language %}` tag to retrieve the current language.
3. You get the languages defined in the `LANGUAGES` setting using the `{% get_available_languages %}` template tag.
4. You use the tag `{% get_language_info_list %}` to provide easy access to the language attributes.
5. You build an HTML list to display all available languages, and you add a `selected` class attribute to the currently active language.

In the code for the language selector, you used the template tags provided by `i18n`, based on the languages available in the settings of your project. Now, open `http://127.0.0.1:8000/` in your browser and take a look. You should see the language selector in the top right-hand corner of the site, as follows:

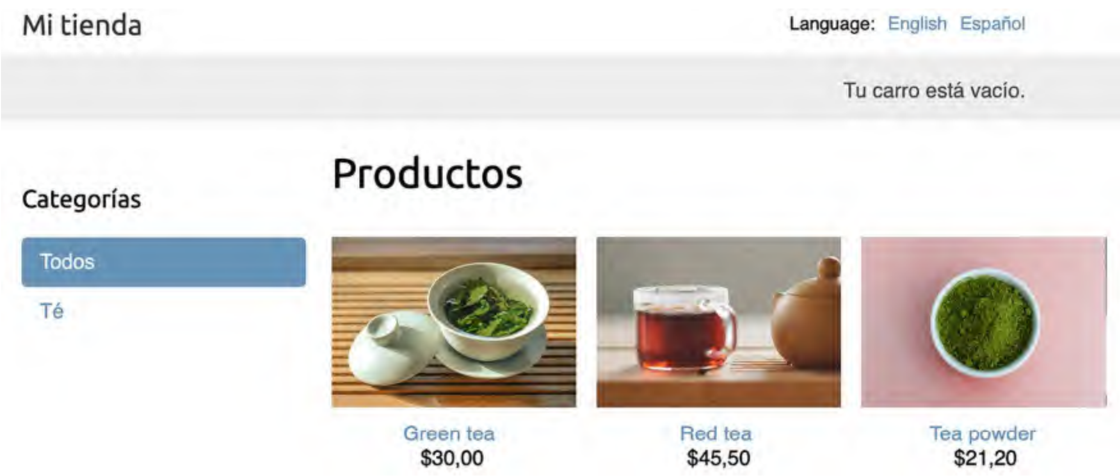


Figure 11.9: The product list page, including a language selector in the site header

> Images in this chapter:
>
> *Green tea*: Photo by Jia Ye on Unsplash
>
> *Red tea*: Photo by Manki Kim on Unsplash
>
> *Tea powder*: Photo by Phuong Nguyen on Unsplash

Users can now effortlessly switch to their preferred language by selecting from the options available in the language selector.

Translating models with django-parler

Django does not include built-in support to translate models. To manage content in multiple languages, you can either develop a custom solution or opt for a third-party module that facilitates model translation. There are several third-party applications available, each employing a unique method for storing and retrieving translations. One of these applications is `django-parler`. This module provides a very effective approach for translating models and integrates smoothly with Django's administration site.

`django-parler` generates a separate database table for each model that contains translations. This table includes all the translated fields and a foreign key for the original object that the translation belongs to. It also contains a language field, since each row stores the content for a single language.

> The `django-parler` package has not received updates for several years. Despite this, many developers continue to use it because of its proven effectiveness in facilitating model translations.

Installing django-parler

Install `django-parler` via `pip` using the following command:

```
python -m pip install django-parler==2.3
```

Edit the `settings.py` file of your project and add `'parler'` to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'parler',
]
```

Also, add the following code to your settings:

```
# django-parler settings
PARLER_LANGUAGES = {
    None: (
        {'code': 'en'},
        {'code': 'es'},
    ),
    'default': {
        'fallback': 'en',
        'hide_untranslated': False,
    }
}
```

This setting defines the available languages, `en` and `es`, for `django-parler`. You specify the default language, `en`, and indicate that `django-parler` should not hide untranslated content.

Parler is now activated in our project. Let's add translation capabilities to our model fields.

Translating model fields

Let's add translations to your product catalog. `django-parler` provides a `TranslatableModel` model class and a `TranslatedFields` wrapper to translate model fields. You can follow these instructions:

Edit the `models.py` file inside the `shop` application directory and add the following import:

```
from parler.models import TranslatableModel, TranslatedFields
```

Then, modify the `Category` model to make the `name` and `slug` fields translatable, as follows:

```
class Category(TranslatableModel):
    translations = TranslatedFields(
        name = models.CharField(max_length=200),
        slug = models.SlugField(max_length=200, unique=True),
    )
```

The `Category` model now inherits from `TranslatableModel` instead of `models.Model`, and both the `name` and `slug` fields are included in the `TranslatedFields` wrapper.

Edit the `Product` model to add translations for the `name`, `slug`, and `description` fields, as follows:

```
class Product(TranslatableModel):
    translations = TranslatedFields(
        name = models.CharField(max_length=200),
        slug = models.SlugField(max_length=200),
        description = models.TextField(blank=True)
    )
    category = models.ForeignKey(
        Category,
        related_name='products',
        on_delete=models.CASCADE
    )
    image = models.ImageField(
        upload_to='products/%Y/%m/%d',
        blank=True
    )
    price = models.DecimalField(max_digits=10, decimal_places=2)
    available = models.BooleanField(default=True)
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)
```

`django-parler` manages translations by generating another model for each translatable model. In the following schema, you can see the fields of the `Product` model and what the generated `ProductTranslation` model will look like:

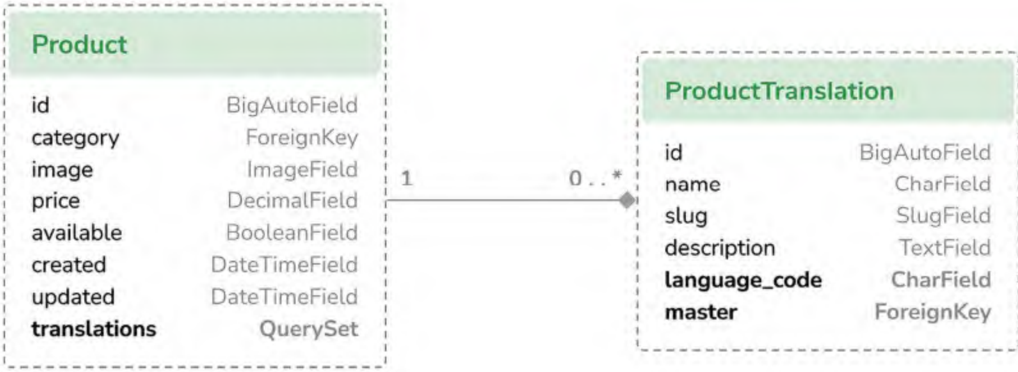


Figure 11.10: The Product model and related ProductTranslation model generated by django-parler

The `ProductTranslation` model generated by `django-parler` includes the `name`, `slug`, and `description` translatable fields, a `language_code` field, and a `ForeignKey` for the master `Product` object. There is a one-to-many relationship from `Product` to `ProductTranslation`. A `ProductTranslation` object will exist for each available language of each `Product` object.

Since Django uses a separate table for translations, there are some Django features that you can't use. It is not possible to use a default order with a translated field. You can filter by translated fields in queries, but you can't include a translatable field in the `ordering Meta` options. Also, you can't use indexes for the fields that are translated, as these fields will not exist in the original model because they will reside in the translation model.

Edit the `models.py` file of the `shop` application and comment out the `ordering` and `indexes` attributes of the `Category Meta` class:

```
class Category(TranslatableModel):
    # ...
    class Meta:
        # ordering = ['name']
        # indexes = [
        #     models.Index(fields=['name']),
        # ]
        verbose_name = 'category'
        verbose_name_plural = 'categories'
```

You also have to comment out the `ordering` and attribute of the `Product Meta` class and the indexes that refer to the translated fields. Comment out the following lines of the `Product Meta` class:

```
class Product(TranslatableModel):
    # ...
    class Meta:
```

```
        # ordering = ['name']
        indexes = [
            # models.Index(fields=['id', 'slug']),
            # models.Index(fields=['name']),
            models.Index(fields=['-created']),
        ]
```

You can read more about the `django-parler` module's compatibility with Django at `https://django-parler.readthedocs.io/en/latest/compatibility.html`.

Let's continue by integrating the translatable models into the administration site.

Integrating translations into the administration site

`django-parler` integrates seamlessly with the Django administration site. This allows you to easily edit different translations of your objects through the user-friendly admin interface. It includes a `TranslatableAdmin` class that overrides the `ModelAdmin` class provided by Django to manage model translations.

Edit the `admin.py` file of the `shop` application and add the following import to it:

```
from parler.admin import TranslatableAdmin
```

Modify the `CategoryAdmin` and `ProductAdmin` classes to inherit from `TranslatableAdmin` instead of `ModelAdmin`. The `django-parler` module doesn't support the `prepopulated_fields` attribute, but it does support the `get_prepopulated_fields()` method that provides the same functionality. Let's change this accordingly. Edit the `admin.py` file to make it look like the following:

```
from django.contrib import admin
from parler.admin import TranslatableAdmin
from .models import Category, Product


@admin.register(Category)
class CategoryAdmin(TranslatableAdmin):
    list_display = ['name', 'slug']

    def get_prepopulated_fields(self, request, obj=None):
        return {'slug': ('name',)}


@admin.register(Product)
class ProductAdmin(TranslatableAdmin):
    list_display = [
        'name',
        'slug',
```

```
            'price',
            'available',
            'created',
            'updated'
        ]
        list_filter = ['available', 'created', 'updated']
        list_editable = ['price', 'available']

    def get_prepopulated_fields(self, request, obj=None):
        return {'slug': ('name',)}
```

You have adapted the administration site to work with the new translated models. You can now sync the database with the model changes that you made.

Creating migrations for model translations

To create migrations, follow these instructions:

Open the shell and run the following command to create a new migration for the model translations:

```
python manage.py makemigrations shop --name "translations"
```

You will see the following output:

```
Migrations for 'shop':
  shop/migrations/0002_translations.py
    - Create model CategoryTranslation
    - Create model ProductTranslation
    - Change Meta options on category
    - Change Meta options on product
    - Remove index shop_catego_name_289c7e_idx from category
    - Remove index shop_produc_id_f21274_idx from product
    - Remove index shop_produc_name_a2070e_idx from product
    - Remove field name from category
    - Remove field slug from category
    - Remove field description from product
    - Remove field name from product
    - Remove field slug from product
    - Add field master to producttranslation
    - Add field master to categorytranslation
    - Alter unique_together for producttranslation (1 constraint(s))
    - Alter unique_together for categorytranslation (1 constraint(s))
```

This migration automatically includes the `CategoryTranslation` and `ProductTranslation` models created dynamically by `django-parler`. It's important to note that this migration deletes the previous existing fields from your models.

This means that you will lose that data and need to set your categories and products again on the administration site after running it.

Edit the file `migrations/0002_translations.py` of the `shop` application and identify the two occurrences of the following line:

```
bases=(parler.models.TranslatedFieldsModelMixin, models.Model),
```

Replace those occurrences with the following:

```
bases=(parler.models.TranslatableModel, models.Model),
```

This is a fix for a minor issue found in the `django-parler` version you are using. This change is necessary to prevent the migration from failing when applying it. This issue is related to creating translations for existing fields in the model and shall be fixed in newer `django-parler` versions.

Run the following command to apply the migration:

```
python manage.py migrate shop
```

You will see an output that ends with the following line:

```
Applying shop.0002_ categorytranslation_producttranslation_and_more... OK
```

Your models are now synchronized with the database.

Run the development server using the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/en/admin/shop/category/` in your browser. You will see that existing categories lost their name and slug, due to deleting those fields and using the translatable models generated by `django-parler` instead. You will just see a dash under each column, like in *Figure 11.11*:

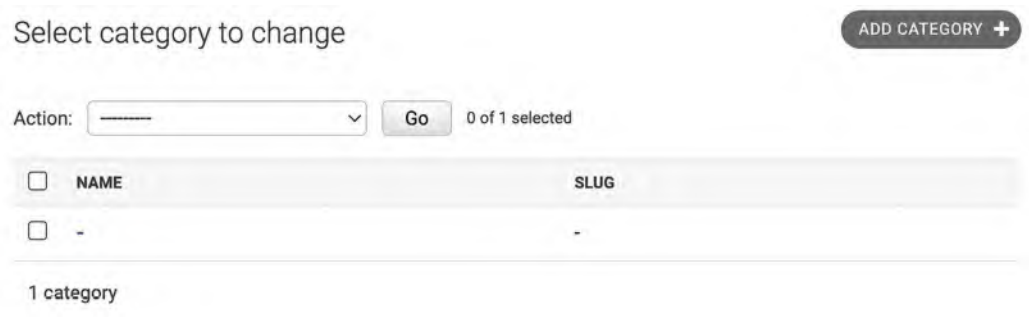


Figure 11.11: The category list on the Django administration site after creating the translation models

Click on the dash under the category name to edit it. You will see that the **Change category** page includes two different tabs, one for English and one for Spanish translations:

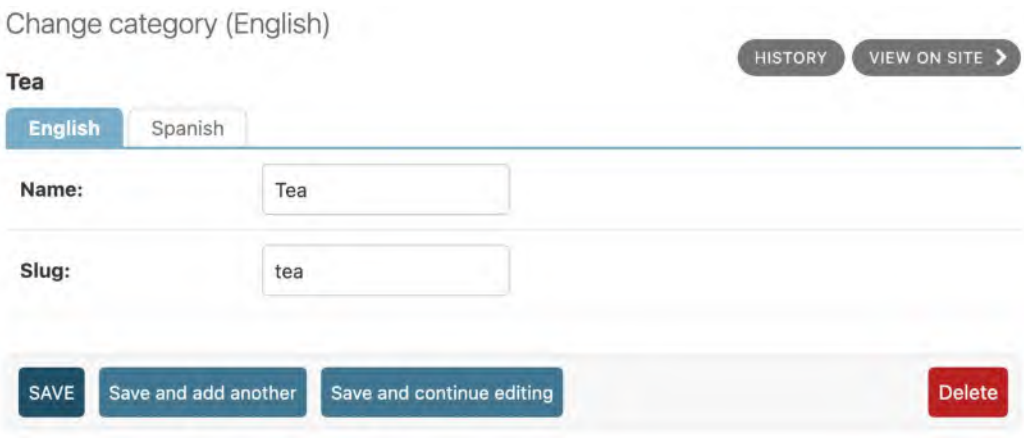


Figure 11.12: The category edit form, including the language tabs added by django-parler

Make sure that you fill in a name and slug for all existing categories. When you edit a category, enter the English details and click on **Save and continue editing**. Then, click on **Spanish**, add the Spanish translation for the fields, and click on **SAVE**:

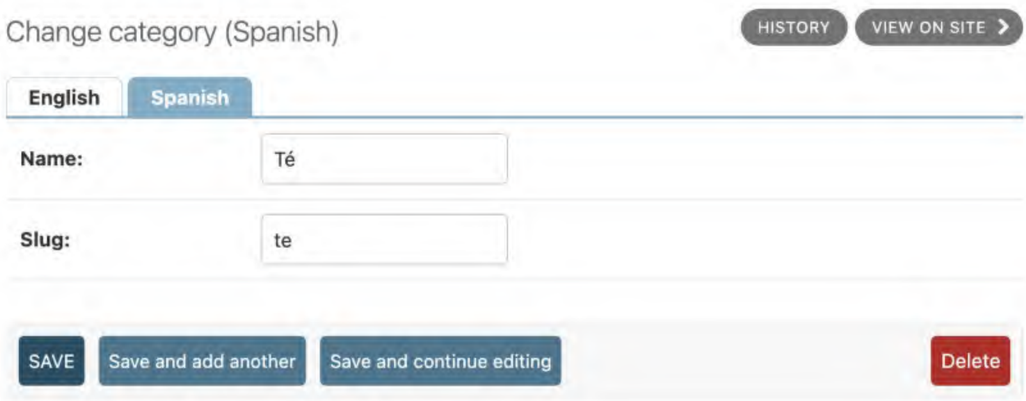


Figure 11.13: The Spanish translation of the category edit form

Make sure to save the changes before switching between the language tabs.

After you complete the data for existing categories, open `http://127.0.0.1:8000/en/admin/shop/product/` and edit each of the products, providing an English and Spanish name, a slug, and a description.

Once the translations are in place, the next step will be to explore how to interact with the translated fields through the Django ORM.

Using translations in QuerySets

Let's take a look at how to work with translations in QuerySets. Run the following command to open the Python shell:

```
python manage.py shell
```

Let's take a look at how you can retrieve and query translation fields. To get the object with translatable fields translated into a specific language, you can use Django's `activate()` function, as follows:

```
>>> from shop.models import Product
>>> from django.utils.translation import activate
>>> activate('es')
>>> product=Product.objects.first()
>>> product.name
'Té verde'
```

Another way to do this is by using the `language()` manager provided by `django-parler`, as follows:

```
>>> product=Product.objects.language('en').first()
>>> product.name
'Green tea'
```

When you access translated fields, they are resolved using the current language. You can set a different current language for an object to access that specific translation, as follows:

```
>>> product.set_current_language('es')
>>> product.name
'Té verde'
>>> product.get_current_language()
'es'
```

When performing a QuerySet using `filter()`, you can filter using the related translation objects with the `translations__` syntax, as follows:

```
>>> Product.objects.filter(translations__name='Green tea')
<TranslatableQuerySet [<Product: Té verde>]>
```

Let's apply what we have learned to our views.

Adapting views for translations

Let's adapt the product catalog views:

Edit the `views.py` file of the `shop` application and add the following code highlighted in bold to the `product_list` view:

```
def product_list(request, category_slug=None):
    category = None
```

```
    categories = Category.objects.all()
    products = Product.objects.filter(available=True)
    if category_slug:
        language = request.LANGUAGE_CODE
        category = get_object_or_404(
            Category,
            translations__language_code=language,
            translations__slug=category_slug
        )
        products = products.filter(category=category)
    return render(
        request,
        'shop/product/list.html',
        {
            'category': category,
            'categories': categories,
            'products': products
        }
    )
```

Then, edit the `product_detail` view and add the following code highlighted in bold:

```
def product_detail(request, id, slug):
    language = request.LANGUAGE_CODE
    product = get_object_or_404(
        Product,
        id=id,
        translations__language_code=language,
        translations__slug=slug,
        available=True
    )
    cart_product_form = CartAddProductForm()
    r = Recommender()
    recommended_products = r.suggest_products_for([product], 4)
    return render(
        request,
        'shop/product/detail.html',
        {
            'product': product,
            'cart_product_form': cart_product_form,
            'recommended_products': recommended_products
        }
    )
```

The `product_list` and `product_detail` views are now adapted to retrieve objects using translated fields.

Run the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/es/` in your browser. You should see the product list page, including all products translated into Spanish:

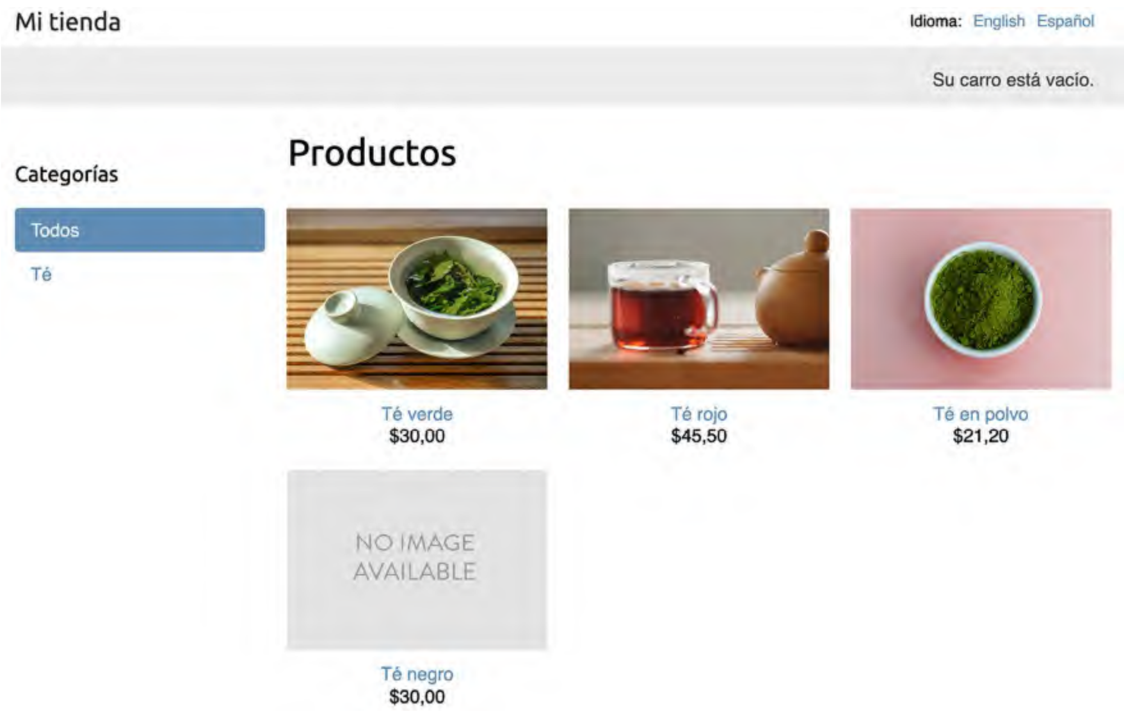


Figure 11.14: The Spanish version of the product list page

Now, each product's URL is built using the `slug` field translated into the current language. For example, the URL for a product in Spanish is `http://127.0.0.1:8000/es/2/te-rojo/`, whereas, in English, the URL is `http://127.0.0.1:8000/en/2/red-tea/`. If you navigate to a product details page, you will see the translated URL and the contents of the selected language, as shown in the following example:

Figure 11.15: The Spanish version of the product details page

If you want to know more about `django-parler`, you can find the full documentation at `https://django-parler.readthedocs.io/en/latest/`.

You have learned how to translate Python code, templates, URL patterns, and model fields. To complete the internationalization and localization process, you need to use localized formatting for dates, times, and numbers as well.

Format localization

To enhance user experience, it's important to present dates, times, and numbers in formats that align with the user's locale. Adapting your site to the data formats familiar to users in various regions significantly improves its accessibility. Since Django 5.0, localized formatting of data is always enabled. Django displays numbers and dates using the format of the current locale.

Django tries to use a locale-specific format whenever it outputs a value in a template. *Figure 11.16* shows the format localization for decimal numbers in the English and Spanish versions of the site:

Figure 11.16: Format localization in English and Spanish

Decimal numbers in the English version are displayed with a dot separator for decimal places, while in the Spanish version, a comma is used as the separator. This is due to the locale formats specified for the `en` and `es` locales by Django. You can take a look at the English formatting configuration at `https://github.com/django/django/blob/stable/5.0.x/django/conf/locale/en/formats.py` and the Spanish formatting configuration at `https://github.com/django/django/blob/stable/5.0.x/django/conf/locale/es/formats.py`.

By default, Django applies the format localization for each locale. However, there might be cases for which you don't want to use localized values. This is especially relevant when outputting JavaScript or JSON, which has to provide a machine-readable format.

Django offers a `{% localize %}` template tag that allows you to turn on/off localization for template fragments. This gives you control over localized formatting. You will have to load the `l10n` (localization) tags to be able to use this template tag. The following is an example of how to turn localization on and off in a template:

```
{% load l10n %}

{% localize on %}
  {{ value }}
{% endlocalize %}

{% localize off %}
  {{ value }}
{% endlocalize %}
```

Django also offers the `localize` and `unlocalize` template filters to force or avoid the localization of a value. These filters can be applied as follows:

```
{{ value|localize }}
{{ value|unlocalize }}
```

You can also create custom format files to specify locale formatting. You can find further information about format localization at `https://docs.djangoproject.com/en/5.0/topics/i18n/formatting/`.

Next, you will learn how to create localized form fields.

Using django-localflavor to validate form fields

`django-localflavor` is a third-party module that contains a collection of utilities, such as form fields or model fields, that are specific for each country. It's very useful for validating local regions, local phone numbers, identity card numbers, social security numbers, and so on. The package is organized into a series of modules named after ISO 3166 country codes. Follow these instructions to set it up:

Install `django-localflavor` using the following command:

```
python -m pip install django-localflavor==4.0
```

Edit the `settings.py` file of your project and add `localflavor` to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'localflavor',
]
```

You are going to add the United States zip code field so that a valid United States zip code is required to create a new order. Edit the `forms.py` file of the `orders` application and make it look like the following:

```
from django import forms
from localflavor.us.forms import USZipCodeField
from .models import Order


class OrderCreateForm(forms.ModelForm):
    postal_code = USZipCodeField()
    class Meta:
        model = Order
        fields = [
            'first_name',
            'last_name',
            'email',
            'address',
            'postal_code',
            'city'
        ]
```

You import the `USZipCodeField` field from the `us` package of `localflavor` and use it for the `postal_code` field of the `OrderCreateForm` form.

Run the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/en/orders/create/` in your browser. Fill in all the fields, enter a three-letter zip code, and then submit the form. You will get the following validation error, which is raised by `USZipCodeField`:

```
Enter a zip code in the format XXXXX or XXXXX-XXXX.
```

Figure 11.17 shows the form validation error:

Figure 11.17: The validation error for an invalid US zip code

This is just a brief example of how to use a custom field from `localflavor` in your own project for validation purposes. The local components provided by `localflavor` are very useful for adapting your application to specific countries. You can read the `django-localflavor` documentation and see all the available local components for each country at `https://django-localflavor.readthedocs.io/en/latest/`.

Expanding your project using AI

In this section, you are presented with a task to extend your project, accompanied by a sample prompt for ChatGPT to assist you. To engage with ChatGPT, visit `https://chat.openai.com/`. If this is your first interaction with ChatGPT, you can revisit the *Expanding your project using AI* section in *Chapter 3, Extending Your Blog Application*.

In this project example, we have implemented an online shop. We have added orders, payments, and a coupon system. Now, another typical feature of e-commerce platforms is managing shipping costs. Let's consider adding a weight attribute to products and implementing shipping costs based on the total weight of the items shipped. Use ChatGPT to help you implement shipping costs for products, making them dependent on the product's weight. Ensure that Stripe charges the correct amount, including the calculated shipping costs. You can use the prompt provided at `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter11/prompts/task.md`.

> Use ChatGPT as a debugging companion. If you find yourself stuck on a particularly stubborn bug, describe the problem and the context. It can provide a fresh perspective, often prompting you to consider angles you might have overlooked, leading to quicker problem resolution.

Summary

In this chapter, you learned the basics of the internationalization and localization of Django projects. You marked code and template strings for translation, and you discovered how to generate and compile translation files. You also installed Rosetta in your project to manage translations through a web interface. You translated URL patterns, and you created a language selector to allow users to switch the language of the site. Then, you used `django-parler` to translate models, and you used `django-localflavor` to validate localized form fields.

In the next chapter, you will start a new Django project that will consist of an e-learning platform. You will learn how to use model inheritance to implement polymorphism, and you will lay the foundations for a flexible content management system. You will create the application models, and you will learn how to create and apply fixtures to provide initial data for the models. You will build a custom model field and use it in your models. You will also build authentication views for your new application.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- The source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter11`
- A list of valid language IDs: `http://www.i18nguy.com/unicode/language-identifiers.html`
- A list of internationalization and localization settings: `https://docs.djangoproject.com/en/5.0/ref/settings/#globalization-i18n-l10n`
- Homebrew package manager: `https://brew.sh/`
- Installing `gettext` on Windows: `https://docs.djangoproject.com/en/5.0/topics/i18n/translation/#gettext-on-windows`
- Precompiled `gettext` binary installer for Windows: `https://mlocati.github.io/articles/gettext-iconv-windows.html`
- Documentation about translations: `https://docs.djangoproject.com/en/5.0/topics/i18n/translation/`
- Poedit translation file editor: `https://poedit.net/`
- Documentation for Django Rosetta: `https://django-rosetta.readthedocs.io/`
- The `django-parler` module's compatibility with Django: `https://django-parler.readthedocs.io/en/latest/compatibility.html`
- Documentation for `django-parler`: `https://django-parler.readthedocs.io/en/latest/`
- Django formatting configuration for the English locale: `https://github.com/django/django/blob/stable/5.0.x/django/conf/locale/en/formats.py`
- Django formatting configuration for the Spanish locale: `https://github.com/django/django/blob/stable/5.0.x/django/conf/locale/es/formats.py`
- Django format localization: `https://docs.djangoproject.com/en/5.0/topics/i18n/formatting/`
- Documentation for `django-localflavor`: `https://django-localflavor.readthedocs.io/en/latest/`

12

Building an E-Learning Platform

In the previous chapter, you learned the basics of the internationalization and localization of Django projects, adapting your project to meet the local formats and languages for your users.

In this chapter, you will start a new Django project that will consist of an e-learning platform with your own **content management system** (**CMS**). Online learning platforms are a great example of applications that require tools for advanced content handling. You will learn how to create flexible data models that accommodate diverse data types and discover how to implement custom model functionalities that you can apply to your future Django projects.

In this chapter, you will learn how to:

- Create models for the CMS
- Create fixtures for your models and apply them
- Use model inheritance to create data models for polymorphic content
- Create custom model fields
- Order course contents and modules
- Build authentication views for the CMS

Functional overview

In previous chapters, diagrams at the start represented views, templates, and end-to-end functionalities. This chapter, however, shifts the focus to implementing model inheritance and creating custom model fields, topics not easily captured in our usual diagrams. Instead, you will see specific diagrams to illustrate these concepts throughout the chapter.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter12`.

All the Python modules used in this chapter are included in the `requirements.txt` file in the source code that comes with this chapter. You can follow the instructions to install each Python module below, or you can install all the requirements at once with the command `python -m pip install -r requirements.txt`.

Setting up the e-learning project

Your final practical project will be an e-learning platform. First, create a virtual environment for your new project within the `env/` directory with the following command:

```
python -m venv env/educa
```

If you are using Linux or macOS, run the following command to activate your virtual environment:

```
source env/educa/bin/activate
```

If you are using Windows, use the following command instead:

```
.\env\educa\Scripts\activate
```

Install Django in your virtual environment with the following command:

```
python -m pip install Django~=5.0.4
```

You are going to manage image uploads in your project, so you also need to install `Pillow` with the following command:

```
python -m pip install Pillow==10.3.0
```

Create a new project using the following command:

```
django-admin startproject educa
```

Enter the new `educa` directory and create a new application using the following commands:

```
cd educa
django-admin startapp courses
```

Edit the `settings.py` file of the `educa` project and add `courses` to the `INSTALLED_APPS` setting, as follows. The new line is highlighted in bold:

```
INSTALLED_APPS = [
    'courses.apps.CoursesConfig',
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.staticfiles',
]
```

The `courses` application is now active for the project. Next, we are going to prepare our project to serve media files and we will define the models for the courses and course contents.

Serving media files

Before creating the models for courses and course contents, we will prepare the project to serve media files. Course instructors will be able to upload media files to course content using the CMS that we will build. Therefore, we will configure the project to serve media files.

Edit the `settings.py` file of the project and add the following lines:

```
MEDIA_URL = 'media/'
MEDIA_ROOT = BASE_DIR / 'media'
```

This will enable Django to manage file uploads and serve media files. `MEDIA_URL` is the base URL used to serve the media files uploaded by users. `MEDIA_ROOT` is the local path where they reside. Paths and URLs for files are built dynamically by prepending the project path or the media URL to them for portability.

Now, edit the main `urls.py` file of the `educa` project and modify the code, as follows. New lines are highlighted in bold:

```
from django.conf import settings
from django.conf.urls.static import static
from django.contrib import admin
from django.urls import path


urlpatterns = [
    path('admin/', admin.site.urls),
]

if settings.DEBUG:
    urlpatterns += static(
        settings.MEDIA_URL, document_root=settings.MEDIA_ROOT
    )
```

We have added the `static()` helper function to serve media files with the Django development server during development (that is, when the `DEBUG` setting is set to `True`).

> Remember that the `static()` helper function is suitable for development but not for production use. Django is inefficient at serving static files. Never serve your static files with the Django development server in a production environment. You will learn how to serve static files in a production environment in *Chapter 17*, *Going Live*.

The project is now ready to serve media files. Let's create the models for the courses and course contents.

Building the course models

Your e-learning platform will offer courses on various subjects. Each course will be divided into a configurable number of modules, and each module will contain a configurable number of contents. The contents will be of various types: text, files, images, or videos. The following example shows what the data structure of your course catalog will look like:

```
Subject 1
  Course 1
    Module 1
      Content 1 (image)
      Content 2 (text)
    Module 2
      Content 3 (text)
      Content 4 (file)
      Content 5 (video)
      ...
```

Let's build the course models. Edit the `models.py` file of the `courses` application and add the following code to it:

```
from django.contrib.auth.models import User
from django.db import models


class Subject(models.Model):
    title = models.CharField(max_length=200)
    slug = models.SlugField(max_length=200, unique=True)

    class Meta:
        ordering = ['title']

    def __str__(self):
        return self.title


class Course(models.Model):
    owner = models.ForeignKey(
        User,
        related_name='courses_created',
        on_delete=models.CASCADE
    )
    subject = models.ForeignKey(
```

```
        Subject,
        related_name='courses',
        on_delete=models.CASCADE
    )
    title = models.CharField(max_length=200)
    slug = models.SlugField(max_length=200, unique=True)
    overview = models.TextField()
    created = models.DateTimeField(auto_now_add=True)

    class Meta:
        ordering = ['-created']

    def __str__(self):
        return self.title


class Module(models.Model):
    course = models.ForeignKey(
        Course, related_name='modules', on_delete=models.CASCADE
    )
    title = models.CharField(max_length=200)
    description = models.TextField(blank=True)

    def __str__(self):
        return self.title
```

These are the initial `Subject`, `Course`, and `Module` models. The `Course` model fields are as follows:

- `owner`: The instructor who created this course.
- `subject`: The subject that this course belongs to. It is a `ForeignKey` field that points to the `Subject` model.
- `title`: The title of the course.
- `slug`: The slug of the course. This will be used in URLs later.
- `overview`: A `TextField` column to store an overview of the course.
- `created`: The date and time when the course was created. It will be automatically set by Django when creating new objects because of `auto_now_add=True`.

Each course is divided into several modules. Therefore, the `Module` model contains a `ForeignKey` field that points to the `Course` model.

Open the shell and run the following command to create the initial migration for this application:

```
python manage.py makemigrations
```

You will see the following output:

```
Migrations for 'courses':
  courses/migrations/0001_initial.py:
    - Create model Course
    - Create model Module
    - Create model Subject
    - Add field subject to course
```

Then, run the following command to apply all migrations to the database:

```
python manage.py migrate
```

You should see output that includes all applied migrations, including those of Django. The output will contain the following line:

```
Applying courses.0001_initial... OK
```

The models of your `courses` application have been synced with the database. Next, we are going to add the course models to the administration site.

Registering the models in the administration site

Let's register the course models on the administration site so that we can manage the data easily. Edit the `admin.py` file inside the `courses` application directory and add the following code to it:

```python
from django.contrib import admin
from .models import Subject, Course, Module


@admin.register(Subject)
class SubjectAdmin(admin.ModelAdmin):
    list_display = ['title', 'slug']
    prepopulated_fields = {'slug': ('title',)}


class ModuleInline(admin.StackedInline):
    model = Module


@admin.register(Course)
class CourseAdmin(admin.ModelAdmin):
    list_display = ['title', 'subject', 'created']
    list_filter = ['created', 'subject']
    search_fields = ['title', 'overview']
```

```
    prepopulated_fields = {'slug': ('title',)}
    inlines = [ModuleInline]
```

The models for the `courses` application are now registered on the administration site. Remember that you use the `@admin.register()` decorator to register models on the administration site.

In the next section, you will learn how to create initial data to populate your models.

Using fixtures to provide initial data for models

Sometimes, you might want to prepopulate your database with hardcoded data. This is useful for automatically including initial data in the project setup, instead of having to add it manually. Django comes with a simple way to load and dump data from the database into files that are called **fixtures**. Django supports fixtures in JSON, XML, or YAML formats. The structure of a fixture closely resembles the API representation of a model, making it straightforward to translate data between internal database formats and external applications. You are going to create a fixture to include several initial `Subject` objects for your project.

First, create a superuser using the following command:

```
python manage.py createsuperuser
```

Then, run the development server using the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/courses/subject/` in your browser. Create several subjects using the administration site. The change list page should look as follows:

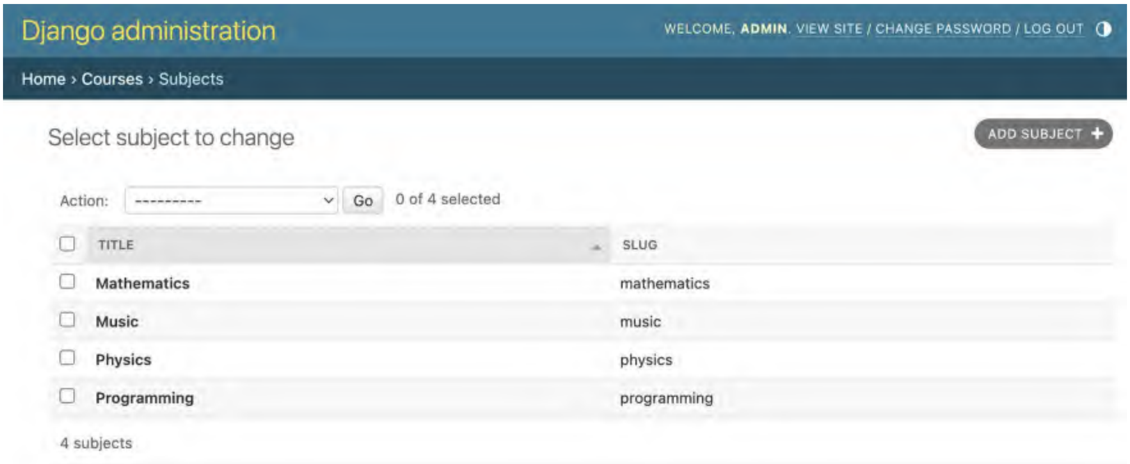


Figure 12.1: The subject change list view on the administration site

Run the following command from the shell:

```
python manage.py dumpdata courses --indent=2
```

You will see an output similar to the following:


```
[
{
  "model": "courses.subject",
  "pk": 1,
  "fields": {
    "title": "Mathematics",
    "slug": "mathematics"
  }
},
{
  "model": "courses.subject",
  "pk": 2,
  "fields": {
    "title": "Music",
    "slug": "music"
  }
},
{
  "model": "courses.subject",
  "pk": 3,
  "fields": {
    "title": "Physics",
    "slug": "physics"
  }
},
{
  "model": "courses.subject",
  "pk": 4,
  "fields": {
    "title": "Programming",
    "slug": "programming"
  }
}
]
```


The `dumpdata` command dumps data from the database into the standard output, serialized in JSON format by default. The resulting data structure includes information about the model and its fields for Django to be able to load it into the database.

You can limit the output to the models of an application by providing the application names to the command or specifying single models for outputting data using the `app.Model` format.

You can also specify the format using the `--format` flag. By default, `dumpdata` outputs the serialized data to the standard output. However, you can indicate an output file using the `--output` flag, which allows you to store the output. The `--indent` flag allows you to specify indentations. For more information on `dumpdata` parameters, run `python manage.py dumpdata --help`.

Save this dump to a fixtures file in a new `fixtures/` directory in the `courses` application using the following commands:

```
mkdir courses/fixtures
python manage.py dumpdata courses --indent=2 --output=courses/fixtures/
subjects.json
```

Run the development server and use the administration site to remove the subjects you created, as shown in *Figure 12.2*:

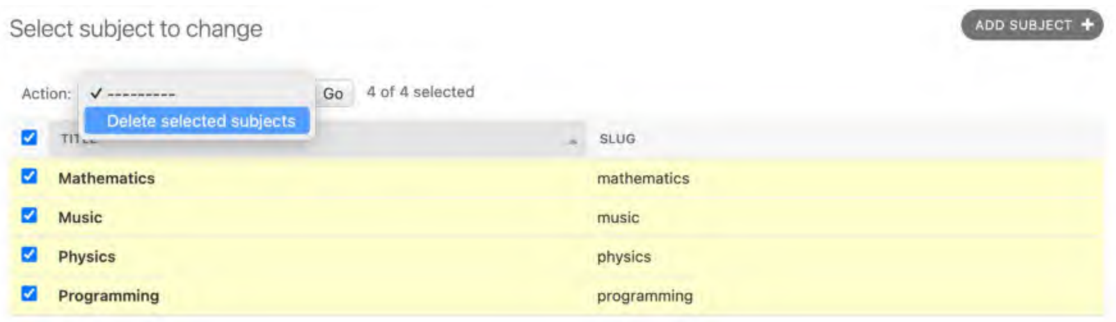


Figure 12.2: Deleting all existing subjects

After deleting all subjects, load the fixture into the database using the following command:

```
python manage.py loaddata subjects.json
```

All `Subject` objects included in the fixture are loaded into the database again:

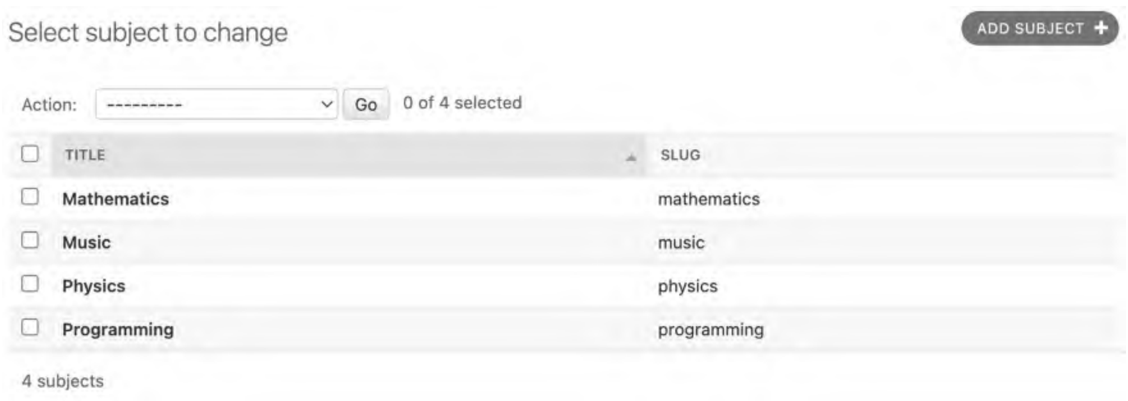


Figure 12.3: Subjects from the fixture are now loaded into the database

By default, Django looks for files in the `fixtures/` directory of each application, but you can specify the complete path to the fixture file for the `loaddata` command. You can also use the `FIXTURE_DIRS` setting to tell Django about additional directories to look in for fixtures.

> Fixtures are not only useful for setting up initial data but also for providing sample data for your application or data required for your tests. You can also use fixtures to populate necessary data for production environments.

You can read about how to use fixtures for testing at `https://docs.djangoproject.com/en/5.0/topics/testing/tools/#fixture-loading`.

If you want to load fixtures in model migrations, look at Django's documentation about data migrations. You can find the documentation for migrating data at `https://docs.djangoproject.com/en/5.0/topics/migrations/#data-migrations`.

You have created the models to manage course subjects, courses, and course modules. Next, you will create models to manage different types of module content.

Creating models for polymorphic content

You plan to add different types of content to the course modules, such as text, images, files, and videos. **Polymorphism** is the provision of a single interface to entities of different types. You need a versatile data model that allows you to store diverse content that is accessible through a single interface. In *Chapter 7*, *Tracking User Actions*, you learned about the convenience of using generic relations to create foreign keys that can point to the objects of any model. You are going to create a `Content` model that represents the modules' contents and define a generic relation to associate any object with the content object.

Edit the `models.py` file of the `courses` application and add the following imports:

```
from django.contrib.contenttypes.fields import GenericForeignKey
from django.contrib.contenttypes.models import ContentType
```

Then, add the following code to the end of the file:

```
class Content(models.Model):
    module = models.ForeignKey(
        Module,
        related_name='contents',
        on_delete=models.CASCADE
    )
    content_type = models.ForeignKey(
        ContentType,
        on_delete=models.CASCADE
    )
```

```
    object_id = models.PositiveIntegerField()
    item = GenericForeignKey('content_type', 'object_id')
```

This is the `Content` model. A module contains multiple contents, so you define a `ForeignKey` field that points to the `Module` model. You can also set up a generic relation to associate objects from different models that represent different types of content. Remember that you need three different fields to set up a generic relation. In your `Content` model, these are:

- `content_type`: A `ForeignKey` field to the `ContentType` model
- `object_id`: A `PositiveIntegerField` to store the primary key of the related object
- `item`: A `GenericForeignKey` field to the related object combining the two previous fields

Only the `content_type` and `object_id` fields have a corresponding column in the database table of this model. The `item` field allows you to retrieve or set the related object directly, and its functionality is built on top of the other two fields.

You are going to use a distinct model for each type of content; text, image, video, and document. Your `Content` models will share some common fields but they will vary in the specific data that they store. For example, for text content, you will store the actual text, but for video content, you will store the video URL. To accomplish this, you will need to employ model inheritance. We will dive into the options that Django offers for model inheritance before building our `Content` models.

Using model inheritance

Django supports model inheritance. It works in a similar way to standard class inheritance in Python. If you are not familiar with class inheritance, it involves defining a new class that inherits methods and properties from an existing class. This facilitates code reusability and can simplify the creation of related classes. You can read more about class inheritance at `https://docs.python.org/3/tutorial/classes.html#inheritance`.

Django offers the following three options to use model inheritance:

- **Abstract models**: Useful when you want to put some common information into several models
- **Multi-table model inheritance**: Applicable when each model in the hierarchy is considered a complete model by itself
- **Proxy models**: Useful when you need to change the behavior of a model, for example, by including additional methods, changing the default manager, or using different meta options

Let's take a closer look at each of them.

Abstract models

An abstract model is a base class in which you define the fields you want to include in all child models. Django doesn't create any database tables for abstract models. A database table is created for each child model, including the fields inherited from the abstract class and the ones defined in the child model.

To mark a model as abstract, you need to include `abstract=True` in its `Meta` class. Django will recognize that it is an abstract model and will not create a database table for it. To create child models, you just need to subclass the abstract model.

The following example shows an abstract `BaseContent` model and a child `Text` model:

```
from django.db import models


class BaseContent(models.Model):
    title = models.CharField(max_length=100)
    created = models.DateTimeField(auto_now_add=True)
    class Meta:
        abstract = True


class Text(BaseContent):
    body = models.TextField()
```

In this case, Django would create a table for the `Text` model only, including the `title`, `created`, and `body` fields.

Figure 12.4 shows the models and associated database tables for the code example provided:

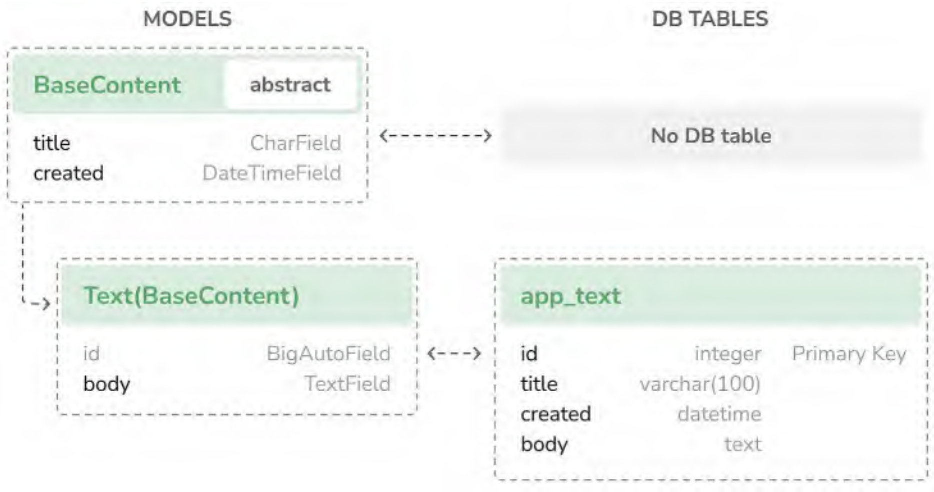


Figure 12.4: Sample models and database tables for inheritance using abstract models

Next, we are going to learn about a different model inheritance approach, where multiple database tables are created.

Multi-table model inheritance

In multi-table inheritance, each model corresponds to a database table. Django creates a `OneToOneField` field for the relationship between the child model and its parent model. To use multi-table inheritance, you have to subclass an existing model. Django will create a database table for both the original model and the sub-model. The following example shows multi-table inheritance:

```
from django.db import models


class BaseContent(models.Model):
    title = models.CharField(max_length=100)
    created = models.DateTimeField(auto_now_add=True)


class Text(BaseContent):
    body = models.TextField()
```

Django will include an automatically generated `OneToOneField` field in the `Text` model that points to the `BaseContent` model. The name for this field is `basecontent_ptr`, where `ptr` stands for *pointer*. A database table is created for each model.

Figure 12.5 shows the models and associated database tables for the multi-table model inheritance code example provided:

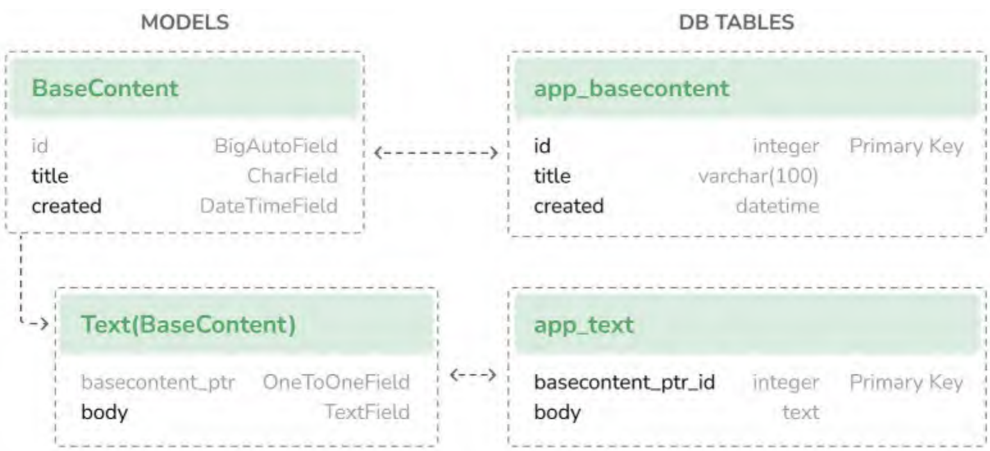


Figure 12.5: Sample models and database tables for multi-table model inheritance

Next, we are going to learn about another model inheritance approach, where multiple models serve as a proxy to a single database table.

Proxy models

A proxy model changes the behavior of a model. Both models operate on the database table of the original model. This allows you to customize behavior for different models without creating a new database table, creating different versions of the same model that are tailored for different purposes. To create a proxy model, add `proxy=True` to the `Meta` class of the model. The following example illustrates how to create a proxy model:

```
from django.db import models
from django.utils import timezone
```

```
class BaseContent(models.Model):
    title = models.CharField(max_length=100)
    created = models.DateTimeField(auto_now_add=True)


class OrderedContent(BaseContent):
    class Meta:
        proxy = True
        ordering = ['created']

    def created_delta(self):
        return timezone.now() - self.created
```

Here, you define an `OrderedContent` model that is a proxy model for the `Content` model. This model provides a default ordering for QuerySets and an additional `created_delta()` method. Both models, `Content` and `OrderedContent`, operate on the same database table, and objects are accessible via the ORM through either model.

Figure 12.6 shows the models and associated database tables for the proxy model inheritance code example provided:

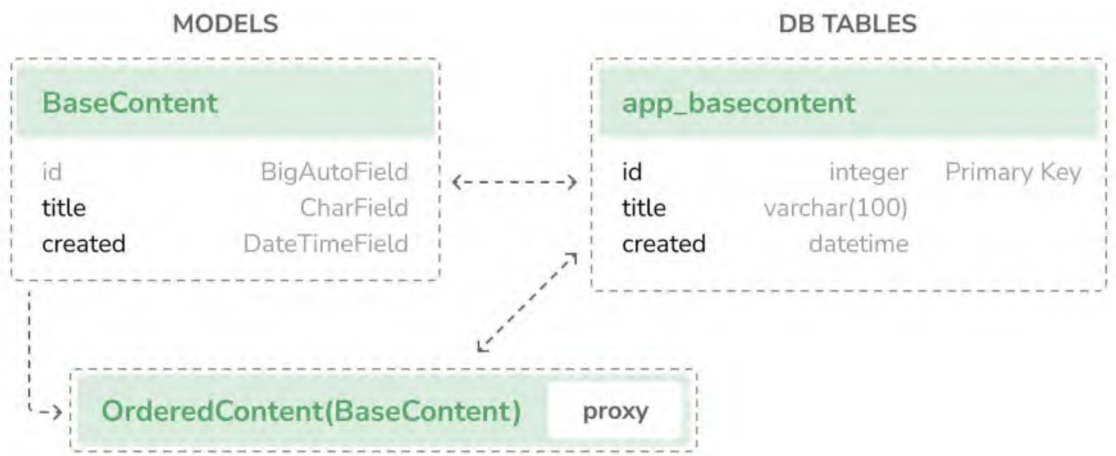


Figure 12.6: Sample models and database tables for inheritance using proxy models

You have now become familiar with the three types of model inheritance. For additional information on model inheritance, you can visit `https://docs.djangoproject.com/en/5.0/topics/db/models/#model-inheritance`. Now, we will apply model inheritance in practice by using a base abstract model to develop models for various content types.

Creating the Content models

Let's use model inheritance to implement polymorphic models. You will create a versatile data model that enables storing diverse content accessible through a unified interface. The ideal approach for this use case is to create an abstract base model that is then extended by models – each designed to store a particular type of data: text, image, video, and file. This flexible approach will equip you with the tools needed for scenarios where polymorphism is required.

The `Content` model of your `courses` application contains a generic relation to associate different types of content with it. You will create a different model for each type of content. All `Content` models will have some fields in common and additional fields to store custom data. You are going to create an abstract model that provides the common fields for all `Content` models.

Edit the `models.py` file of the `courses` application and add the following code to it:

```
class ItemBase(models.Model):
    owner = models.ForeignKey(User,
        related_name='%(class)s_related',
        on_delete=models.CASCADE
    )
    title = models.CharField(max_length=250)
    created = models.DateTimeField(auto_now_add=True)
    updated = models.DateTimeField(auto_now=True)

    class Meta:
        abstract = True

    def __str__(self):
        return self.title


class Text(ItemBase):
    content = models.TextField()


class File(ItemBase):
    file = models.FileField(upload_to='files')


class Image(ItemBase):
    file = models.FileField(upload_to='images')
```

```
class Video(ItemBase):
    url = models.URLField()
```

In this code, you define an abstract model named `ItemBase`. Therefore, you set `abstract=True` in its `Meta` class.

In this model, you define the `owner`, `title`, `created`, and `updated` fields. These common fields will be used for all types of content.

The `owner` field allows you to store which user created the content. Since this field is defined in an abstract class, you need a different `related_name` for each sub-model. Django allows you to specify a placeholder for the model class name in the `related_name` attribute as `%(class)s`. By doing so, the `related_name` for each child model will be generated automatically. Since you are using `'%(class)s_related'` as the `related_name`, the reverse relationship for child models will be `text_related`, `file_related`, `image_related`, and `video_related`, respectively.

You have defined four different `Content` models that inherit from the `ItemBase` abstract model. They are as follows:

- `Text`: To store text content
- `File`: To store files, such as PDFs
- `Image`: To store image files
- `Video`: To store videos; you use a `URLField` field to provide a video URL in order to embed it

Each child model contains the fields defined in the `ItemBase` class in addition to its own fields. A database table will be created for the `Text`, `File`, `Image`, and `Video` models, respectively. There will be no database table associated with the `ItemBase` model since it is an abstract model.

Figure 12.7 shows the `Content`

Edit the `Content` model you created previously and modify its `content_type` field, as follows:

```
content_type = models.ForeignKey(
        ContentType,
        on_delete=models.CASCADE,
        limit_choices_to={
            'model__in':('text', 'video', 'image', 'file')
        }
    )
```

You add a `limit_choices_to` argument to limit the `ContentType` objects that can be used for the generic relation. You use the `model__in` field lookup to filter the query to the `ContentType` objects with a `model` attribute that is `'text'`, `'video'`, `'image'`, or `'file'`.

Let's create a migration to include the new models you have added. Run the following command from the command line:

```
python manage.py makemigrations
```

You will see the following output:

```
Migrations for 'courses':
  courses/migrations/0002_video_text_image_file_content.py
    - Create model Video
    - Create model Text
    - Create model Image
    - Create model File
    - Create model Content
```

Then, run the following command to apply the new migration:

```
python manage.py migrate
```

The output you see should end with the following line:

```
Applying courses.0002_video_text_image_file_content... OK
```

You have created models that are suitable for adding diverse content to the course modules. However, there is still something missing in your models: the course modules and contents should follow a particular order. You need a field that allows you to order them easily.

Creating custom model fields

Django comes with a complete collection of model fields that you can use to build your models. However, you can also create your own model fields to store custom data or alter the behavior of existing fields. Custom fields allow you to store unique data types, implement custom validations, encapsulate complex data logic related to the field, or define specific rendering forms using custom widgets.

You need a field that allows you to define an order for the objects. An easy way to specify an order for objects using existing Django fields is by adding a `PositiveIntegerField` to your models. Using integers, you can easily specify the order of the objects. You can create a custom order field that inherits from `PositiveIntegerField` and provides additional behavior.

There are two relevant functionalities that you will build into your order field:

- **Automatically assign an order value when no specific order is provided:** When saving a new object with no specific order, your field should automatically assign the number that comes after the last existing ordered object. If there are two objects with orders `1` and `2` respectively, when saving a third object, you should automatically assign order `3` to it if no specific order has been provided.
- **Order objects with respect to other fields:** Course modules will be ordered with respect to the course they belong to and module contents with respect to the module they belong to.

Create a new `fields.py` file inside the `courses` application directory and add the following code to it:

```
from django.core.exceptions import ObjectDoesNotExist
from django.db import models


class OrderField(models.PositiveIntegerField):
    def __init__(self, for_fields=None, *args, **kwargs):
        self.for_fields = for_fields
        super().__init__(*args, **kwargs)

    def pre_save(self, model_instance, add):
        if getattr(model_instance, self.attname) is None:
            # no current value
            try:
                qs = self.model.objects.all()
                if self.for_fields:
                    # filter by objects with the same field values
                    # for the fields in "for_fields"
                    query = {
                        field: getattr(model_instance, field)
                        for field in self.for_fields
                    }
                    qs = qs.filter(**query)
                # get the order of the last item
                last_item = qs.latest(self.attname)
                value = getattr(last_item, self.attname) + 1
            except ObjectDoesNotExist:
                value = 0
            setattr(model_instance, self.attname, value)
```

```
            return value
        else:
            return super().pre_save(model_instance, add)
```

This is the custom `OrderField`. It inherits from the `PositiveIntegerField` field provided by Django. Your `OrderField` field takes an optional `for_fields` parameter, which allows you to indicate the fields used to order the data.

Your field overrides the `pre_save()` method of the `PositiveIntegerField` field, which is executed before saving the field to the database. In this method, you perform the following actions:

1. You check whether a value already exists for this field in the model instance. You use `self.attname`, which is the attribute name given to the field in the model. If the attribute's value is different from `None`, you calculate the order you should give it as follows:
    a. You build a QuerySet to retrieve all objects for the field's model. You retrieve the model class the field belongs to by accessing `self.model`.
    b. If there are any field names in the `for_fields` attribute of the field, you filter the QuerySet by the current value of the model fields in `for_fields`. By doing so, you calculate the order with respect to the given fields.
    c. You retrieve the object with the highest order with `last_item = qs.latest(self.attname)` from the database. If no object is found, you assume this object is the first one and assign order `0` to it.
    d. If an object is found, you add `1` to the highest order found.
    e. You assign the calculated order to the field's value in the model instance using `setattr()` and return it.
2. If the model instance has a value for the current field, you use it instead of calculating it.

> When you create custom model fields, make them generic. Avoid hardcoding data that depends on a specific model or field. Your field should work in any model.

You can find more information about writing custom model fields at `https://docs.djangoproject.com/en/5.0/howto/custom-model-fields/`.

Next, we are going to use the custom field we have created.

Adding ordering to Module and Content objects

Let's add the new field to your models. Edit the `models.py` file of the `courses` application, and import the `OrderField` class and a field to the `Module` model, as follows:

```
from .fields import OrderField
```

```
class Module(models.Model):
    # ...
    order = OrderField(blank=True, for_fields=['course'])
```

You name the new field `order` and specify that the ordering is calculated with respect to the course by setting `for_fields=['course']`. This means that the order for a new module will be assigned by adding `1` to the last module of the same `Course` object.

Now, you can edit the `__str__()` method of the `Module` model to include its order, as follows:

```
class Module(models.Model):
    # ...
    def __str__(self):
        return f'{self.order}. {self.title}'
```

Module contents also need to follow a particular order. Add an `OrderField` field to the `Content` model, as follows:

```
class Content(models.Model):
    # ...
    order = OrderField(blank=True, for_fields=['module'])
```

This time, you specify that the order is calculated with respect to the `module` field.

Finally, let's add a default ordering for both models. Add the following `Meta` class to the `Module` and `Content` models:

```
class Module(models.Model):
    # ...
    class Meta:
        ordering = ['order']


class Content(models.Model):
    # ...
    class Meta:
        ordering = ['order']
```

The `Module` and `Content` models should now look as follows:

```
class Module(models.Model):
    course = models.ForeignKey(
        Course, related_name='modules', on_delete=models.CASCADE
    )
    title = models.CharField(max_length=200)
    description = models.TextField(blank=True)
    order = OrderField(blank=True, for_fields=['course'])
```

```
    class Meta:
        ordering = ['order']

    def __str__(self):
        return f'{self.order}. {self.title}'


class Content(models.Model):
    module = models.ForeignKey(
        Module,
        related_name='contents',
        on_delete=models.CASCADE
    )
    content_type = models.ForeignKey(
        ContentType,
        on_delete=models.CASCADE,
        limit_choices_to={
            'model__in':('text', 'video', 'image', 'file')
        }
    )
    object_id = models.PositiveIntegerField()
    item = GenericForeignKey('content_type', 'object_id')
    order = OrderField(blank=True, for_fields=['module'])

    class Meta:
            ordering = ['order']
```

Let's create a new model migration that reflects the new `order` fields. Open the shell and run the following command:

```
python manage.py makemigrations courses
```

You will see the following output:

```
It is impossible to add a non-nullable field 'order' to content without
specifying a default. This is because the database needs something to populate
existing rows.
Please select a fix:
 1) Provide a one-off default now (will be set on all existing rows with a null
value for this column)
 2) Quit and manually define a default value in models.py.
Select an option:
```

Django is telling you that you have to provide a default value for the new `order` field for existing rows in the database. If the field includes `null=True`, it accepts null values and Django creates the migration automatically instead of asking for a default value. You can specify a default value or cancel the migration and add a `default` attribute to the `order` field in the `models.py` file before creating the migration.

Enter `1` and press *Enter* to provide a default value for existing records. You will see the following output:

```
Please enter the default value as valid Python.
The datetime and django.utils.timezone modules are available, so it is possible
to provide e.g. timezone.now as a value.
Type 'exit' to exit this prompt
>>>
```

Enter `0` so that this is the default value for existing records and press *Enter*. Django will ask you for a default value for the `Module` model, too. Choose the first option and enter `0` as the default value again. Finally, you will see an output similar to the following one:

```
Migrations for 'courses':
courses/migrations/0003_alter_content_options_alter_module_options_and_more.py
    - Change Meta options on content
    - Change Meta options on module
    - Add field order to content
    - Add field order to module
```

Then, apply the new migrations with the following command:

```
python manage.py migrate
```

The output of the command will inform you that the migration was successfully applied, as follows:

```
Applying courses.0003_alter_content_options_alter_module_options_and_more... OK
```

Let's test your new field. Open the shell with the following command:

```
python manage.py shell
```

Create a new course, as follows:

```
>>> from django.contrib.auth.models import User
>>> from courses.models import Subject, Course, Module
>>> user = User.objects.last()
>>> subject = Subject.objects.last()
>>> c1 = Course.objects.create(subject=subject, owner=user, title='Course 1',
slug='course1')
```

You have created a course in the database. Now, you will add modules to the course and see how their order is automatically calculated. You create an initial module and check its order:

```
>>> m1 = Module.objects.create(course=c1, title='Module 1')
```

```
>>> m1.order
0
```

`OrderField` sets its value to `0` since this is the first `Module` object created for the given course. You can create a second module for the same course:

```
>>> m2 = Module.objects.create(course=c1, title='Module 2')
>>> m2.order
1
```

`OrderField` calculates the next order value, adding `1` to the highest order for existing objects. Let's create a third module, forcing a specific order:

```
>>> m3 = Module.objects.create(course=c1, title='Module 3', order=5)
>>> m3.order
5
```

If you provide a custom order when creating or saving an object, `OrderField` will use that value instead of calculating the order.

Let's add a fourth module:

```
>>> m4 = Module.objects.create(course=c1, title='Module 4')
>>> m4.order
6
```

The order for this module has been automatically set. Your `OrderField` field does not guarantee that all order values are consecutive. However, it respects existing order values and always assigns the next order based on the highest existing order.

Let's create a second course and add a module to it:

```
>>> c2 = Course.objects.create(subject=subject, title='Course 2',
slug='course2', owner=user)
>>> m5 = Module.objects.create(course=c2, title='Module 1')
>>> m5.order
0
```

To calculate the new module's order, the field only takes into consideration existing modules that belong to the same course. Since this is the first module of the second course, the resulting order is `0`. This is because you specified `for_fields=['course']` in the `order` field of the `Module` model.

Congratulations! You have successfully created your first custom model field. Next, you are going to create an authentication system for the CMS.

Adding authentication views

Now that you have created a polymorphic data model, you are going to build a CMS to manage the courses and their contents. The first step is to add an authentication system for the CMS.

Adding an authentication system

You are going to use Django's authentication framework for users to authenticate to the e-learning platform. You learned how to use the Django authentication views in *Chapter 4, Building a Social Website*.

Both instructors and students will be instances of Django's `User` model, so they will be able to log in to the site using the authentication views of `django.contrib.auth`.

Edit the main `urls.py` file of the `educa` project and include the `login` and `logout` views of Django's authentication framework:

```
from django.conf import settings
from django.conf.urls.static import static
from django.contrib import admin
from django.contrib.auth import views as auth_views
from django.urls import path


urlpatterns = [
    path(
        'accounts/login/', auth_views.LoginView.as_view(), name='login'
    ),
    path(
        'accounts/logout/',
        auth_views.LogoutView.as_view(),
        name='logout'
    ),
    path('admin/', admin.site.urls),
]

if settings.DEBUG:
    urlpatterns += static(
        settings.MEDIA_URL, document_root=settings.MEDIA_ROOT
    )
```

Next, we are going to create the authentication templates for the Django authentication views.

Creating the authentication templates

Create the following file structure inside the `courses` application directory:

```
templates/
    base.html
    registration/
        login.html
        logged_out.html
```

Before building the authentication templates, you need to prepare the base template for your project. Edit the `base.html` template file and add the following content to it:

```
{% load static %}
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8" />
    <title>{% block title %}Educa{% endblock %}</title>
    <link href="{% static "css/base.css" %}" rel="stylesheet">
  </head>
  <body>
    <div id="header">
      <a href="/" class="logo">Educa</a>
      <ul class="menu">
        {% if request.user.is_authenticated %}
          <li>
            <form action="{% url "logout" %}" method="post">
              <button type="submit">Sign out</button>
            </form>
          </li>
        {% else %}
          <li><a href="{% url "login" %}">Sign in</a></li>
        {% endif %}
      </ul>
    </div>
    <div id="content">
      {% block content %}
      {% endblock %}
    </div>
    <script>
      document.addEventListener('DOMContentLoaded', (event) => {
        // DOM Loaded
        {% block domready %}
        {% endblock %}
      })
    </script>
  </body>
</html>
```

This is the base template that will be extended by the rest of the templates. In this template, you define the following blocks:

- `title`: The block for other templates to add a custom title for each page.
- `content`: The main block for content. All templates that extend the base template should add content to this block.
- `domready`: Located inside the JavaScript event listener for the `DOMContentLoaded` event. This allows you to execute code when the **Document Object Model** (**DOM**) has finished loading.

The CSS styles used in this template are located in the `static/` directory of the `courses` application in the code that comes with this chapter. Copy the `static/` directory into the same directory of your project to use them. You can find the contents of the directory at `https://github.com/PacktPublishing/Django-5-by-Example/tree/main/Chapter12/educa/courses/static`.

Edit the `registration/login.html` template and add the following code to it:

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

{% block title %}Log-in{% endblock %}

{% block content %}
  <h1>Log-in</h1>
  <div class="module">
    {% if form.errors %}
      <p>Your username and password didn't match. Please try again.</p>
    {% else %}
      <p>Please, use the following form to log-in:</p>
    {% endif %}
    <div class="login-form">
      <form action="{% url 'login' %}" method="post">
        {{ form.as_p }}
        {% csrf_token %}
        <input type="hidden" name="next" value="{{ next }}" />
        <p><input type="submit" value="Log-in"></p>
      </form>
    </div>
  </div>
{% endblock %}
```

This is a standard login template for Django's `login` view.

Edit the `registration/logged_out.html` template and add the following code to it:

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

{% block title %}Logged out{% endblock %}

{% block content %}
  <h1>Logged out</h1>
  <div class="module">
    <p>
      You have been successfully logged out.
      You can <a href="{% url "login" %}">log-in again</a>.
     </p>
  </div>
{% endblock %}
```

This is the template that will be displayed to the user after logging out. Run the development server with the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/accounts/login/` in your browser. You should see the login page:

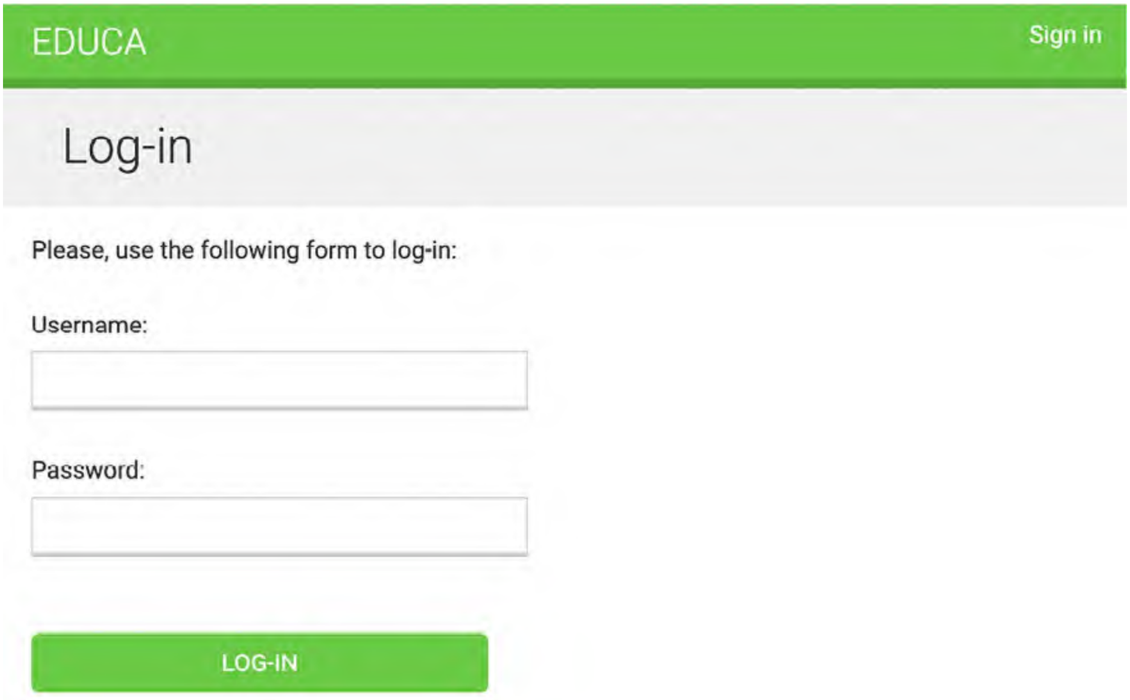


Figure 12.8: The account login page

Log in with the superuser credentials. You will be redirected to the URL `http://127.0.0.1:8000/accounts/profile/`, which is the default redirect URL for the `auth` module. You will get an HTTP `404` response because the given URL doesn't exist yet. The URL to redirect users after a successful login is defined in the setting `LOGIN_REDIRECT_URL`. You will define a custom redirect URL in *Chapter 14, Rendering and Caching Content*.

Open `http://127.0.0.1:8000/accounts/login/` again in your browser. Now, you should see the **Sign out** button in the header of the page. Click on the **Sign out** button. You should see the **Logged out** page now, as shown in *Figure 12.9*:

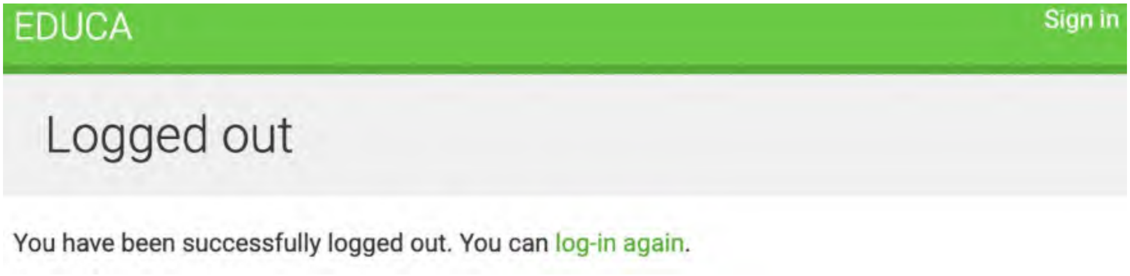


Figure 12.9: The account Logged out page

You have successfully created an authentication system for the CMS.

Summary

In this chapter, you learned how to use fixtures to provide initial data for models. By using model inheritance, you created a flexible system to manage different types of content for the course modules. You also implemented a custom model field on order objects and created an authentication system for the e-learning platform.

In the next chapter, you will implement the CMS functionality to manage course contents using class-based views. You will use the Django groups and permissions system to restrict access to views, and you will implement formsets to edit the content of courses. You will also create a drag-and-drop functionality to reorder course modules and their content using JavaScript and Django.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter12`
- Using Django fixtures for testing: `https://docs.djangoproject.com/en/5.0/topics/testing/tools/#fixture-loading`
- Data migrations: `https://docs.djangoproject.com/en/5.0/topics/migrations/#data-migrations`
- Class inheritance in Python: `https://docs.python.org/3/tutorial/classes.html#inheritance`

- Django model inheritance: `https://docs.djangoproject.com/en/5.0/topics/db/models/#model-inheritance`
- Creating custom model fields: `https://docs.djangoproject.com/en/5.0/howto/custom-model-fields/`
- Static directory for the e-learning project: `https://github.com/PacktPublishing/Django-5-by-Example/tree/main/Chapter12/educa/courses/static`

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`https://packt.link/Django5ByExample`

13

Creating a Content Management System

In the previous chapter, you created the application models for the e-learning platform and learned how to create and apply data fixtures for models. You created a custom model field to order objects and implemented user authentication.

In this chapter, you will learn how to build the functionality for instructors to create courses and manage the contents of those courses in a versatile and efficient manner.

You will be introduced to class-based views, which offer a new perspective to build your application compared to the function-based views you have built in previous examples. You will also explore code reusability and modularity through the use of mixins, which are techniques that you can apply in future projects.

In this chapter, you will learn how to:

- Create a **content management system** (**CMS**) using class-based views and mixins
- Build formsets and model formsets to edit course modules and module contents
- Manage groups and permissions
- Implement a drag-and-drop functionality to reorder modules and content

Functional overview

Figure 13.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

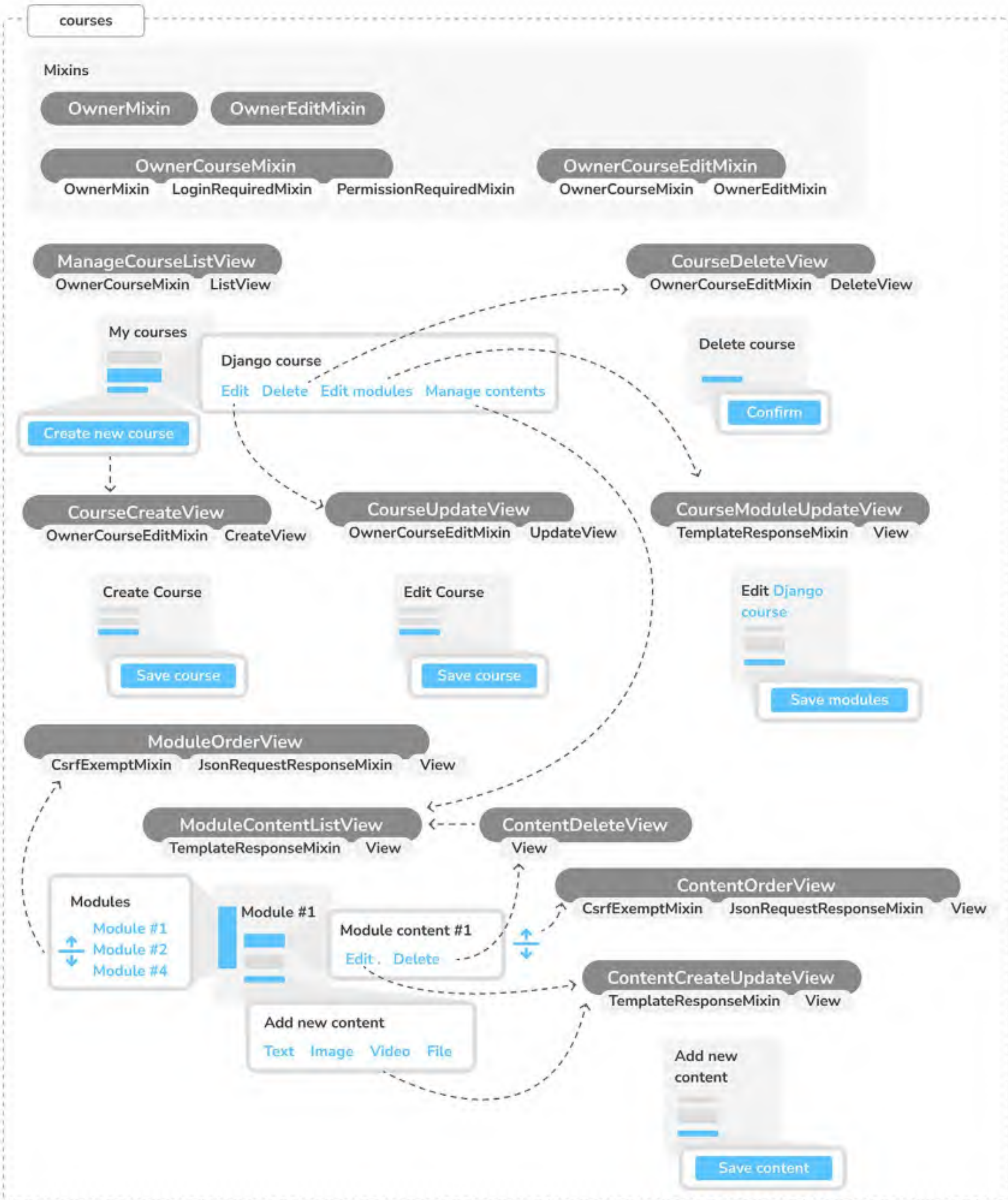


Figure 13.1: Diagram of functionalities built in Chapter 13

In this chapter, you will implement different class-based views. You will create the mixin classes `OwnerMixin`, `OwnerEditMixin`, and `OwnerCourseMixin`, which will contain common functionality that you will reuse in other classes. You will create **CRUD** (**Create**, **Read**, **Update**, **Delete**) views for the `Course` model by implementing `ManageCourseListView` to list courses, `CourseCreateView` to create courses, `CourseUpdateView` to update courses, and `CourseDeleteView` to delete courses. You will build the `CourseModuleUpdateView` view to add/edit/delete course modules and `ModuleContentListView` to list the module's contents. You will also implement `ContentCreateUpdateView` to create and update course contents and `ContentDeleteView` to delete contents. You will finally implement a drag-and-drop functionality to reorder course modules and contents using the `ModuleOrderView` and `ContentOrderView` views, respectively.

Note that all views that inherit the mixin `OwnerCourseMixin` redirect the user back to the `ManageCourseListView` view after a successful action. These redirects have not been added to the diagram for simplicity.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter13`.

All Python modules used in this chapter are included in the `requirements.txt` file in the source code that comes along with this chapter. You can follow the instructions to install each Python module below or you can install all the requirements at once with the command `python -m pip install -r requirements.txt`.

Creating a CMS

Now that you have created a versatile data model, you are going to build the CMS. The CMS will allow instructors to create courses and manage their content. You need to provide the following functionality:

- List the courses created by the instructor
- Create, edit, and delete courses
- Add modules to a course and reorder them
- Add different types of content to each module
- Reorder course modules and content

Let's start with the basic CRUD views.

Creating class-based views

You are going to build views to create, edit, and delete courses. You will use class-based views for this. Edit the `views.py` file of the `courses` application and add the following code:

```
from django.views.generic.list import ListView
from .models import Course


class ManageCourseListView(ListView):
    model = Course
    template_name = 'courses/manage/course/list.html'
```

```
    def get_queryset(self):
        qs = super().get_queryset()
        return qs.filter(owner=self.request.user)
```

This is the `ManageCourseListView` view. It inherits from Django's generic `ListView`. You override the `get_queryset()` method of the view to retrieve only courses created by the current user. To prevent users from editing, updating, or deleting courses they didn't create, you will also need to override the `get_queryset()` method in the create, update, and delete views. When you need to provide a specific behavior for several class-based views, it is recommended that you use *mixins*.

Using mixins for class-based views

Mixins are a special kind of multiple inheritance for a class. If you are new to mixins in Python, all you need to understand is that they are a type of class designed to supply methods to other classes but aren't intended to be used independently. This allows you to develop shared functionalities that can be incorporated into various classes in a modular manner, simply by having those classes inherit from mixins. The concept is similar to a base class but you can use multiple mixins to extend the functionality of a given class.

There are two main situations for using mixins:

- You want to provide multiple optional features for a class
- You want to use a particular feature in several classes

Django comes with several mixins that provide additional functionality to your class-based views. You can learn more about mixins at `https://docs.djangoproject.com/en/5.0/topics/class-based-views/mixins/`.

You are going to implement a common behavior for multiple views in mixin classes and use it for the course views. Edit the `views.py` file of the `courses` application and modify it as follows:

```
from django.urls import reverse_lazy
from django.views.generic.edit import CreateView, DeleteView, UpdateView
from django.views.generic.list import ListView
from .models import Course

class OwnerMixin:
    def get_queryset(self):
        qs = super().get_queryset()
        return qs.filter(owner=self.request.user)

class OwnerEditMixin:
    def form_valid(self, form):
        form.instance.owner = self.request.user
```

```
        return super().form_valid(form)

class OwnerCourseMixin(OwnerMixin):
    model = Course
    fields = ['subject', 'title', 'slug', 'overview']
    success_url = reverse_lazy('manage_course_list')

class OwnerCourseEditMixin(OwnerCourseMixin, OwnerEditMixin):
    template_name = 'courses/manage/course/form.html'

class ManageCourseListView(OwnerCourseMixin, ListView):
    template_name = 'courses/manage/course/list.html'

class CourseCreateView(OwnerCourseEditMixin, CreateView):
    pass

class CourseUpdateView(OwnerCourseEditMixin, UpdateView):
    pass

class CourseDeleteView(OwnerCourseMixin, DeleteView):
    template_name = 'courses/manage/course/delete.html'
```

In this code, you create the `OwnerMixin` and `OwnerEditMixin` mixins. You will use these mixins together with the `ListView`, `CreateView`, `UpdateView`, and `DeleteView` views provided by Django. `OwnerMixin` implements the `get_queryset()` method, which is used by the views to get the base QuerySet. Your mixin will override this method to filter objects by the `owner` attribute to retrieve objects that belong to the current user (`request.user`).

`OwnerEditMixin` implements the `form_valid()` method, which is used by views that use Django's `ModelFormMixin` mixin – that is, views with forms or model forms such as `CreateView` – and `UpdateView`. `form_valid()` is executed when the submitted form is valid.

The default behavior for this method is saving the instance (for model forms) and redirecting the user to `success_url`. You override this method to automatically set the current user in the `owner` attribute of the object being saved. By doing so, you set the owner for an object automatically when it is saved.

Your `OwnerMixin` class can be used for views that interact with any model that contains an `owner` attribute.

You also define an `OwnerCourseMixin` class that inherits `OwnerMixin` and provides the following attributes for child views:

- `model`: The model used for QuerySets; it is used by all views.
- `fields`: The fields of the model to build the model form of the `CreateView` and `UpdateView` views.

- `success_url`: Used by `CreateView`, `UpdateView`, and `DeleteView` to redirect the user after the form is successfully submitted or the object is deleted. You use a URL with the name `manage_course_list`, which you are going to create later.

You define an `OwnerCourseEditMixin` mixin with the following attribute:

- `template_name`: The template you will use for the `CreateView` and `UpdateView` views.

Finally, you create the following views that subclass `OwnerCourseMixin`:

- `ManageCourseListView`: Lists the courses created by the user. It inherits from `OwnerCourseMixin` and `ListView`. It defines a specific `template_name` attribute for a template to list courses.
- `CourseCreateView`: Uses a model form to create a new `Course` object. It uses the fields defined in `OwnerCourseMixin` to build a model form and also subclasses `CreateView`. It uses the template defined in `OwnerCourseEditMixin`.
- `CourseUpdateView`: Allows the editing of an existing `Course` object. It uses the fields defined in `OwnerCourseMixin` to build a model form and also subclasses `UpdateView`. It uses the template defined in `OwnerCourseEditMixin`.
- `CourseDeleteView`: Inherits from `OwnerCourseMixin` and the generic `DeleteView`. It defines a specific `template_name` attribute for a template to confirm the course deletion.

You have created the basic views to manage courses. While you have implemented CRUD views on your own, the third-party application Neapolitan allows you to implement the standard list, detail, create, and delete views within a single view. You can learn more about Neapolitan at `https://github.com/carltongibson/neapolitan`.

Next, you are going to use Django authentication groups and permissions to limit access to these views.

Working with groups and permissions

Currently, any user can access the views to manage courses. You want to restrict these views so that only instructors have permission to create and manage courses.

Django's authentication framework includes a permission system. By default, Django generates four permissions for each model in the installed applications: `add`, `view`, `change`, and `delete`. These permissions correspond to the actions of creating new instances, viewing existing ones, editing, and deleting instances of a model.

Permissions can be assigned directly to individual users or groups of users. This approach simplifies user management by grouping permissions and enhances the security of your application.

You are going to create a group for instructor users and assign permissions to create, update, and delete courses.

Run the development server using the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/admin/auth/group/add/` in your browser to create a new `Group` object. Add the name `Instructors` and choose all permissions of the `courses` application, except those of the `Subject` model, as follows:

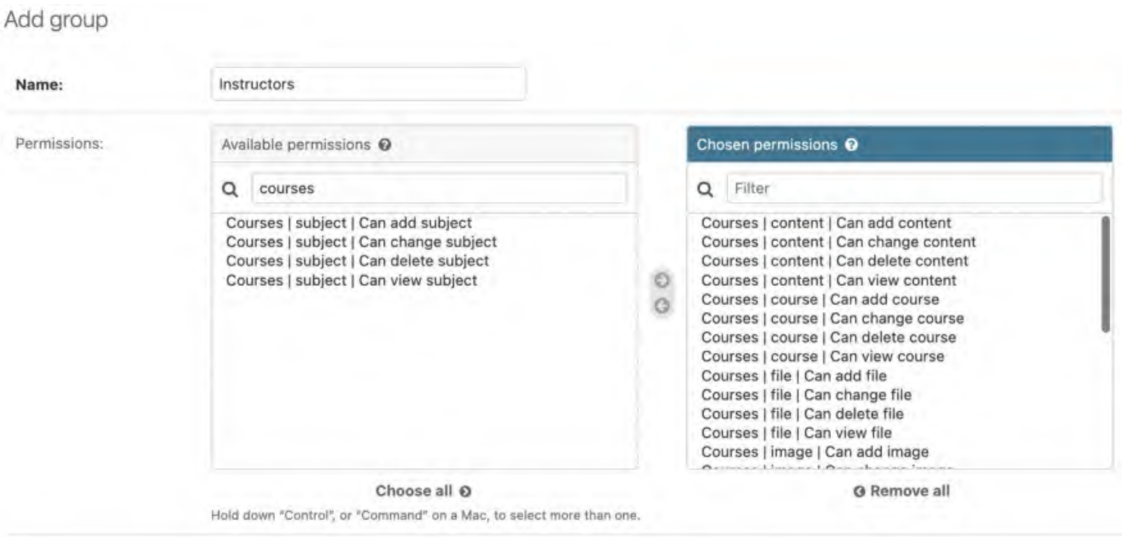


Figure 13.2: The Instructors group permissions

As you can see, there are four different permissions for each model: *can view*, *can add*, *can change*, and *can delete*. After choosing permissions for this group, click the **SAVE** button.

Django creates permissions for models automatically but you can also create custom permissions. You will learn how to create custom permissions in *Chapter 15, Building an API*. You can read more about adding custom permissions at `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#custom-permissions`.

Open `http://127.0.0.1:8000/admin/auth/user/add/` and create a new user. Edit the user and add it to the **Instructors** group, as follows:

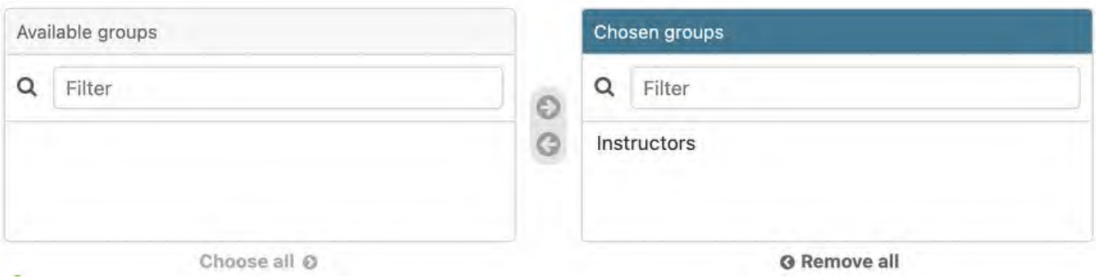


Figure 13.3: User group selection

Users inherit the permissions of the groups they belong to, but you can also add individual permissions to a single user using the administration site. Users that have `is_superuser` set to `True` have all permissions automatically.

Next, you will apply permissions in practice by incorporating them into our views.

Restricting access to class-based views

You are going to restrict access to the views so that only users with the appropriate permissions can add, change, or delete `Course` objects. You are going to use the following two mixins provided by `django.contrib.auth` to limit access to views:

- `LoginRequiredMixin`: Replicates the `login_required` decorator's functionality.
- `PermissionRequiredMixin`: Grants access to the view to users with a specific permission. Remember that superusers automatically have all permissions.

Edit the `views.py` file of the `courses` application and add the following import:

```
from django.contrib.auth.mixins import (
    LoginRequiredMixin,
    PermissionRequiredMixin
)
```

Make `OwnerCourseMixin` inherit `LoginRequiredMixin` and `PermissionRequiredMixin`, like this:

```
class OwnerCourseMixin(
    OwnerMixin, LoginRequiredMixin, PermissionRequiredMixin
):
    model = Course
    fields = ['subject', 'title', 'slug', 'overview']
    success_url = reverse_lazy('manage_course_list')
```

Then, add a `permission_required` attribute to the course views, as follows:

```
class ManageCourseListView(OwnerCourseMixin, ListView):
    template_name = 'courses/manage/course/list.html'
    permission_required = 'courses.view_course'

class CourseCreateView(OwnerCourseEditMixin, CreateView):
    permission_required = 'courses.add_course'

class CourseUpdateView(OwnerCourseEditMixin, UpdateView):
    permission_required = 'courses.change_course'

class CourseDeleteView(OwnerCourseMixin, DeleteView):
    template_name = 'courses/manage/course/delete.html'
    permission_required = 'courses.delete_course'
```

`PermissionRequiredMixin` checks that the user accessing the view has the permission specified in the `permission_required` attribute. Your views are now only accessible to users with the proper permissions.

Let's create URLs for these views. Create a new file inside the `courses` application directory and name it `urls.py`. Add the following code to it:

```
from django.urls import path
from . import views

urlpatterns = [
    path(
        'mine/',
        views.ManageCourseListView.as_view(),
        name='manage_course_list'
    ),
    path(
        'create/',
        views.CourseCreateView.as_view(),
        name='course_create'
    ),
    path(
        '<pk>/edit/',
        views.CourseUpdateView.as_view(),
        name='course_edit'
    ),
    path(
        '<pk>/delete/',
        views.CourseDeleteView.as_view(),
        name='course_delete'
    ),
]
```

These are the URL patterns for the list, create, edit, and delete course views. The `pk` parameter refers to the primary key field. Remember that **pk is short for primary key**. Every Django model has a field that serves as its primary key. By default, the primary key is the automatically generated `id` field. The Django generic views for single objects retrieve an object by its `pk` field. Edit the main `urls.py` file of the `educa` project and include the URL patterns of the `courses` application, as follows.

New code is highlighted in bold:

```
from django.conf import settings
from django.conf.urls.static import static
from django.contrib import admin
from django.contrib.auth import views as auth_views
from django.urls import include, path

urlpatterns = [
```

```
    path(
        'accounts/login/', auth_views.LoginView.as_view(), name='login'
    ),
    path(
        'accounts/logout/',
        auth_views.LogoutView.as_view(),
        name='logout'
    ),
    path('admin/', admin.site.urls),
    path('course/', include('courses.urls')),
]

if settings.DEBUG:
    urlpatterns += static(
        settings.MEDIA_URL, document_root=settings.MEDIA_ROOT
    )
```

You need to create the templates for these views. Create the following directories and files inside the `templates/` directory of the `courses` application:

```
courses/
    manage/
        course/
            list.html
            form.html
            delete.html
```

Edit the `courses/manage/course/list.html` template and add the following code to it:

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

{% block title %}My courses{% endblock %}

{% block content %}
  <h1>My courses</h1>
  <div class="module">
    {% for course in object_list %}
      <div class="course-info">
        <h3>{{ course.title }}</h3>
        <p>
          <a href="{% url "course_edit" course.id %}">Edit</a>
```

```
            <a href="{% url "course_delete" course.id %}">Delete</a>
          </p>
        </div>
      {% empty %}
        <p>You haven't created any courses yet.</p>
      {% endfor %}
      <p>
        <a href="{% url "course_create" %}" class="button">Create new course</a>
      </p>
    </div>
  {% endblock %}
```

This is the template for the `ManageCourseListView` view. In this template, you list the courses created by the current user. You include links to edit or delete each course and a link to create new courses.

Run the development server using the following command:

```
python manage.py runserver
```

Open `http://127.0.0.1:8000/accounts/login/?next=/course/mine/` in your browser and log in with a user belonging to the `Instructors` group. After logging in, you will be redirected to the `http://127.0.0.1:8000/course/mine/` URL and you should see the following page:

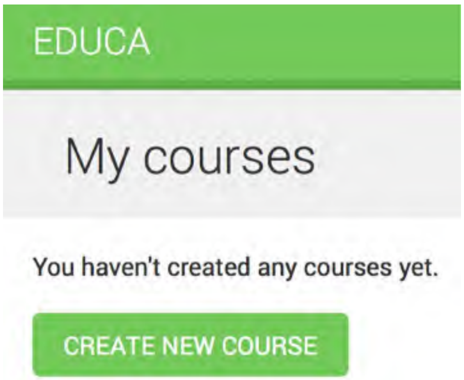


Figure 13.4: The instructor courses page with no courses

This page will display all courses created by the current user.

Let's create the template that displays the form for the create and update course views. Edit the `courses/manage/course/form.html` template and write the following code:

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

{% block title %}
```

```
  {% if object %}
    Edit course "{{ object.title }}"
  {% else %}
    Create a new course
  {% endif %}
{% endblock %}

{% block content %}
  <h1>
    {% if object %}
      Edit course "{{ object.title }}"
    {% else %}
      Create a new course
    {% endif %}
  </h1>
  <div class="module">
    <h2>Course info</h2>
    <form method="post">
      {{ form.as_p }}
      {% csrf_token %}
      <p><input type="submit" value="Save course"></p>
    </form>
  </div>
{% endblock %}
```

The `form.html` template is used for both the `CourseCreateView` and `CourseUpdateView` views. In this template, you check whether an `object` variable is in the context. If `object` exists in the context, you know that you are updating an existing course and you use it in the page title. Otherwise, you are creating a new `Course` object.

Open `http://127.0.0.1:8000/course/mine/` in your browser and click the **CREATE NEW COURSE** button. You will see the following page:

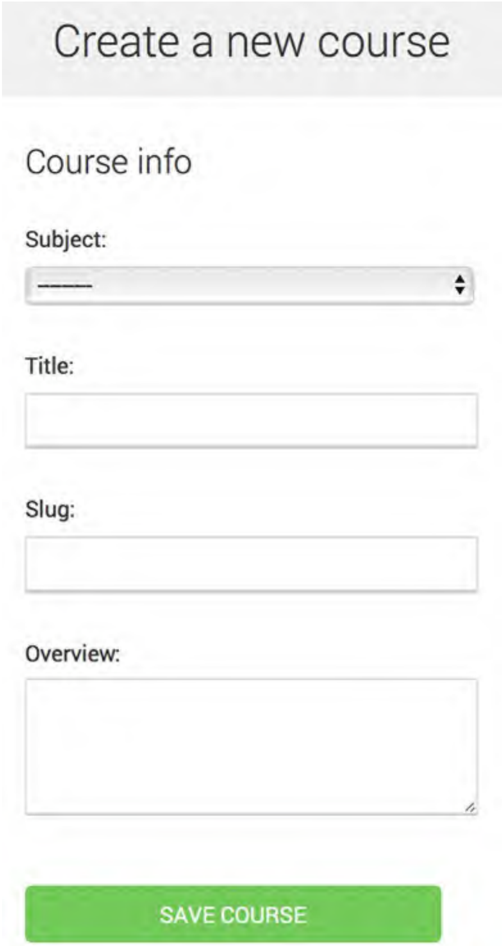


Figure 13.5: The form to create a new course

Fill in the form and click the **SAVE COURSE** button. The course will be saved and you will be redirected to the course list page. It should look as follows:

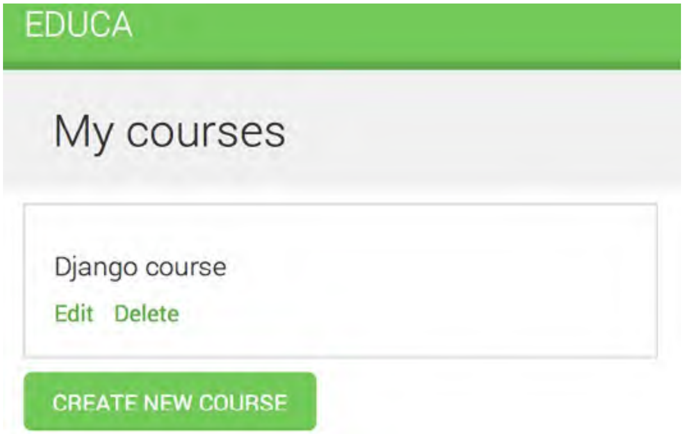


Figure 13.6: The instructor courses page with one course

Then, click the **Edit** link for the course you have just created. You will see the form again but, this time, you are editing an existing `Course` object instead of creating one.

Finally, edit the `courses/manage/course/delete.html` template and add the following code:

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

{% block title %}Delete course{% endblock %}

{% block content %}
  <h1>Delete course "{{ object.title }}"</h1>
  <div class="module">
    <form action="" method="post">
      {% csrf_token %}
      <p>Are you sure you want to delete "{{ object }}"?</p>
      <input type="submit" value="Confirm">
    </form>
  </div>
{% endblock %}
```

This is the template for the `CourseDeleteView` view. This view inherits from `DeleteView`, provided by Django, which expects user confirmation to delete an object.

Open the course list in the browser and click the **Delete** link of your course. You should see the following confirmation page:

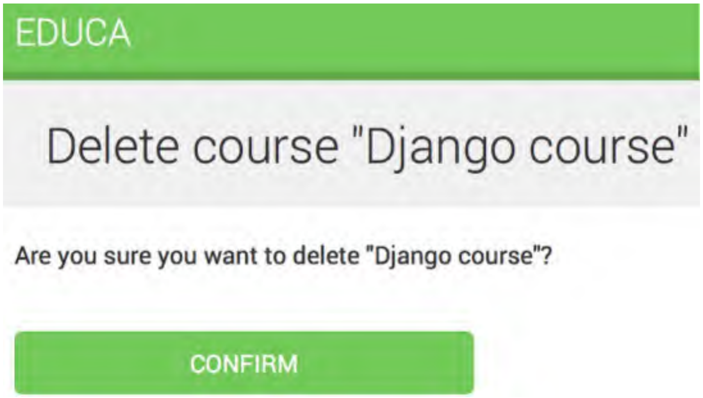


Figure 13.7: The Delete course confirmation page

Click the **CONFIRM** button. The course will be deleted and you will be redirected to the course list page again.

Instructors can now create, edit, and delete courses. Next, you need to provide them with a CMS to add course modules and their contents. You will start by managing course modules.

Managing course modules and their contents

You are going to build a system to manage course modules and their contents. You will need to build forms that can be used for managing multiple modules per course and different types of content for each module. Both modules and their contents will have to follow a specific order and you should be able to reorder them using the CMS.

Using formsets for course modules

Django comes with an abstraction layer to work with multiple forms on the same page. These groups of forms are known as *formsets*. Formsets manage multiple instances of a certain `Form` or `ModelForm`. All forms are submitted at once and the formset takes care of the initial number of forms to display, limiting the maximum number of forms that can be submitted and validating all the forms.

Formsets include an `is_valid()` method to validate all forms at once. You can also provide initial data for the forms and specify how many additional empty forms to display. You can learn more about formsets at `https://docs.djangoproject.com/en/5.0/topics/forms/formsets/` and about model formsets at `https://docs.djangoproject.com/en/5.0/topics/forms/modelforms/#model-formsets`.

Since a course is divided into a variable number of modules, it makes sense to use formsets to manage them. Create a `forms.py` file in the `courses` application directory and add the following code to it:

```
from django.forms.models import inlineformset_factory
from .models import Course, Module

ModuleFormSet = inlineformset_factory(
    Course,
    Module,
    fields=['title', 'description'],
    extra=2,
    can_delete=True
)
```

This is the `ModuleFormSet` formset. You build it using the `inlineformset_factory()` function provided by Django. Inline formsets are a small abstraction on top of formsets that simplify working with related objects. This function allows you to build a model formset dynamically for the `Module` objects related to a `Course` object.

You use the following parameters to build the formset:

- `fields`: The fields that will be included in each form of the formset.
- `extra`: Allows you to set the number of empty extra forms to display in the formset.
- `can_delete`: If you set this to `True`, Django will include a Boolean field for each form that will be rendered as a checkbox input. It allows you to mark the objects that you want to delete.

Edit the `views.py` file of the `courses` application and add the following code to it:

```
from django.shortcuts import get_object_or_404, redirect
from django.views.generic.base import TemplateResponseMixin, View
from .forms import ModuleFormSet


class CourseModuleUpdateView(TemplateResponseMixin, View):
    template_name = 'courses/manage/module/formset.html'
    course = None

    def get_formset(self, data=None):
        return ModuleFormSet(instance=self.course, data=data)

    def dispatch(self, request, pk):
        self.course = get_object_or_404(
            Course, id=pk, owner=request.user
        )
        return super().dispatch(request, pk)
```

```
    def get(self, request, *args, **kwargs):
        formset = self.get_formset()
        return self.render_to_response(
            {'course': self.course, 'formset': formset}
        )

    def post(self, request, *args, **kwargs):
        formset = self.get_formset(data=request.POST)
        if formset.is_valid():
            formset.save()
            return redirect('manage_course_list')
        return self.render_to_response(
            {'course': self.course, 'formset': formset}
        )
```

The `CourseModuleUpdateView` view handles the formset to add, update, and delete modules for a specific course. This view inherits from the following mixins and views:

- `TemplateResponseMixin`: This mixin takes charge of rendering templates and returning an HTTP response. It requires a `template_name` attribute that indicates the template to be rendered and provides the `render_to_response()` method to pass it a context and render the template.
- `View`: The basic class-based view provided by Django.

In this view, you implement the following methods:

- `get_formset()`: You define this method to avoid repeating the code to build the formset. You create a `ModuleFormSet` object for the given `Course` object with optional data.
- `dispatch()`: This method is provided by the `View` class. It takes an HTTP request and its parameters and attempts to delegate to a lowercase method that matches the HTTP method used. A `GET` request is delegated to the `get()` method and a `POST` request to `post()`, respectively. In this method, you use the `get_object_or_404()` shortcut function to get the `Course` object for the given `id` parameter that belongs to the current user. You include this code in the `dispatch()` method because you need to retrieve the course for both `GET` and `POST` requests. You save it into the `course` attribute of the view to make it accessible to other methods.
- `get()`: Executed for `GET` requests. You build an empty `ModuleFormSet` formset and render it to the template together with the current `Course` object, using the `render_to_response()` method provided by `TemplateResponseMixin`.
- `post()`: Executed for `POST` requests. In this method, you perform the following actions:
    1. You build a `ModuleFormSet` instance using the submitted data.
    2. You execute the `is_valid()` method of the formset to validate all of its forms.

3. If the formset is valid, you save it by calling the `save()` method. At this point, any changes made, such as adding, updating, or marking modules for deletion, are applied to the database. Then, you redirect users to the `manage_course_list` URL. If the formset is not valid, you render the template to display any errors instead.

Edit the `urls.py` file of the `courses` application and add the following URL pattern to it:

```
path(
    '<pk>/module/',
    views.CourseModuleUpdateView.as_view(),
    name='course_module_update'
),
```

Create a new directory inside the `courses/manage/` template directory and name it `module`. Create a `courses/manage/module/formset.html` template and add the following code to it:

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

{% block title %}
  Edit "{{ course.title }}"
{% endblock %}

{% block content %}
  <h1>Edit "{{ course.title }}"</h1>
  <div class="module">
    <h2>Course modules</h2>
    <form method="post">
      {{ formset }}
      {{ formset.management_form }}
      {% csrf_token %}
      <input type="submit" value="Save modules">
    </form>
  </div>
{% endblock %}
```

In this template, you create a `<form>` HTML element in which you include `formset`. You also include the management form for the formset with the variable `{{ formset.management_form }}`. The management form includes hidden fields to control the initial, total, minimum, and maximum number of forms.

Edit the `courses/manage/course/list.html` template and add the following link for the `course_module_update` URL below the course **Edit** and **Delete** links:

```
<a href="{% url "course_edit" course.id %}">Edit</a>
<a href="{% url "course_delete" course.id %}">Delete</a>
<a href="{% url "course_module_update" course.id %}">Edit modules</a>
```

You have included the link to edit the course modules.

Open `http://127.0.0.1:8000/course/mine/` in your browser. Create a course and click the **Edit modules** link for it. You should see a formset, as follows:

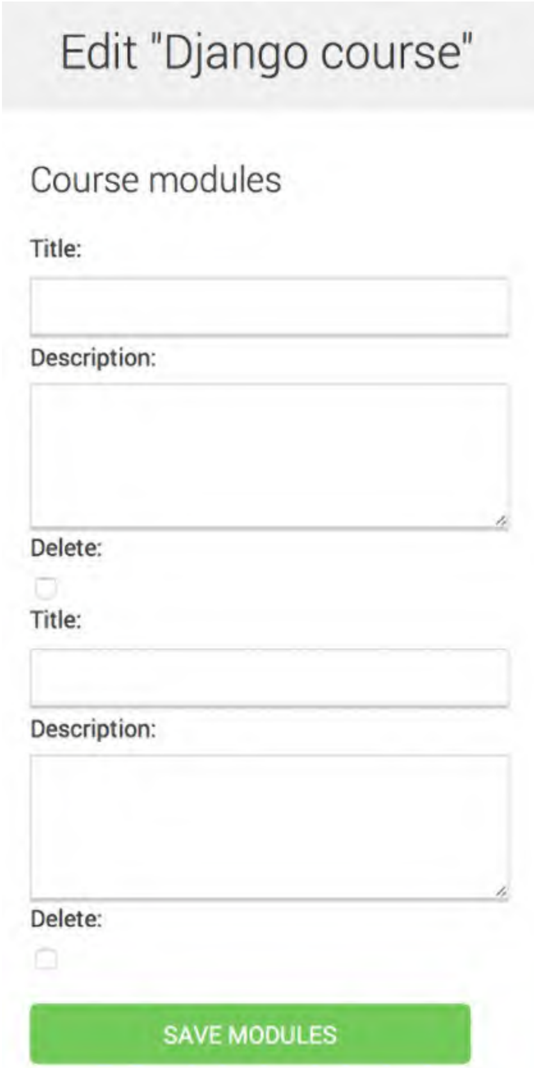


Figure 13.8: The course edit page, including the formset for course modules

The formset includes a form for each `Module` object contained in the course. After these, two empty extra forms are displayed because you set `extra=2` for `ModuleFormSet`. When you save the formset, Django will include another two extra fields to add new modules.

You can see that formsets are incredibly useful for managing multiple instances of forms on a single page. Formsets simplify the process of collecting and validating data from sets of similar forms efficiently.

After understanding how formsets work, you will explore advanced form capabilities by creating forms dynamically that adapt to the various types of content that will be added to course modules.

Adding content to course modules

Now, you need a way to add content to course modules. You have four different types of content: text, video, image, and file. You could consider creating four different views to create content, with one form for each model. However, you are going to take a more versatile approach and create a view that handles creating or updating the objects of any content model. You will build the form for this view dynamically, according to the type of content the instructor wants to add to the course: `Text`, `Video`, `Image`, or `File`.

Edit the `views.py` file of the `courses` application and add the following code to it:

```
from django.apps import apps
from django.forms.models import modelform_factory
from .models import Module, Content


class ContentCreateUpdateView(TemplateResponseMixin, View):
    module = None
    model = None
    obj = None
    template_name = 'courses/manage/content/form.html'

    def get_model(self, model_name):
        if model_name in ['text', 'video', 'image', 'file']:
            return apps.get_model(
                app_label='courses', model_name=model_name
            )
        return None

    def get_form(self, model, *args, **kwargs):
        Form = modelform_factory(
            model, exclude=['owner', 'order', 'created', 'updated']
        )
        return Form(*args, **kwargs)

    def dispatch(self, request, module_id, model_name, id=None):
        self.module = get_object_or_404(
            Module, id=module_id, course__owner=request.user
        )
        self.model = self.get_model(model_name)
        if id:
```

```
            self.obj = get_object_or_404(
                self.model, id=id, owner=request.user
            )
        return super().dispatch(request, module_id, model_name, id)
```

This is the first part of `ContentCreateUpdateView`. It will allow you to create and update different models' contents. This view defines the following methods:

- `get_model()`: Here, you check that the given model name is one of the four content models: `Text`, `Video`, `Image`, or `File`. Then, you use Django's `apps` module to obtain the actual class for the given model name. If the given model name is not one of the valid ones, you return `None`.
- `get_form()`: You build a dynamic form using the `modelform_factory()` function of the form's framework. Since you are going to build a form for the `Text`, `Video`, `Image`, and `File` models, you use the `exclude` parameter to specify the common fields to exclude from the form and let all other attributes be included automatically. By doing so, you don't have to know which fields to include depending on the model.
- `dispatch()`: This receives the following URL parameters and stores the corresponding module, model, and content object as class attributes:
    - `module_id`: The ID for the module that the content is/will be associated with.
    - `model_name`: The model name of the content to create/update.
    - `id`: The ID of the object that is being updated. It's `None` to create new objects.

Add the following `get()` and `post()` methods to `ContentCreateUpdateView`:

```
def get(self, request, module_id, model_name, id=None):
    form = self.get_form(self.model, instance=self.obj)
    return self.render_to_response(
        {'form': form, 'object': self.obj}
    )

def post(self, request, module_id, model_name, id=None):
    form = self.get_form(
        self.model,
        instance=self.obj,
        data=request.POST,
        files=request.FILES
    )
    if form.is_valid():
        obj = form.save(commit=False)
        obj.owner = request.user
        obj.save()
        if not id:
            # new content
```

```
            Content.objects.create(module=self.module, item=obj)
        return redirect('module_content_list', self.module.id)
    return self.render_to_response(
        {'form': form, 'object': self.obj}
    )
```

These methods are as follows:

- `get()`: Executed when a `GET` request is received. You build the model form for the `Text`, `Video`, `Image`, or `File` instance that is being updated. Otherwise, you pass no instance to create a new object since `self.obj` is `None` if no ID is provided.
- `post()`: Executed when a `POST` request is received. You build the model form, passing any submitted data and files to it. Then, you validate it. If the form is valid, you create a new object and assign `request.user` as its owner before saving it to the database. You check for the `id` parameter. If no ID is provided, you know the user is creating a new object instead of updating an existing one. If this is a new object, you create a `content` object for the given module and associate the new content with it.

Edit the `urls.py` file of the `courses` application and add the following URL patterns to it:

```
path(
    'module/<int:module_id>/content/<model_name>/create/',
    views.ContentCreateUpdateView.as_view(),
    name='module_content_create'
),
path(
    'module/<int:module_id>/content/<model_name>/<id>/',
    views.ContentCreateUpdateView.as_view(),
    name='module_content_update'
),
```

The new URL patterns are as follows:

- `module_content_create`: To create new text, video, image, or file objects and add them to a module. It includes the `module_id` and `model_name` parameters. The first one allows you to link the new content object to the given module. The latter specifies the content model for which to build the form.
- `module_content_update`: To update an existing text, video, image, or file object. It includes the `module_id` and `model_name` parameters and an `id` parameter to identify the content that is being updated.

Create a new directory inside the `courses/manage/` template directory and name it `content`. Create the template `courses/manage/content/form.html` and add the following code to it:

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

{% block title %}
```

```
    {% if object %}
      Edit content "{{ object.title }}"
    {% else %}
      Add new content
    {% endif %}
  {% endblock %}

  {% block content %}
    <h1>
      {% if object %}
        Edit content "{{ object.title }}"
      {% else %}
        Add new content
      {% endif %}
    </h1>
    <div class="module">
      <h2>Course info</h2>
      <form action="" method="post" enctype="multipart/form-data">
        {{ form.as_p }}
        {% csrf_token %}
        <p><input type="submit" value="Save content"></p>
      </form>
    </div>
  {% endblock %}
```

This is the template for the `ContentCreateUpdateView` view. In this template, you check whether an `object` variable is in the context. If `object` exists in the context, you are updating an existing object. Otherwise, you are creating a new object.

You include `enctype="multipart/form-data"` in the `<form>` HTML element because the form contains a file upload for the `File` and `Image` content models.

Run the development server, open `http://127.0.0.1:8000/course/mine/`, click **Edit modules** for an existing course, and create a module.

Then, open the Python shell with the following command:

```
python manage.py shell
```

Obtain the ID of the most recently created module, as follows:

```
>>> from courses.models import Module
>>> Module.objects.latest('id').id
6
```

Run the development server and open `http://127.0.0.1:8000/course/module/6/content/image/create/` in your browser, replacing the module ID with the one you obtained before. You will see the form to create an `Image` object, as follows:

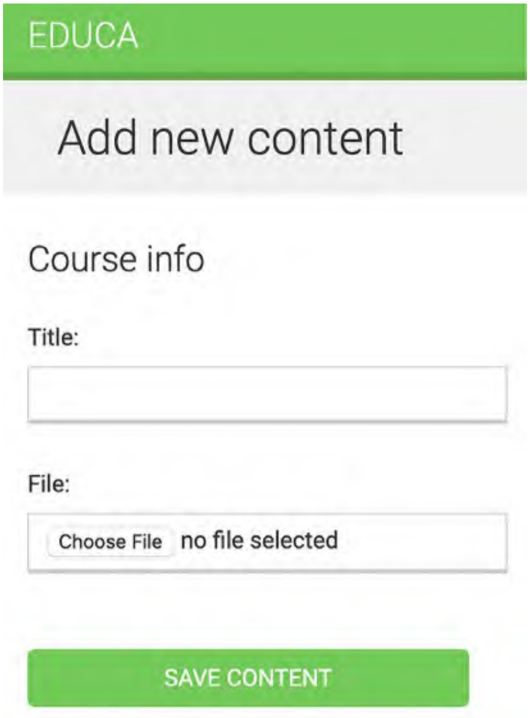


Figure 13.9: The course Add new content form

Don't submit the form yet. If you try to do so, it will fail because you haven't defined the `module_content_list` URL yet. You are going to create it in a bit.

You also need a view for deleting content. Edit the `views.py` file of the `courses` application and add the following code:

```
class ContentDeleteView(View):
    def post(self, request, id):
        content = get_object_or_404(
            Content, id=id, module__course__owner=request.user
        )
        module = content.module
        content.item.delete()
        content.delete()
        return redirect('module_content_list', module.id)
```

The `ContentDeleteView` class retrieves the `content` object with the given ID. It deletes the related `Text`, `Video`, `Image`, or `File` object. Finally, it deletes the `content` object and redirects the user to the `module_content_list` URL to list the other contents of the module.

Edit the `urls.py` file of the `courses` application and add the following URL pattern to it:

```
path(
    'content/<int:id>/delete/',
    views.ContentDeleteView.as_view(),
    name='module_content_delete'
),
```

Now, instructors can create, update, and delete content easily. The approach you have learned in this section is very useful for managing forms with diverse data in a generic manner. This method can be applied in other situations where a flexible solution is needed to handle data inputs.

In the next section, we are going to create the views and templates to display course modules and contents.

Managing modules and their contents

You have built views to create, edit, and delete course modules and their contents. Next, you need a view to display all modules for a course and list the contents of a specific module.

Edit the `views.py` file of the `courses` application and add the following code to it:

```
class ModuleContentListView(TemplateResponseMixin, View):
    template_name = 'courses/manage/module/content_list.html'

    def get(self, request, module_id):
        module = get_object_or_404(
            Module, id=module_id, course__owner=request.user
        )
        return self.render_to_response({'module': module})
```

This is the `ModuleContentListView` view. This view gets the `Module` object with the given ID that belongs to the current user and renders a template with the given module.

Edit the `urls.py` file of the `courses` application and add the following URL pattern to it:

```
path(
    'module/<int:module_id>/',
    views.ModuleContentListView.as_view(),
    name='module_content_list'
),
```

Create a new template inside the `templates/courses/manage/module/` directory and name it `content_list.html`. Add the following code to it:

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

{% block title %}
  Module {{ module.order|add:1 }}: {{ module.title }}
{% endblock %}

{% block content %}
{% with course=module.course %}
  <h1>Course "{{ course.title }}"</h1>
  <div class="contents">
    <h3>Modules</h3>
    <ul id="modules">
      {% for m in course.modules.all %}
        <li data-id="{{ m.id }}" {% if m == module %}
         class="selected"{% endif %}>
          <a href="{% url "module_content_list" m.id %}">
            <span>
              Module <span class="order">{{ m.order|add:1 }}</span>
            </span>
            <br>
            {{ m.title }}
          </a>
        </li>
      {% empty %}
        <li>No modules yet.</li>
      {% endfor %}
    </ul>
    <p><a href="{% url "course_module_update" course.id %}">
    Edit modules</a></p>
  </div>
  <div class="module">
    <h2>Module {{ module.order|add:1 }}: {{ module.title }}</h2>
    <h3>Module contents:</h3>
    <div id="module-contents">
      {% for content in module.contents.all %}
        <div data-id="{{ content.id }}">
          {% with item=content.item %}
            <p>{{ item }}</p>
            <a href="#">Edit</a>
```

```
              <form action="{% url "module_content_delete" content.id %}"
               method="post">
                <input type="submit" value="Delete">
                {% csrf_token %}
              </form>
            {% endwith %}
          </div>
        {% empty %}
          <p>This module has no contents yet.</p>
        {% endfor %}
      </div>
      <h3>Add new content:</h3>
      <ul class="content-types">
        <li>
          <a href="{% url "module_content_create" module.id "text" %}">
            Text
          </a>
        </li>
        <li>
          <a href="{% url "module_content_create" module.id "image" %}">
            Image
          </a>
        </li>
        <li>
          <a href="{% url "module_content_create" module.id "video" %}">
            Video
          </a>
        </li>
        <li>
          <a href="{% url "module_content_create" module.id "file" %}">
            File
          </a>
        </li>
      </ul>
    </div>
  {% endwith %}
  {% endblock %}
```

Make sure that no template tag is split over multiple lines; the Django template engine expects the tags to be clearly defined and uninterrupted.

This is the template that displays all modules for a course and the contents of the selected module. You iterate over the course modules to display them in a sidebar. You iterate over a module's contents and access `content.item` to get the related `Text`, `Video`, `Image`, or `File` object. You also include links to create new text, video, image, or file content.

You want to know which type of object each of the `item` objects is: `Text`, `Video`, `Image`, or `File`. You need the model name to build the URL to edit the object. Besides this, you could display each item in the template differently based on the type of content it is. You can get the model name for an object from the model's `Meta` class by accessing the object's `_meta` attribute. However, Django doesn't allow you to access variables or attributes starting with an underscore in templates to prevent retrieving private attributes or calling private methods. You can solve this by writing a custom template filter.

Create the following file structure inside the `courses` application directory:

```
templatetags/
    __init__.py
    course.py
```

Edit the `course.py` module and add the following code to it:

```
from django import template

register = template.Library()

@register.filter
def model_name(obj):
    try:
        return obj._meta.model_name
    except AttributeError:
        return None
```

This is the `model_name` template filter. You can apply it in templates as `object|model_name` to get the model name for an object.

Edit the `templates/courses/manage/module/content_list.html` template and add the following line below the `{% extends %}` template tag:

```
{% load course %}
```

This will load the `course` template tags. Then, find the following lines:

```
<p>{{ item }}</p>
<a href="#">Edit</a>
```

Replace them with the following ones:

```
<p>{{ item }} ({{ item|model_name }})</p>
<a href="{% url "module_content_update" module.id item|model_name item.id %}">
```

```
  Edit
</a>
```

In the preceding code, you display the item model name in the template and also use the model name to build the link to edit the object.

Edit the `courses/manage/course/list.html` template and add a link to the `module_content_list` URL, like this:

```
<a href="{% url "course_module_update" course.id %}">Edit modules</a>
{% if course.modules.count > 0 %}
  <a href="{% url "module_content_list" course.modules.first.id %}">
    Manage contents
  </a>
{% endif %}
```

The new link allows users to access the contents of the first module of the course if there are any.

Stop the development server and run it again using the following command:

```
python manage.py runserver
```

By stopping and running the development server, you make sure that the `course` template tags file gets loaded.

Open `http://127.0.0.1:8000/course/mine/` and click the **Manage contents** link for a course that contains at least one module. You will see a page like the following one:

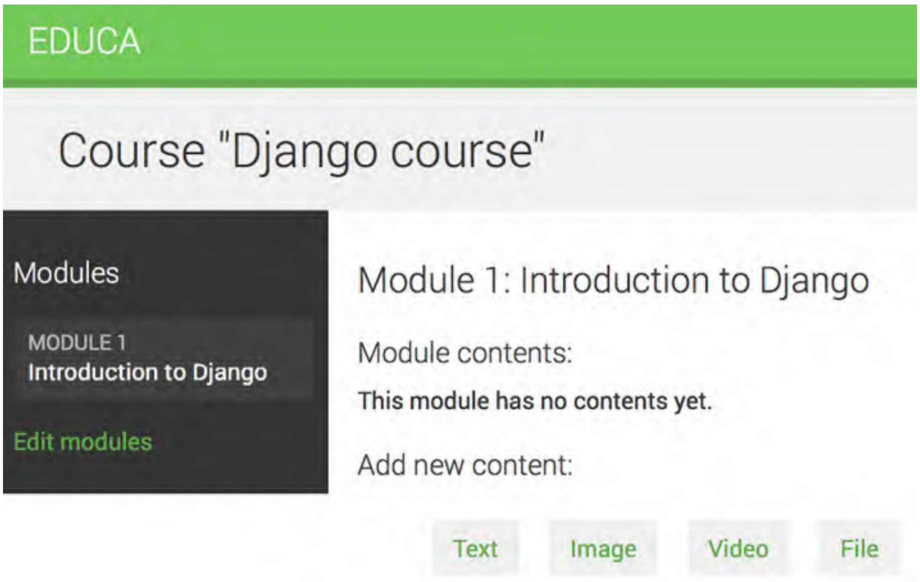


Figure 13.10: The page to manage course module contents

When you click on a module in the left sidebar, its contents are displayed in the main area. The template also includes links to add new text, video, image, or file content for the module being displayed.

Add a couple of different types of content to the module and look at the result. Module contents will appear below **Module contents:**

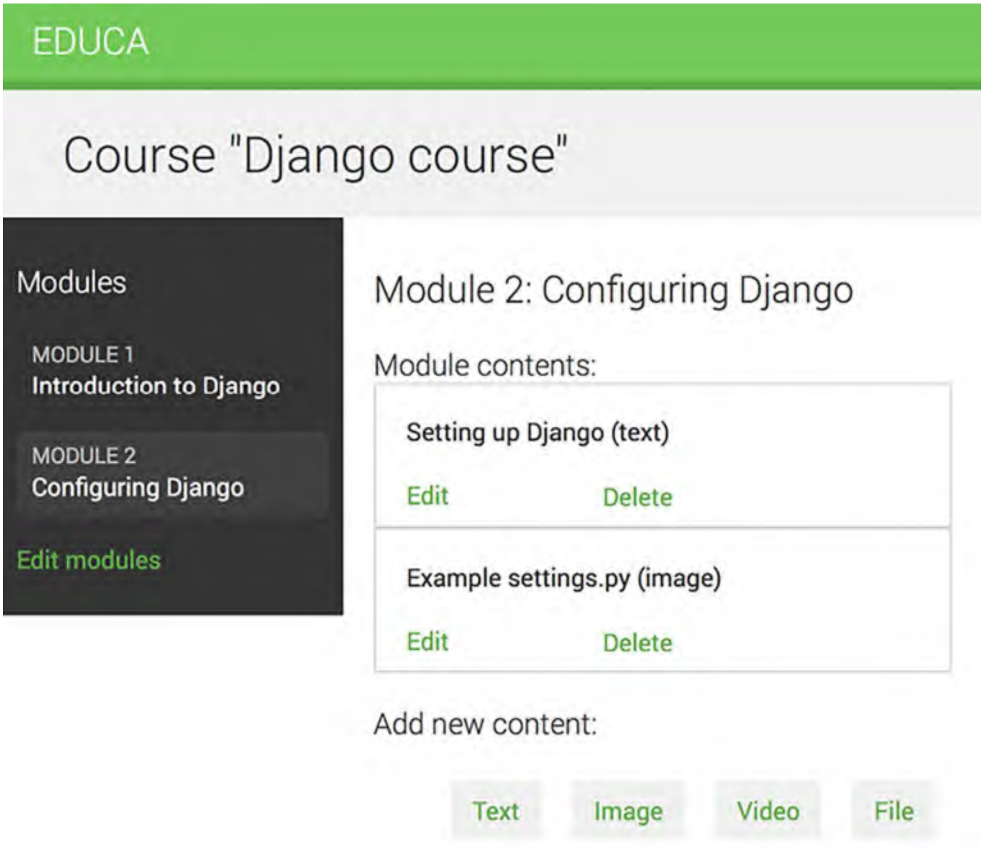


Figure 13.11: Managing different module contents

Next, we will allow course instructors to reorder modules and module contents with a simple drag-and-drop functionality.

Reordering modules and their contents

We will implement a JavaScript drag-and-drop functionality to let course instructors reorder the modules of a course by dragging them. Drag-and-drop enhances the user interface, offering a natural way to reorder elements that is more intuitive than using numbers or clicking buttons. It is also a time-saver for course instructors, who will be able to reorganize course modules and their contents easily.

To implement this feature, we will use the HTML5 Sortable library, which simplifies the process of creating sortable lists using the native HTML5 Drag and Drop API.

When users finish dragging a module, you will use the JavaScript Fetch API to send an asynchronous HTTP request to the server that stores the new module order.

You can read more information about the HTML5 Drag and Drop API at `https://www.w3schools.com/html/html5_draganddrop.asp`. You can find examples built with the HTML5 Sortable library at `https://lukasoppermann.github.io/html5sortable/`. Documentation for the HTML5 Sortable library is available at `https://github.com/lukasoppermann/html5sortable`.

Let's implement the views to update the order of course modules and module contents.

Using mixins from django-braces

`django-braces` is a third-party module that contains a collection of generic mixins for Django. These mixins provide additional features for class-based views that are useful for various common scenarios. You can see a list of all mixins provided by `django-braces` at `https://django-braces.readthedocs.io/`.

You will use the following mixins of `django-braces`:

- `CsrfExemptMixin`: Used to avoid checking the **cross-site request forgery** (**CSRF**) token in the `POST` requests. You need this to perform AJAX `POST` requests without the need to pass a `csrf_token`.
- `JsonRequestResponseMixin`: Parses the request data as JSON and also serializes the response as JSON and returns an HTTP response with the `application/json` content type.

Install `django-braces` via `pip` using the following command:

```
python -m pip install django-braces==1.15.0
```

You need a view that receives the new order of module IDs encoded in JSON and updates the order accordingly. Edit the `views.py` file of the `courses` application and add the following code to it:

```
from braces.views import CsrfExemptMixin, JsonRequestResponseMixin

class ModuleOrderView(CsrfExemptMixin, JsonRequestResponseMixin, View):
    def post(self, request):
        for id, order in self.request_json.items():
            Module.objects.filter(
                id=id, course__owner=request.user
            ).update(order=order)
        return self.render_json_response({'saved': 'OK'})
```

This is the `ModuleOrderView` view, which allows you to update the order of course modules.

You can build a similar view to order a module's contents. Add the following code to the `views.py` file:

```
class ContentOrderView(CsrfExemptMixin, JsonRequestResponseMixin, View):
    def post(self, request):
        for id, order in self.request_json.items():
```

```
            Content.objects.filter(
                id=id, module__course__owner=request.user
            ).update(order=order)
        return self.render_json_response({'saved': 'OK'})
```

Now, edit the `urls.py` file of the `courses` application and add the following URL patterns to it:

```
path(
    'module/order/',
    views.ModuleOrderView.as_view(),
    name='module_order'
),
path(
    'content/order/',
    views.ContentOrderView.as_view(),
    name='content_order'
),
```

Finally, you need to implement the drag-and-drop functionality in the template. We will use the HTML5 Sortable library, which simplifies the creation of sortable elements using the standard HTML Drag and Drop API. There are other JavaScript libraries that will allow you to achieve the same, but we chose HTML5 Sortable because it is lightweight and leverages the native HTML5 Drag and Drop API.

Edit the `base.html` template located in the `templates/` directory of the `courses` application and add the following block highlighted in bold:

```
{% load static %}
<!DOCTYPE html>
<html>
  <head>
    # ...
  </head>
  <body>
    <div id="header">
      # ...
    </div>
    <div id="content">
      {% block content %}
      {% endblock %}
    </div>
    {% block include_js %}
    {% endblock %}
    <script>
      document.addEventListener('DOMContentLoaded', (event) => {
```

```
        // DOM loaded
        {% block domready %}
        {% endblock %}
      })
    </script>
  </body>
</html>
```

This new block named `include_js` will allow you to insert JavaScript files into any template that extends the `base.html` template.

Next, edit the `courses/manage/module/content_list.html` template and add the following code highlighted in bold to the bottom of the template:

```
# ...
{% block content %}
  # ...
{% endblock %}

{% block include_js %}
  <script src="https://cdnjs.cloudflare.com/ajax/libs/html5sortable/0.13.3/
html5sortable.min.js"></script>
{% endblock %}
```

In this code, you load the HTML5 Sortable library from a public **content delivery network** (**CDN**). Remember you loaded a JavaScript library from a CDN before in *Chapter 6, Sharing Content on Your Website*.

Now add the following `domready` block highlighted in bold to the `courses/manage/module/content_list.html` template:

```
# ...
{% block content %}
  # ...
{% endblock %}
{% block include_js %}
  <script src="https://cdnjs.cloudflare.com/ajax/libs/html5sortable/0.13.3/
html5sortable.min.js"></script>
{% endblock %}

{% block domready %}
  var options = {
      method: 'POST',
      mode: 'same-origin'
  }
  const moduleOrderUrl = '{% url "module_order" %}';
{% endblock %}
```

In these new lines, you add JavaScript code to the `{% block domready %}` block that was defined in the event listener for the `DOMContentLoaded` event in the `base.html` template. This guarantees that your JavaScript code will be executed once the page has been loaded. With this code, you define the options for the HTTP request to reorder modules that you will implement next. You will send a `POST` request using the Fetch API to update the module order. The `module_order` URL path is built and stored in the JavaScript constant `moduleOrderUrl`.

Add the following code highlighted in bold to the `domready` block:

```
{% block domready %}
  var options = {
      method: 'POST',
      mode: 'same-origin'
  }
  const moduleOrderUrl = '{% url "module_order" %}';

  sortable('#modules', {
    forcePlaceholderSize: true,
    placeholderClass: 'placeholder'
  });
{% endblock %}
```

In the new code, you define a `sortable` element for the HTML element with `id="modules"`, which is the module list in the sidebar. Remember that you use a CSS selector `#` to select the element with the given `id`. When you start dragging an item, the HTML5 Sortable library creates a placeholder item so that you can easily see where the element will be placed.

You set the `forcePlacehoderSize` option to `true`, to force the placeholder element to have a height, and you use `placeholderClass` to define the CSS class for the placeholder element. You use the class named `placeholder` that is defined in the `css/base.css` static file loaded in the `base.html` template.

Open `http://127.0.0.1:8000/course/mine/` in your browser and click on **Manage contents** for any course. Now, you can drag and drop the course modules in the left sidebar, as in *Figure 13.12*:

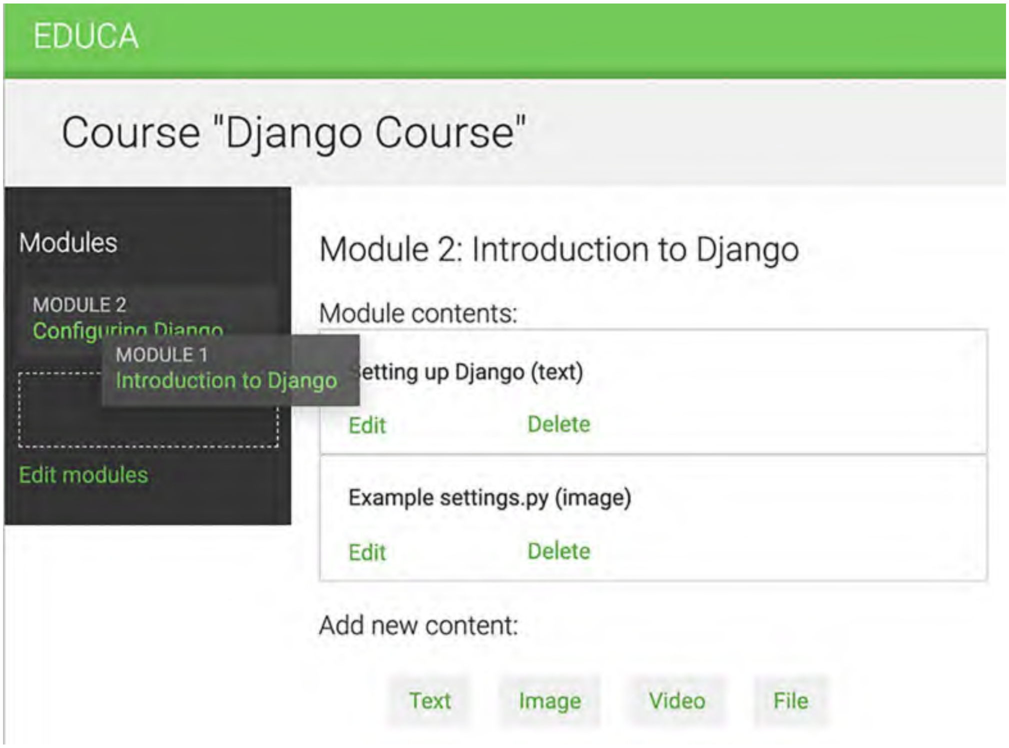


Figure 13.12: Reordering modules with the drag-and-drop functionality

While you drag the element, you will see the placeholder item created by the Sortable library, which has a dashed-line border. The placeholder element allows you to identify the position in which the dragged element will be dropped.

When you drag a module to a different position, you need to send an HTTP request to the server to store the new order. This can be done by attaching an event handler to the sortable element and sending a request to the server using the JavaScript Fetch API.

Edit the `domready` block of the `courses/manage/module/content_list.html` template and add the following code highlighted in bold:

```
{% block domready %}
  var options = {
      method: 'POST',
      mode: 'same-origin'
  }
  const moduleOrderUrl = '{% url "module_order" %}';

  sortable('#modules', {
    forcePlaceholderSize: true,
    placeholderClass: 'placeholder'
  })[0].addEventListener('sortupdate', function(e) {

    modulesOrder = {};
    var modules = document.querySelectorAll('#modules li');
    modules.forEach(function (module, index) {
      // update module index
      modulesOrder[module.dataset.id] = index;
      // update index in HTML element
      module.querySelector('.order').innerHTML = index + 1;
    });

    // add new order to the HTTP request options
    options['body'] = JSON.stringify(modulesOrder);

    // send HTTP request
    fetch(moduleOrderUrl, options)
  });
{% endblock %}
```

In the new code, an event listener is created for the `sortupdate` event of the sortable element. The `sortupdate` event is triggered when an element is dropped in a different position. The following tasks are performed in the event function:

1. An empty `modulesOrder` dictionary is created. The keys for this dictionary will be the module IDs, and the values will contain the index of each module.
2. The list elements of the `#modules` HTML element are selected with `document.querySelectorAll()`, using the `#modules li` CSS selector.
3. `forEach()` is used to iterate over each list element.

4. The new index for each module is stored in the `modulesOrder` dictionary. The ID of each module is retrieved from the HTML `data-id` attribute by accessing `module.dataset.id`. You use the ID as the key of the `modulesOrder` dictionary and the new index of the module as the value.
5. The order displayed for each module is updated by selecting the element with the `order` CSS class. Since the index is zero-based and we want to display a one-based index, we add `1` to `index`.
6. A key named `body` is added to the `options` dictionary with the new order contained in `modulesOrder`. The `JSON.stringify()` method converts the JavaScript object into a JSON string. This is the body for the HTTP request to update the module order.
7. The Fetch API is used by creating a `fetch()` HTTP request to update the module order. The `ModuleOrderView` view that corresponds to the `module_order` URL takes care of updating the order of the modules.

You can now drag and drop modules. When you finish dragging a module, an HTTP request is sent to the `module_order` URL to update the order of the modules. If you refresh the page, the latest module order will be kept because it was updated in the database. *Figure 13.13* shows a different order for the modules in the sidebar after sorting them using drag and drop:

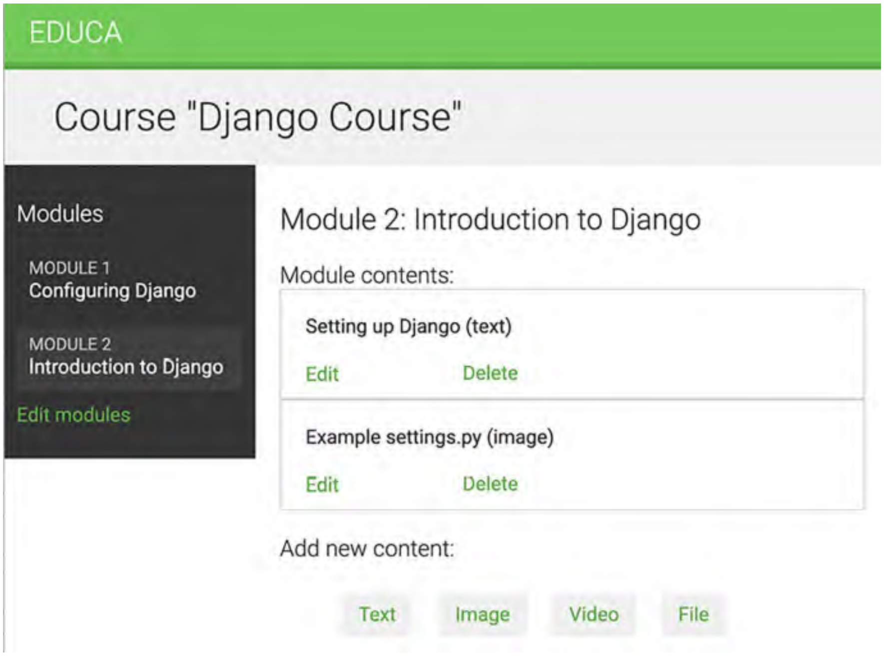


Figure 13.13: New order for modules after reordering them with drag and drop

If you run into any issues, remember to use your browser's developer tools to debug JavaScript and HTTP requests. Usually, you can right-click anywhere on the website to open the contextual menu and click on **Inspect** or **Inspect Element** to access the web developer tools of your browser.

Let's add the same drag-and-drop functionality to allow course instructors to sort module contents as well.

Edit the `domready` block of the `courses/manage/module/content_list.html` template and add the following code highlighted in bold:

```
{% block domready %}

  // ...

  const contentOrderUrl = '{% url "content_order" %}';

  sortable('#module-contents', {
    forcePlaceholderSize: true,
    placeholderClass: 'placeholder'
  })[0].addEventListener('sortupdate', function(e) {

    contentOrder = {};
    var contents = document.querySelectorAll('#module-contents div');
    contents.forEach(function (content, index) {
      // update content index
      contentOrder[content.dataset.id] = index;
    });

    // add new order to the HTTP request options
    options['body'] = JSON.stringify(contentOrder);

    // send HTTP request
    fetch(contentOrderUrl, options)
  });
{% endblock %}
```

In this case, you use the `content_order` URL instead of `module_order` and build the `sortable` functionality on the HTML element with the ID `module-contents`. The functionality is mainly the same as for ordering course modules. In this case, you don't need to update the numbering of the contents because they don't include any visible index.

Now, you can drag and drop both modules and module contents, as in *Figure 13.14*:

Figure 13.14: Reordering module contents with the drag-and-drop functionality

Great! You built a very versatile CMS for the course instructors.

Summary

In this chapter, you learned how to use class-based views and mixins to create a CMS. You acquired knowledge about reusability and modularity that you can apply to your future applications. You also worked with groups and permissions to restrict access to your views, gaining insights into security and how to control actions on data. You learned how to use formsets and model formsets to manage course modules and their content in a flexible manner. You also built a drag-and-drop functionality with JavaScript to reorder course modules and their contents with an improved user interface.

In the next chapter, you will create a student registration system and manage student enrollment in courses. You will also learn how to render different types of content and improve the performance of your application by caching content using Django's cache framework.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter13`
- Django mixins documentation: `https://docs.djangoproject.com/en/5.0/topics/class-based-views/mixins/`
- Neapolitan package to create CRUD views: `https://github.com/carltongibson/neapolitan`
- Creating custom permissions: `https://docs.djangoproject.com/en/5.0/topics/auth/customizing/#custom-permissions`
- Django formsets: `https://docs.djangoproject.com/en/5.0/topics/forms/formsets/`
- Django model formsets: `https://docs.djangoproject.com/en/5.0/topics/forms/modelforms/#model-formsets`
- HTML5 Drag and Drop API: `https://www.w3schools.com/html/html5_draganddrop.asp`
- HTML5 Sortable library documentation: `https://github.com/lukasoppermann/html5sortable`
- HTML5 Sortable library examples: `https://lukasoppermann.github.io/html5sortable/`
- `django-braces` documentation: `https://django-braces.readthedocs.io/`

14

Rendering and Caching Content

In the previous chapter, you used model inheritance and generic relations to create flexible course content models. You implemented a custom model field and you built a course management system using class-based views. Finally, you created a JavaScript drag-and-drop functionality using asynchronous HTTP requests to order course modules and their contents.

In this chapter, you will build the functionality to create a student registration system and manage student enrollment in courses. You will implement rendering of the different types of course content and learn how to cache data using the Django cache framework.

Rendering diverse content types is essential in e-learning platforms, where courses are typically structured with flexible modules that include a mix of text, images, videos, and documents. In this context, caching also becomes crucial. Since course content usually remains unchanged for extended periods – days, weeks, or even months – caching helps conserve computing power and reduces the need to query the database each time students access the same materials. By caching data, you not only save system resources but also improve performance when delivering content to a large number of students.

In this chapter, you will:

- Create public views for displaying course information
- Build a student registration system
- Manage student enrollment in courses
- Render diverse content for course modules
- Install and configure Memcached
- Cache content using the Django cache framework
- Use the Memcached and Redis cache backends
- Monitor your Redis server in the Django administration site

Functional overview

Figure 14.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

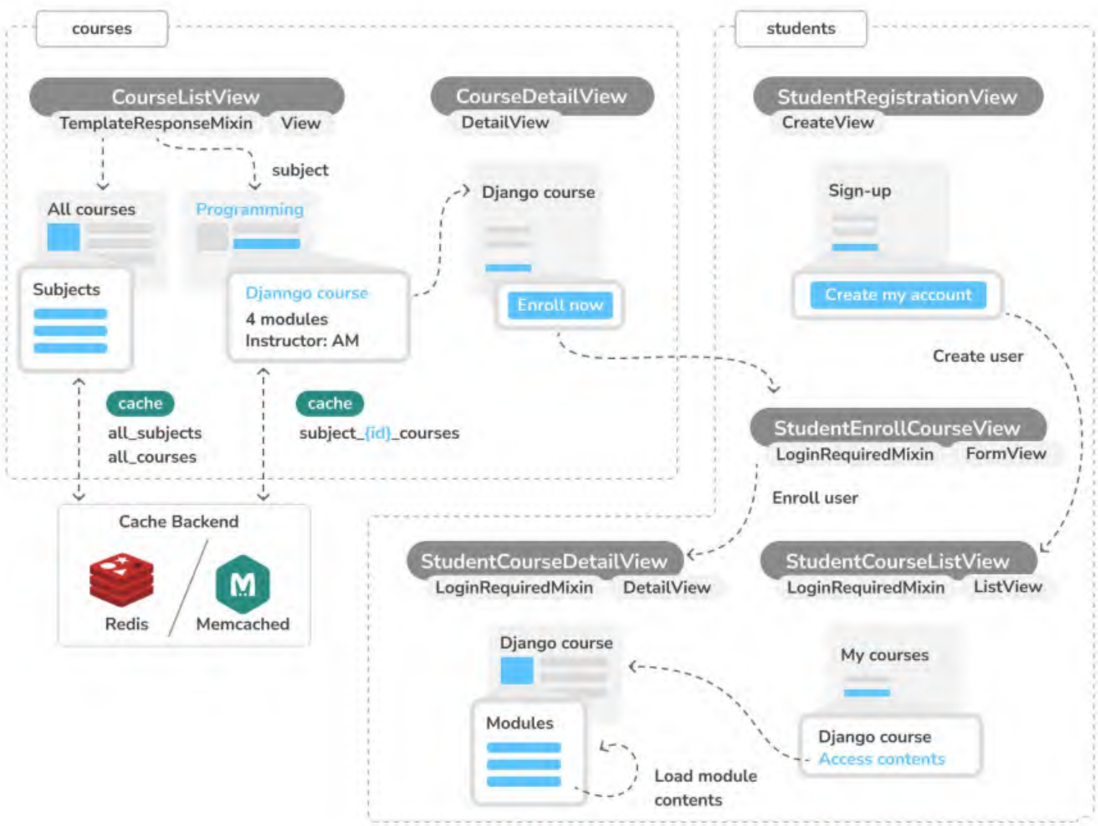


Figure 14.1: Diagram of functionalities built in Chapter 14

In this chapter, you will implement the `CourseListView` public view to list courses and `CourseDetailView` to show the details of a course. You will implement `StudentRegistrationView` to allow students to create user accounts and `StudentCourseListView` for students to enroll in courses. You will create the `StudentCourseListView` for students to see the list of courses they are enrolled in and the `StudentCourseDetailView` to access all the content of a course, organized in the different course modules. You will also add a cache to your views using the Django cache framework, first with the Memcached backend and then replacing it with the Redis cache backend.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter14`.

All Python modules used in this chapter are included in the `requirements.txt` file in the source code that comes along with this chapter. You can follow the instructions to install each Python module below or you can install all requirements at once with the `python -m pip install -r requirements.txt` command.

Displaying the catalog of courses

You might be eager to get to rendering and caching but there are a few items we must set up before we can do that. Let's start with the course catalog. For your course catalog, you have to build the following functionalities:

- List all available courses, optionally filtered by subject
- Display a single course overview

This will allow students to see all the courses available on the platform and enroll in those they are interested in. Edit the `views.py` file of the `courses` application and add the following code:

```
from django.db.models import Count
from .models import Subject


class CourseListView(TemplateResponseMixin, View):
    model = Course
    template_name = 'courses/course/list.html'
    def get(self, request, subject=None):
        subjects = Subject.objects.annotate(
            total_courses=Count('courses')
        )
        courses = Course.objects.annotate(
            total_modules=Count('modules')
        )
        if subject:
            subject = get_object_or_404(Subject, slug=subject)
            courses = courses.filter(subject=subject)
        return self.render_to_response(
            {
                'subjects': subjects,
                'subject': subject,
                'courses': courses
            }
        )
```

This is the `CourseListView` view. It inherits from `TemplateResponseMixin` and `View`. In this view, the following tasks are performed:

1. Retrieve all subjects using the ORM's `annotate()` method with the `Count()` aggregation function to include the total number of courses for each subject.
2. Retrieve all available courses, including the total number of modules contained in each course.
3. If a subject slug URL parameter is given, retrieve the corresponding `subject` object and limit the query to the courses that belong to the given subject.

4. Use the `render_to_response()` method provided by `TemplateResponseMixin` to render the objects to a template and return an HTTP response.

Let's create a detail view for displaying a single course overview. Add the following code to the `views.py` file:

```
from django.views.generic.detail import DetailView


class CourseDetailView(DetailView):
    model = Course
    template_name = 'courses/course/detail.html'
```

This view inherits from the generic `DetailView` provided by Django. You specify the `model` and `template_name` attributes. Django's `DetailView` expects a primary key (pk) or slug URL parameter to retrieve a single object for the given model. The view renders the template specified in `template_name`, including the `Course` object in the template context variable `object`.

Edit the main `urls.py` file of the `educa` project and add the following URL pattern to it:

```
from courses.views import CourseListView


urlpatterns = [
    # ...
    path('', CourseListView.as_view(), name='course_list'),
]
```

You add the `course_list` URL pattern to the main `urls.py` file of the project because you want to display the list of courses in the URL `http://127.0.0.1:8000/`, and all other URLs for the `courses` application have the `/course/` prefix.

Edit the `urls.py` file of the `courses` application and add the following URL patterns:

```
path(
    'subject/<slug:subject>/',
    views.CourseListView.as_view(),
    name='course_list_subject'
),
path(
    '<slug:slug>/',
    views.CourseDetailView.as_view(),
    name='course_detail'
),
```

You define the following URL patterns:

- `course_list_subject`: For displaying all courses for a subject
- `course_detail`: For displaying a single course overview

Let's build templates for the `CourseListView` and `CourseDetailView` views.

Create the following file structure inside the `templates/courses/` directory of the `courses` application:

```
course/
    list.html
    detail.html
```

Edit the `courses/course/list.html` template of the `courses` application and write the following code:

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

{% block title %}
  {% if subject %}
    {{ subject.title }} courses
  {% else %}
    All courses
  {% endif %}
{% endblock %}

{% block content %}
  <h1>
    {% if subject %}
      {{ subject.title }} courses
    {% else %}
      All courses
    {% endif %}
  </h1>
  <div class="contents">
    <h3>Subjects</h3>
    <ul id="modules">
      <li {% if not subject %}class="selected"{% endif %}>
        <a href="{% url "course_list" %}">All</a>
      </li>
      {% for s in subjects %}
        <li {% if subject == s %}class="selected"{% endif %}>
          <a href="{% url "course_list_subject" s.slug %}">
```

```
            {{ s.title }}
            <br>
            <span>
              {{ s.total_courses }} course{{ s.total_courses|pluralize }}
            </span>
          </a>
        </li>
      {% endfor %}
    </ul>
  </div>
  <div class="module">
    {% for course in courses %}
      {% with subject=course.subject %}
        <h3>
          <a href="{% url "course_detail" course.slug %}">
            {{ course.title }}
          </a>
        </h3>
        <p>
          <a href="{% url "course_list_subject" subject.slug %}">{{ subject
}}</a>.
            {{ course.total_modules }} modules.
            Instructor: {{ course.owner.get_full_name }}
        </p>
      {% endwith %}
    {% endfor %}
  </div>
{% endblock %}
```

Make sure that no template tag is split into multiple lines.

This is the template for listing the available courses. You create an HTML list to display all `Subject` objects and build a link to the `course_list_subject` URL for each of them. You also include the total number of courses for each subject and use the `pluralize` template filter to add a plural suffix to the word **course** when the number is different than `1`, to show *0 courses*, *1 course*, *2 courses*, etc. You add a `selected` HTML class to highlight the current subject if a subject is selected. You iterate over every `Course` object, displaying the total number of modules and the instructor's name.

Run the development server and open `http://127.0.0.1:8000/` in your browser. You should see a page similar to the following one:

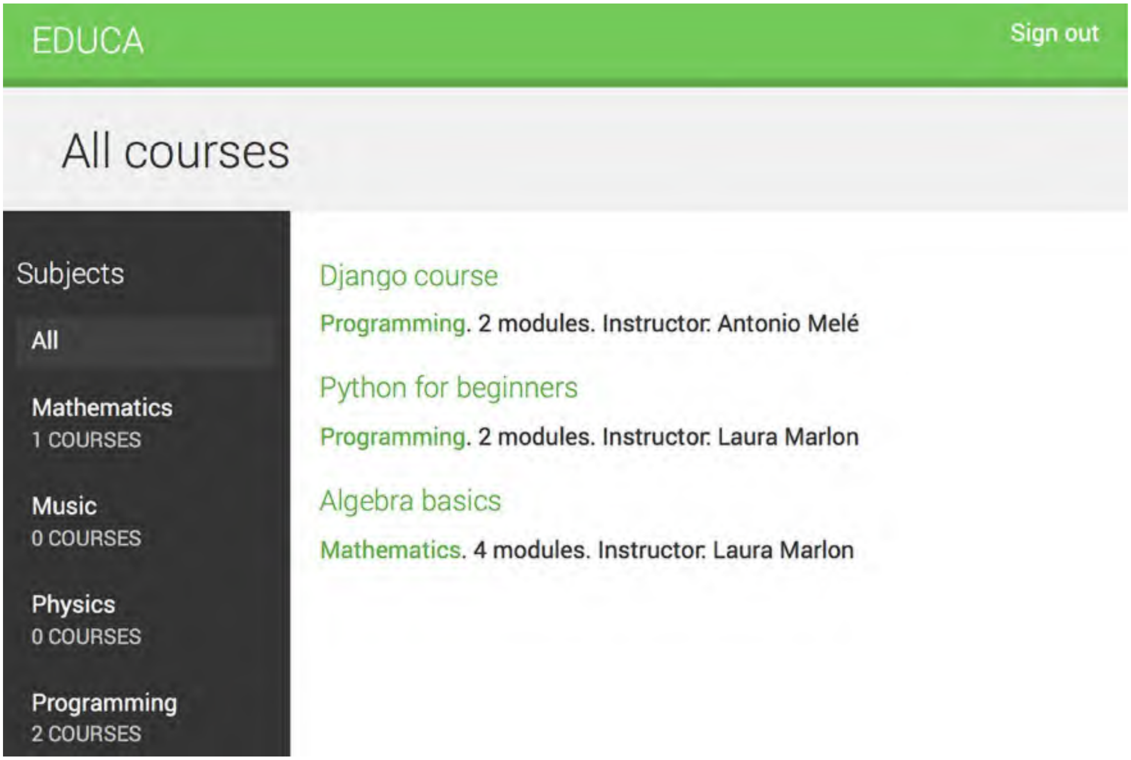


Figure 14.2: The course list page

The left sidebar contains all subjects, including the total number of courses for each of them. You can click any subject to filter the courses displayed.

Edit the `courses/course/detail.html` template and add the following code to it:

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

{% block title %}
  {{ object.title }}
{% endblock %}

{% block content %}
  {% with subject=object.subject %}
    <h1>
      {{ object.title }}
```

```
      </h1>
      <div class="module">
        <h2>Overview</h2>
        <p>
          <a href="{% url "course_list_subject" subject.slug %}">
          {{ subject.title }}</a>.
          {{ object.modules.count }} modules.
          Instructor: {{ object.owner.get_full_name }}
        </p>
        {{ object.overview|linebreaks }}
      </div>
    {% endwith %}
  {% endblock %}
```

This template displays the overview and details for a single course. Open `http://127.0.0.1:8000/` in your browser and click on one of the courses. You should see a page with the following structure:

Figure 14.3: The course overview page

You have created a public area for displaying courses. Next, you need to allow users to register as students and enroll in courses.

Adding student registration

We need to implement student registration to enable enrollment in courses and access to content. Create a new application using the following command:

```
python manage.py startapp students
```

Edit the `settings.py` file of the `educa` project and add the new application to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'students.apps.StudentsConfig',
]
```

Creating a student registration view

Edit the `views.py` file of the `students` application and write the following code:

```
from django.contrib.auth import authenticate, login
from django.contrib.auth.forms import UserCreationForm
from django.urls import reverse_lazy
from django.views.generic.edit import CreateView


class StudentRegistrationView(CreateView):
    template_name = 'students/student/registration.html'
    form_class = UserCreationForm
    success_url = reverse_lazy('student_course_list')

    def form_valid(self, form):
        result = super().form_valid(form)
        cd = form.cleaned_data
        user = authenticate(
            username=cd['username'], password=cd['password1']
        )
        login(self.request, user)
        return result
```

This is the view that allows students to register on your site. You use the generic `CreateView`, which provides the functionality for creating model objects. This view requires the following attributes:

- `template_name`: The path of the template to render this view.
- `form_class`: The form for creating objects, which has to be `ModelForm`. You use Django's `UserCreationForm` as the registration form to create `User` objects.
- `success_url`: The URL to redirect the user to when the form is successfully submitted. For this, you reverse the URL named `student_course_list`, which we will create in the *Accessing the course contents* section for listing the courses that students are enrolled in.

The `form_valid()` method is executed when valid form data has been posted. It has to return an HTTP response. You override this method to log the user in after they have successfully signed up.

Create a new file inside the `students` application directory and name it `urls.py`. Add the following code to it:

```
from django.urls import path
from . import views


urlpatterns = [
    path(
        'register/',
        views.StudentRegistrationView.as_view(),
        name='student_registration'
    ),
]
```

Then, edit the main `urls.py` of the `educa` project and include the URLs for the `students` application by adding the following pattern to your URL configuration:

```
urlpatterns = [
    # ...
    path('students/', include('students.urls')),
]
```

Create the following file structure inside the `students` application directory:

```
templates/
    students/
        student/
            registration.html
```

Edit the `students/student/registration.html` template and add the following code to it:

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

{% block title %}
  Sign up
{% endblock %}

{% block content %}
  <h1>
    Sign up
  </h1>
  <div class="module">
```

```
    <p>Enter your details to create an account:</p>
    <form method="post">
      {{ form.as_p }}
      {% csrf_token %}
      <p><input type="submit" value="Create my account"></p>
    </form>
  </div>
{% endblock %}
```

Run the development server and open `http://127.0.0.1:8000/students/register/` in your browser. You should see a registration form like this:

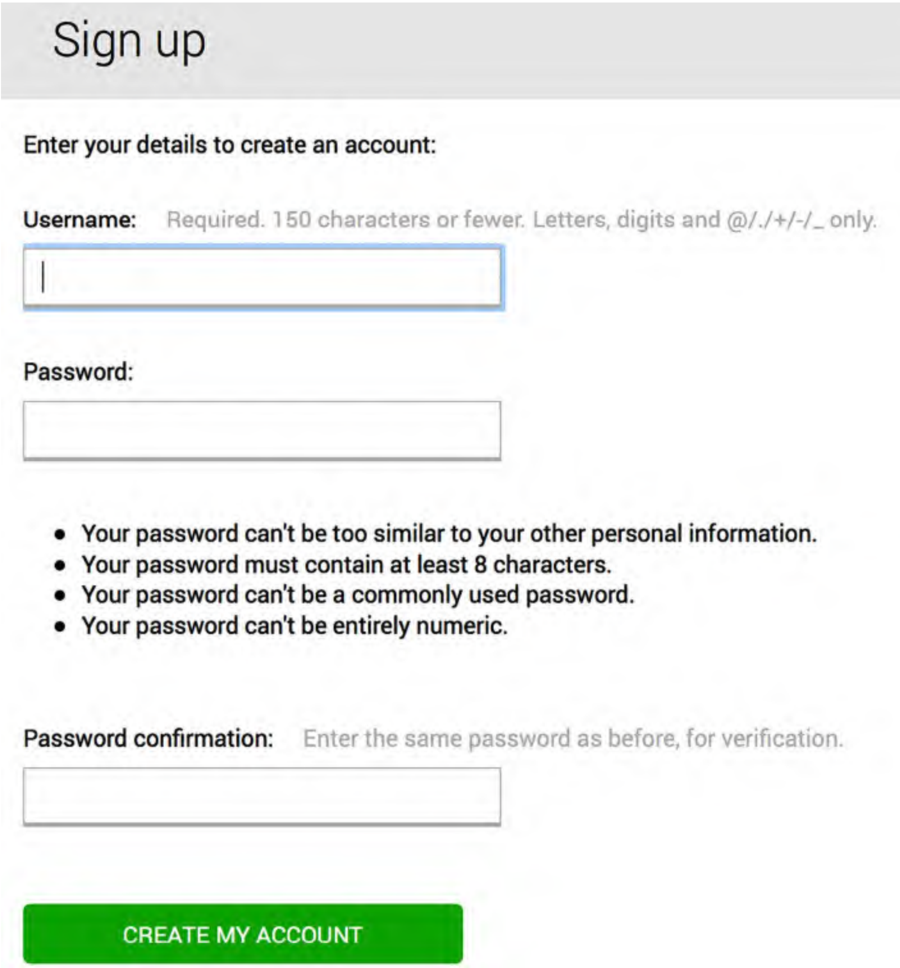


Figure 14.4: The student registration form

Note that the `student_course_list` URL specified in the `success_url` attribute of the `StudentRegistrationView` view doesn't exist yet. If you submit the form, Django won't find the URL to redirect you to after a successful registration. As mentioned, you will create this URL in the *Accessing the course contents* section.

Enrolling in courses

After users create an account, they should be able to enroll in courses. To store enrollments, you need to create a many-to-many relationship between the `Course` and `User` models.

Edit the `models.py` file of the `courses` application and add the following field to the `Course` model:

```
students = models.ManyToManyField(
    User,
    related_name='courses_joined',
    blank=True
)
```

From the shell, execute the following command to create a migration for this change:

```
python manage.py makemigrations
```

You will see output similar to this:

```
Migrations for 'courses':
  courses/migrations/0004_course_students.py
    - Add field students to course
```

Then, execute the next command to apply pending migrations:

```
python manage.py migrate
```

You should see some output that ends with the following line:

```
Applying courses.0004_course_students... OK
```

You can now associate students with the courses in which they are enrolled. Let's create the functionality for students to enroll in courses.

Create a new file inside the `students` application directory and name it `forms.py`. Add the following code to it:

```
from django import forms
from courses.models import Course


class CourseEnrollForm(forms.Form):
    course = forms.ModelChoiceField(
        queryset=Course.objects.none(),
        widget=forms.HiddenInput
```

```
    )

    def __init__ (self, form):
        super(CourseEnrollForm, self).__init__(*args, **kwargs)
        self.fields['course'].queryset = Course.objects.all()
```

This form will be used to enroll students in courses. The `course` field is for the course in which the user will be enrolled; therefore, it's `ModelChoiceField`. You use a `HiddenInput` widget because this field is not intended to be visible to the user. Initially, you define the QuerySet as `Course.objects.none()`. Using `none()` creates an empty QuerySet that does not return any objects and, importantly, does not query the database. This avoids unnecessary database load during form initialization. You populate the actual QuerySet in the `__init__()` method of the form. This dynamic setting allows you to adapt the form to different situations, such as filtering available courses based on specific criteria. Overall, this approach gives you greater flexibility in managing form data, ensuring that data is fetched based on the context in which the form is used. This method also aligns with best practices in Django for handling form QuerySets efficiently.

You are going to use this form in the `CourseDetailView` view to display a button to enroll. Edit the `views.py` file of the `students` application and add the following code:

```
from django.contrib.auth.mixins import LoginRequiredMixin
from django.views.generic.edit import FormView
from .forms import CourseEnrollForm


class StudentEnrollCourseView(LoginRequiredMixin, FormView):
    course = None
    form_class = CourseEnrollForm

    def form_valid(self, form):
        self.course = form.cleaned_data['course']
        self.course.students.add(self.request.user)
        return super().form_valid(form)

    def get_success_url(self):
        return reverse_lazy(
            'student_course_detail', args=[self.course.id]
        )
```

This is the `StudentEnrollCourseView` view. It handles the enrollment of students in courses. The view inherits from the `LoginRequiredMixin` mixin so that only logged-in users can access the view. It also inherits from Django's `FormView` view, since it handles a form submission. You use the `CourseEnrollForm` form for the `form_class` attribute and also define a `course` attribute for storing the given `Course` object. When the form is valid, the current user is added to the students enrolled in the course.

The `get_success_url()` method returns the URL that the user will be redirected to if the form was successfully submitted. This method is equivalent to the `success_url` attribute. Then, you reverse the URL named `student_course_detail`.

Edit the `urls.py` file of the `students` application and add the following URL pattern to it:

```
path(
    'enroll-course/',
    views.StudentEnrollCourseView.as_view(),
    name='student_enroll_course'
),
```

Let's add the enroll button form to the course overview page. Edit the `views.py` file of the `courses` application and modify `CourseDetailView` to make it look as follows:

```
from students.forms import CourseEnrollForm


class CourseDetailView(DetailView):
    model = Course
    template_name = 'courses/course/detail.html'

    def get_context_data(self, **kwargs):
        context = super().get_context_data(**kwargs)
        context['enroll_form'] = CourseEnrollForm(
            initial={'course':self.object}
        )
        return context
```

You use the `get_context_data()` method to include the enrollment form in the context for rendering the templates. You initialize the hidden `course` field of the form with the current `Course` object so that it can be submitted directly.

Edit the `courses/course/detail.html` template and locate the following line:

```
{{ object.overview|linebreaks }}
```

Replace it with the following code:

```
{{ object.overview|linebreaks }}
{% if request.user.is_authenticated %}
  <form action="{% url "student_enroll_course" %}" method="post">
    {{ enroll_form }}
    {% csrf_token %}
    <input type="submit" value="Enroll now">
  </form>
{% else %}
```

```
  <a href="{% url "student_registration" %}" class="button">
    Register to enroll
  </a>
{% endif %}
```

This is the button for enrolling in courses. If the user is authenticated, the enrollment button is displayed, including the hidden form that points to the `student_enroll_course` URL. If the user is not authenticated, a link to register on the platform will be displayed instead.

Make sure that the development server is running, open `http://127.0.0.1:8000/` in your browser, and click a course. If you are logged in, you should see an **ENROLL NOW** button placed below the course overview, as follows:

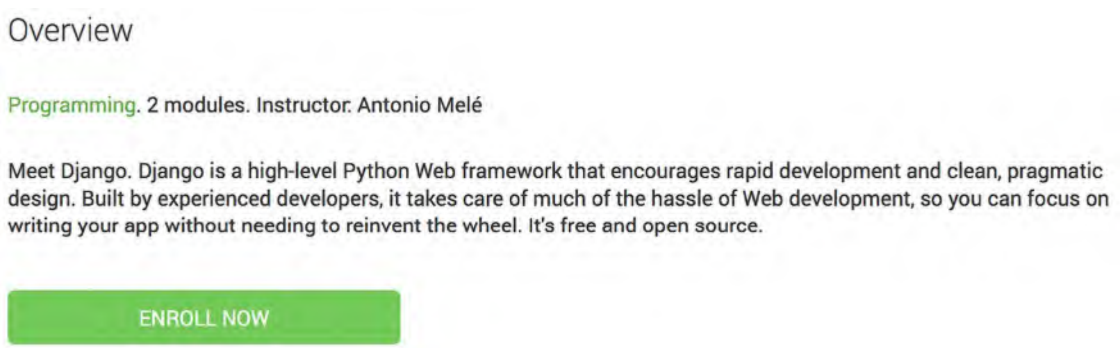


Figure 14.5: The course overview page, including an ENROLL NOW button

If you are not logged in, you will see a **REGISTER TO ENROLL** button instead.

Rendering course contents

Once students are enrolled in courses, they need a central location to access all courses they are signed up for. We need to compile the list of courses the student is enrolled in and provide access to the contents of each course. Then, we need to implement a system to render various types of content, such as text, images, videos and documents, which make up the course modules. Let's build the necessary views and templates for users to access course contents.

Accessing course contents

You need a view for displaying the courses that students are enrolled in and a view for accessing the actual course contents. Edit the `views.py` file of the `students` application and add the following code to it:

```
from django.views.generic.list import ListView
from courses.models import Course


class StudentCourseListView(LoginRequiredMixin, ListView):
    model = Course
```

```
    template_name = 'students/course/list.html'

    def get_queryset(self):
        qs = super().get_queryset()
        return qs.filter(students__in=[self.request.user])
```

This is the view to see courses that students are enrolled in. It inherits from `LoginRequiredMixin` to make sure that only logged-in users can access the view. It also inherits from the generic `ListView` for displaying a list of `Course` objects. You override the `get_queryset()` method to retrieve only the courses that a student is enrolled in; you filter the QuerySet by the student's `ManyToManyField` field to do so.

Then, add the following code to the `views.py` file of the `students` application:

```
from django.views.generic.detail import DetailView


class StudentCourseDetailView(LoginRequiredMixin, DetailView):
    model = Course
    template_name = 'students/course/detail.html'

    def get_queryset(self):
        qs = super().get_queryset()
        return qs.filter(students__in=[self.request.user])

    def get_context_data(self, **kwargs):
        context = super().get_context_data(**kwargs)
        # get course object
        course = self.get_object()
        if 'module_id' in self.kwargs:
            # get current module
            context['module'] = course.modules.get(
                id=self.kwargs['module_id']
            )
        else:
            # get first module
            context['module'] = course.modules.all()[0]
        return context
```

This is the `StudentCourseDetailView` view. You override the `get_queryset()` method to limit the base QuerySet to courses in which the student is enrolled. You also override the `get_context_data()` method to set a course module in the context if the `module_id` URL parameter is given. Otherwise, you set the first module of the course. This way, enrolled students will be able to navigate through modules inside a course.

Edit the `urls.py` file of the `students` application and add the following URL patterns to it:

```
path(
    'courses/',
    views.StudentCourseListView.as_view(),
    name='student_course_list'
),
path(
    'course/<pk>/',
    views.StudentCourseDetailView.as_view(),
    name='student_course_detail'
),
path(
    'course/<pk>/<module_id>/',
    views.StudentCourseDetailView.as_view(),
    name='student_course_detail_module'
),
```

Create the following file structure inside the `templates/students/` directory of the `students` application:

```
course/
    detail.html
    list.html
```

Edit the `students/course/list.html` template and add the following code to it:

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

{% block title %}My courses{% endblock %}

{% block content %}
  <h1>My courses</h1>
  <div class="module">
    {% for course in object_list %}
      <div class="course-info">
        <h3>{{ course.title }}</h3>
        <p><a href="{% url "student_course_detail" course.id %}">
        Access contents</a></p>
      </div>
    {% empty %}
      <p>
        You are not enrolled in any courses yet.
        <a href="{% url "course_list" %}">Browse courses</a>
```

```
        to enroll in a course.
      </p>
    {% endfor %}
  </div>
{% endblock %}
```

This template displays the courses that the student is enrolled in. Remember that when a new student successfully registers with the platform, they will be redirected to the `student_course_list` URL. Let's also redirect students to this URL when they log in to the platform.

Edit the `settings.py` file of the `educa` project and add the following code to it:

```
from django.urls import reverse_lazy
LOGIN_REDIRECT_URL = reverse_lazy('student_course_list')
```

This is the setting used by the `auth` module to redirect the student after a successful login if no `next` parameter is present in the request. After a successful login, a student will be redirected to the `student_course_list` URL to view the courses that they are enrolled in.

Edit the `students/course/detail.html` template and add the following code to it:

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

{% block title %}
  {{ object.title }}
{% endblock %}

{% block content %}
  <h1>
    {{ module.title }}
  </h1>
  <div class="contents">
    <h3>Modules</h3>
    <ul id="modules">
      {% for m in object.modules.all %}
        <li data-id="{{ m.id }}" {% if m == module %}class="selected"{% endif
%}>
          <a href="{% url "student_course_detail_module" object.id m.id %}">
            <span>
              Module <span class="order">{{ m.order|add:1 }}</span>
            </span>
            <br>
            {{ m.title }}
          </a>
        </li>
```

```
        {% empty %}
          <li>No modules yet.</li>
        {% endfor %}
      </ul>
    </div>
    <div class="module">
      {% for content in module.contents.all %}
        {% with item=content.item %}
          <h2>{{ item.title }}</h2>
          {{ item.render }}
        {% endwith %}
      {% endfor %}
    </div>
{% endblock %}
```

Make sure no template tag is split across multiple lines. This is the template for enrolled students to access the contents of a course. First, you build an HTML list including all course modules and highlighting the current module. Then, you iterate over the current module contents and access each content item to display it using `{{ item.render }}`. You will add the `render()` method to the content models next. This method will take care of rendering the content properly.

You can now access `http://127.0.0.1:8000/students/register/`, register a new student account, and enroll in any course.

Rendering different types of content

To display the course contents, you need to render the different content types that you created: *text*, *image*, *video*, and *file*.

Edit the `models.py` file of the `courses` application and add the following `render()` method to the `ItemBase` model:

```python
from django.template.loader import render_to_string


class ItemBase(models.Model):
    # ...
    def render(self):
        return render_to_string(
            f'courses/content/{self._meta.model_name}.html',
            {'item': self}
        )
```

This method uses the `render_to_string()` function for rendering a template and returning the rendered content as a string. Each kind of content is rendered using a template named after the content model. `self._meta.model_name` is used to generate the appropriate template name for each content model dynamically. The `render()` method provides a common interface for rendering diverse content.

Create the following file structure inside the `templates/courses/` directory of the `courses` application:

```
content/
    text.html
    file.html
    image.html
    video.html
```

Edit the `courses/content/text.html` template and write this code:

```
{{ item.content|linebreaks }}
```

This is the template to render text content. The `linebreaks` template filter replaces line breaks in plain text with HTML line breaks.

Edit the `courses/content/file.html` template and add the following:

```
<p>
  <a href="{{ item.file.url }}" class="button">Download file</a>
</p>
```

This is the template to render files. It generates a link to download the file.

Edit the `courses/content/image.html` template and write:

```
<p>
  <img src="{{ item.file.url }}" alt="{{ item.title }}">
</p>
```

This is the template to render images.

You also have to create a template for rendering `Video` objects. You will use `django-embed-video` for embedding video content. `django-embed-video` is a third-party Django application that allows you to embed videos in your templates, from sources such as YouTube or Vimeo, by simply providing their public URL.

Install the package with the following command:

```
python -m pip install django-embed-video==1.4.9
```

Edit the `settings.py` file of your project and add the application to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
```

```
    'embed_video',
]
```

You can find the `django-embed-video` application's documentation at `https://django-embed-video.readthedocs.io/en/latest/`.

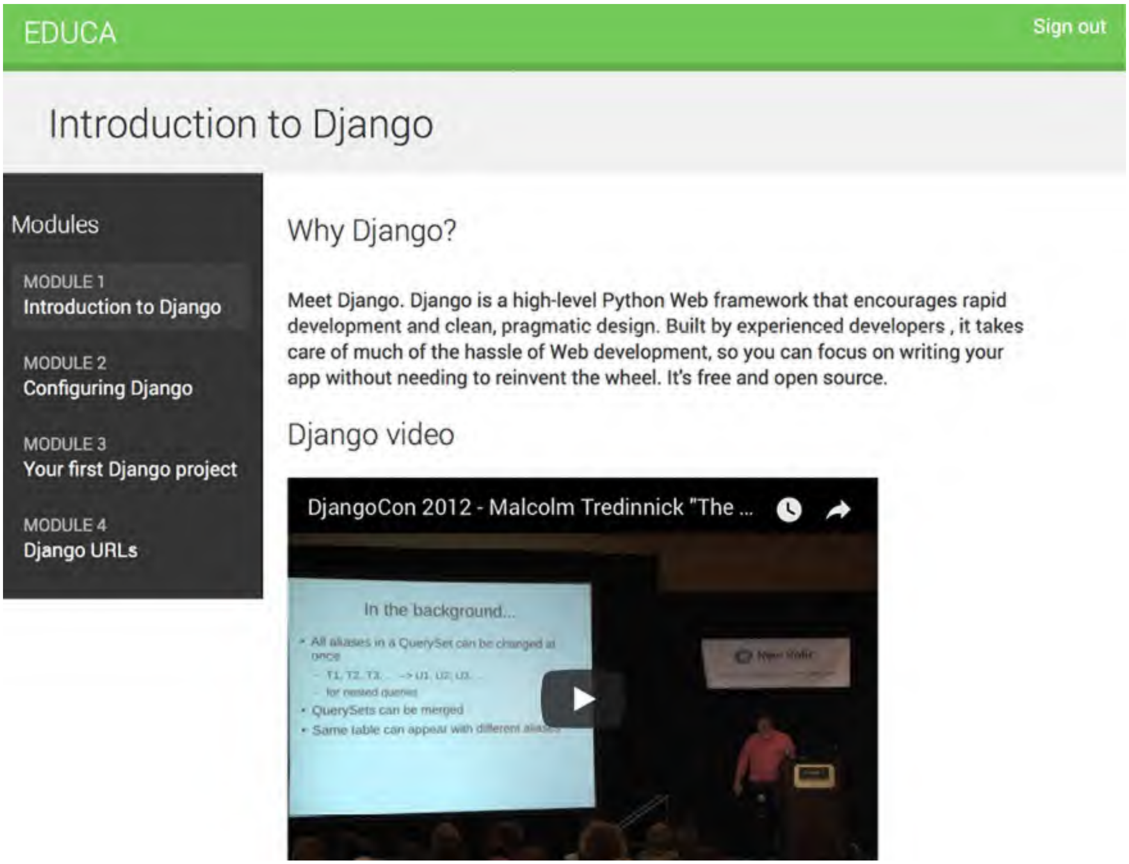
Edit the `courses/content/video.html` template and write the following code:

```
{% load embed_video_tags %}
{% video item.url "small" %}
```

This is the template to render videos.

Now, run the development server and access `http://127.0.0.1:8000/course/mine/` in your browser. Access the site with a user that belongs to the `Instructors` group, and add multiple contents to a course. To include video content, you can just copy any YouTube URL, such as `https://www.youtube.com/watch?v=bgV39DlmZ2U`, and include it in the `url` field of the form.

After adding contents to the course, open `http://127.0.0.1:8000/`, click the course, and click on the **ENROLL NOW** button. You should be enrolled in the course and redirected to the `student_course_detail` URL. *Figure 14.6* shows a sample course contents page:



Great! You have created a common interface for rendering courses with different types of content.

Using the cache framework

Processing HTTP requests to your web application usually entails database access, data manipulation, and template rendering. It is much more expensive in terms of processing than just serving a static website. The overhead in some requests can be significant when your site starts getting more and more traffic. This is where caching becomes essential. By caching queries, calculation results, or rendered content in an HTTP request, you will avoid expensive operations in the following requests that need to return the same data. This translates into shorter response times and less processing on the server side.

Django includes a robust cache system that allows you to cache data with different levels of granularity. You can cache a single query, the output of a specific view, parts of rendered template content, or your entire site. Items are stored in the cache system for a default time, but you can specify the timeout when you cache data.

This is how the cache framework is usually used when your application processes an HTTP request:

1. Try to find the requested data in the cache.
2. If found, return the cached data.
3. If not found, perform the following steps:
    a. Perform the database query or processing required to generate the data.
    b. Save the generated data in the cache.
    c. Return the data.

You can read detailed information about Django's cache system at `https://docs.djangoproject.com/en/5.0/topics/cache/`.

Available cache backends

Django comes with the following cache backends:

- `backends.memcached.PyMemcacheCache` or `backends.memcached.PyLibMCCache`: Memcached backends. Memcached is a fast and efficient memory-based cache server. The backend to use depends on the Memcached Python bindings you choose.
- `backends.redis.RedisCache`: A Redis cache backend. This backend was added in Django 4.0.
- `backends.db.DatabaseCache`: Uses the database as a cache system.
- `backends.filebased.FileBasedCache`: Uses the file storage system. This serializes and stores each cache value as a separate file.
- `backends.locmem.LocMemCache`: A local memory cache backend. This is the default cache backend.
- `backends.dummy.DummyCache`: A dummy cache backend intended only for development. It implements the cache interface without actually caching anything. This cache is per-process and thread-safe.

For optimal performance, use a memory-based cache backend like Memcached or Redis, since accessing memory is faster than accessing data from databases of files.

Installing Memcached

Memcached is a popular high-performance, memory-based cache server. We are going to use Memcached and the `PyMemcacheCache` Memcached backend.

Installing the Memcached Docker image

Run the following command from the shell to pull the Memcached Docker image:

```
docker pull memcached:1.6.26
```

This will download the Memcached Docker image to your local machine. You can find more information about the official Memcached Docker image at `https://hub.docker.com/_/memcached`. If you don't want to use Docker, you can also download Memcached from `https://memcached.org/downloads`.

Run the Memcached Docker container with the following command:

```
docker run -it --rm --name memcached -p 11211:11211 memcached:1.6.26 -m 64
```

Memcached runs on port `11211` by default. The `-p` option is used to publish the `11211` port to the same host interface port. The `-m` option is used to limit the memory for the container to `64` MB. Memcached runs in memory, and it is allotted a specified amount of RAM. When the allotted RAM is full, Memcached starts removing the oldest data to store new data. If you want to run the command in detached mode (in the background of your terminal), you can use the `-d` option.

You can find more information about Memcached at `https://memcached.org`.

Installing the Memcached Python binding

After installing Memcached, you have to install a Memcached Python binding. We will install `pymemcache`, which is a fast, pure-Python Memcached client. Run the following command in the shell:

```
python -m pip install pymemcache==4.0.0
```

You can read more information about the `pymemcache` library at `https://github.com/pinterest/pymemcache`.

Django cache settings

Django provides the following cache settings:

- `CACHES`: A dictionary containing all available caches for the project.
- `CACHE_MIDDLEWARE_ALIAS`: The cache alias to use for storage.

- CACHE_MIDDLEWARE_KEY_PREFIX: The prefix to use for cache keys. Set a prefix to avoid key collisions if you share the same cache between several sites.
- CACHE_MIDDLEWARE_SECONDS: The default number of seconds to cache pages.

The caching system for the project can be configured using the CACHES settings. This setting allows you to specify the configuration for multiple caches. Each cache included in the CACHES dictionary can specify the following data:

- BACKEND: The cache backend to use.
- KEY_FUNCTION: A string containing a dotted path to a callable that takes a prefix, version, and key as arguments and returns a final cache key.
- KEY_PREFIX: A string prefix for all cache keys, to avoid collisions.
- LOCATION: The location of the cache. Depending on the cache backend, this might be a directory, a host and port, or a name for the in-memory backend.
- OPTIONS: Any additional parameters to be passed to the cache backend.
- TIMEOUT: The default timeout, in seconds, for storing the cache keys. It is 300 seconds by default, which is 5 minutes. If set to None, the cache keys will not expire.
- VERSION: The default version number for the cache keys. Useful for cache versioning.

You can find more information about the CACHES settings at https://docs.djangoproject.com/en/5.0/ref/settings/#caches.

Adding Memcached to your project

Let's configure the cache for your project. Edit the settings.py file of the educa project and add the following code to it:

```
CACHES = {
    'default': {
        'BACKEND': 'django.core.cache.backends.memcached.PyMemcacheCache',
        'LOCATION': '127.0.0.1:11211',
    }
}
```

You are using the PyMemcacheCache backend. You specify its location using the address:port notation. If you have multiple Memcached instances, you can use a list for LOCATION.

You have set up Memcached for your project. Let's start caching data!

Cache levels

Django provides the following levels of caching, listed here by ascending order of granularity:

- **Low-level cache API**: Provides the highest granularity. Allows you to cache specific queries or calculations.

- **Template cache:** Allows you to cache template fragments.
- **Per-view cache:** Provides caching for individual views.
- **Per-site cache:** The highest-level cache. It caches your entire site.

Think about your cache strategy before implementing caching. Focus first on expensive queries or calculations that are not calculated on a per-user basis.

In the upcoming sections, we will explore how to use each of these caching levels in our project.

Let's start by learning how to use the low-level cache API in your Python code.

Using the low-level cache API

The low-level cache API allows you to store objects in the cache with any granularity. It is located at `django.core.cache`. You can import it like this:

```
from django.core.cache import cache
```

This uses the default cache. It's equivalent to `caches['default']`. Accessing a specific cache is also possible via its alias:

```
from django.core.cache import caches
my_cache = caches['alias']
```

Let's take a look at how the cache API works. Open the Django shell with the following command:

```
python manage.py shell
```

Execute the following code:

```
>>> from django.core.cache import cache
>>> cache.set('musician', 'Django Reinhardt', 20)
```

You access the default cache backend and use `set(key, value, timeout)` to store a key named `'musician'` with a value that is the string `'Django Reinhardt'` for 20 seconds. If you don't specify a timeout, Django uses the default timeout specified for the cache backend in the `CACHES` settings. Now, execute the following code:

```
>>> cache.get('musician')
'Django Reinhardt'
```

You retrieve the key from the cache. Wait for 20 seconds and execute the same code:

```
>>> cache.get('musician')
```

No value is returned this time. The `'musician'` cache key has expired and the `get()` method returns `None` because the key is not in the cache anymore.

Always avoid storing a None value in a cache key because you won't be able to distinguish between the actual value and a cache miss.

Let's cache a QuerySet with the following code:

```
>>> from courses.models import Subject
>>> subjects = Subject.objects.all()
>>> cache.set('my_subjects', subjects)
```

You perform a QuerySet on the `Subject` model and store the returned objects in the `'my_subjects'` key. Let's retrieve the cached data:

```
>>> cache.get('my_subjects')
<QuerySet [<Subject: Mathematics>, <Subject: Music>, <Subject: Physics>,
<Subject: Programming>]>
```

You are going to cache some queries in your views. Edit the `views.py` file of the `courses` application and add the following import:

```
from django.core.cache import cache
```

In the `get()` method of the `CourseListView`, find the following lines:

```
subjects = Subject.objects.annotate(
    total_courses=Count('courses')
)
```

Replace the lines with the following ones:

```
subjects = cache.get('all_subjects')
if not subjects:
    subjects = Subject.objects.annotate(
        total_courses=Count('courses')
    )
    cache.set('all_subjects', subjects)
```

In this code, you try to get the `all_subjects` key from the cache using `cache.get()`. This returns `None` if the given key is not found. If no key is found (not cached yet or cached but timed out), the query is performed to retrieve all `Subject` objects and their number of courses, and the result is cached using `cache.set()`.

Checking cache requests with Django Debug Toolbar

Let's add Django Debug Toolbar to the project to check the cache queries. You learned how to use Django Debug Toolbar in *Chapter 7*, *Tracking User Actions*.

First, install Django Debug Toolbar with the following command:

```
python -m pip install django-debug-toolbar==4.3.0
```

Edit the `settings.py` file of your project and add `debug_toolbar` to the `INSTALLED_APPS` setting, as follows. The new line is highlighted in bold:

```
INSTALLED_APPS = [
    # ...
    'debug_toolbar',
]
```

In the same file, add the following line highlighted in bold to the `MIDDLEWARE` setting:

```
MIDDLEWARE = [
    'debug_toolbar.middleware.DebugToolbarMiddleware',
    'django.middleware.security.SecurityMiddleware',
    'django.contrib.sessions.middleware.SessionMiddleware',
    'django.middleware.common.CommonMiddleware',
    'django.middleware.csrf.CsrfViewMiddleware',
    'django.contrib.auth.middleware.AuthenticationMiddleware',
    'django.contrib.messages.middleware.MessageMiddleware',
    'django.middleware.clickjacking.XFrameOptionsMiddleware',
]
```

Remember that `DebugToolbarMiddleware` has to be placed before any other middleware, except for middleware that encodes the response's content, such as `GZipMiddleware`, which, if present, should come first.

Add the following lines at the end of the `settings.py` file:

```
INTERNAL_IPS = [
    '127.0.0.1',
]
```

Django Debug Toolbar will only display if your IP address matches an entry in the `INTERNAL_IPS` setting.

Edit the main `urls.py` file of the project and add the following URL pattern to `urlpatterns`:

```
path('__debug__/', include('debug_toolbar.urls')),
```

Run the development server and open `http://127.0.0.1:8000/` in your browser.

You should now see Django Debug Toolbar on the right side of the page. Click on **Cache** in the sidebar menu. You will see the following panel:

Figure 14.7: The Cache panel of Django Debug Toolbar including cache requests for CourseListView on a cache miss

Under **Total calls** you should see **2**. The first time the `CourseListView` view is executed, there are two cache requests. Under **Commands**, you will see that the `get` command has been executed once, and that the `set` command has been executed once as well. The `get` command corresponds to the call that retrieves the `all_subjects` cache key. This is the first call displayed under **Calls**. The first time the view is executed, a cache miss occurs because no data is cached yet. That's why there is **1** under **Cache misses**. Then, the `set` command is used to store the results of the `subjects` QuerySet in the cache using the `all_subjects` cache key. This is the second call displayed under **Calls**.

In the **SQL** menu item of Django Debug Toolbar, you will see the total number of SQL queries executed in this request. This includes the query to retrieve all subjects that are then stored in the cache:

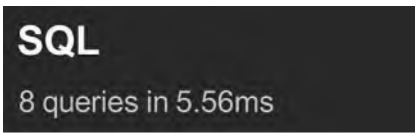


Figure 14.8: SQL queries executed for CourseListView on a cache miss

Reload the page in the browser and click on **Cache** in the sidebar menu:

Figure 14.9: The Cache panel of Django Debug Toolbar, including cache requests for the CourseList-View view on a cache hit

Now, there is only a single cache request. Under **Total calls**, you should see **1**, and under **Commands**, you can see that the cache request corresponds to a `get` command. In this case, there is a cache hit (see **Cache hits**) instead of a cache miss because the data has been found in the cache. Under **Calls**, you can see the `get` request to retrieve the `all_subjects` cache key.

Check the **SQL** menu item of the debug toolbar. You should see that there is one less SQL query in this request. You are saving one SQL query because the view finds the data in the cache and doesn't need to retrieve it from the database:

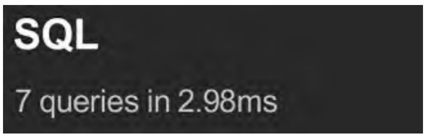


Figure 14.10: SQL queries executed for CourseListView on a cache hit

In this example, for a single request, it takes more time to retrieve the item from the cache than the time saved on the additional SQL query. However, when you have many users accessing your site, you will find that significant time reductions can be achieved by retrieving the data from the cache instead of hitting the database, and you will be able to serve the site to more concurrent users.

Successive requests to the same URL will retrieve the data from the cache. Since we didn't specify a timeout when caching data with `cache.set('all_subjects', subjects)` in the `CourseListView` view, the default timeout will be used (300 seconds by default, which is 5 minutes). When the timeout is reached, the next request to the URL will generate a cache miss, the QuerySet will be executed, and data will be cached for another 5 minutes. You can define a different default timeout in the `TIMEOUT` element of the `CACHES` setting.

Low-level caching based on dynamic data

Often, you will want to cache something that is based on dynamic data. In these cases, you have to build dynamic keys that contain all the information required to uniquely identify the cached data.

Edit the `views.py` file of the `courses` application and modify the `CourseListView` view to make it look like this:

```
class CourseListView(TemplateResponseMixin, View):
    model = Course
    template_name = 'courses/course/list.html'

    def get(self, request, subject=None):
        subjects = cache.get('all_subjects')
        if not subjects:
            subjects = Subject.objects.annotate(
                total_courses=Count('courses')
            )
            cache.set('all_subjects', subjects)
        all_courses = Course.objects.annotate(
            total_modules=Count('modules')
        )
        if subject:
            subject = get_object_or_404(Subject, slug=subject)
            key = f'subject_{subject.id}_courses'
            courses = cache.get(key)
            if not courses:
                courses = all_courses.filter(subject=subject)
                cache.set(key, courses)
        else:
            courses = cache.get('all_courses')
            if not courses:
                courses = all_courses
                cache.set('all_courses', courses)
        return self.render_to_response(
            {
                'subjects': subjects,
                'subject': subject,
                'courses': courses
            }
        )
```

In this case, you also cache both all courses and courses filtered by subject. You use the `all_courses` cache key for storing all courses if no subject is given. If there is a subject, you build the key dynamically with `f'subject_{subject.id}_courses'`.

It's important to note that you can't use a cached QuerySet to build other QuerySets, since what you cached are actually the results of the QuerySet. So you can't do the following:

```
courses = cache.get('all_courses')
courses.filter(subject=subject)
```

Instead, you have to create the base QuerySet `Course.objects.annotate(total_modules=Count('modules'))`, which is not going to be executed until it is forced, and use it to further restrict the QuerySet with `all_courses.filter(subject=subject)` for cases where the data was not found in the cache.

Caching template fragments

Caching template fragments is a higher-level approach. You need to load the cache template tags in your template using `{% load cache %}`. Then, you will be able to use the `{% cache %}` template tag to cache specific template fragments. You usually use the template tag as follows:

```
{% cache 300 fragment_name %}
    ...
{% endcache %}
```

The `{% cache %}` template tag has two required arguments: the timeout in seconds and a name for the fragment. If you need to cache content depending on dynamic data, you can do so by passing additional arguments to the `{% cache %}` template tag to uniquely identify the fragment.

Edit the `/students/course/detail.html` file of the `students` application. Add the following code at the top of it, just after the `{% extends %}` tag:

```
{% load cache %}
```

Then, find the following lines:

```
{% for content in module.contents.all %}
  {% with item=content.item %}
    <h2>{{ item.title }}</h2>
    {{ item.render }}
  {% endwith %}
{% endfor %}
```

Replace them with the following ones:

```
{% cache 600 module_contents module %}
  {% for content in module.contents.all %}
    {% with item=content.item %}
```

```
        <h2>{{ item.title }}</h2>
        {{ item.render }}
      {% endwith %}
    {% endfor %}
  {% endcache %}
```

You cache this template fragment using the name `module_contents` and pass the current `Module` object to it. Thus, you uniquely identify the fragment. This is important to avoid caching a module's contents and serving the wrong content when a different module is requested.

If the `USE_I18N` setting is set to `True`, the per-site middleware cache will respect the active language. If you use the `{% cache %}` template tag, you have to use one of the translation-specific variables available in templates to achieve the same result, such as `{% cache 600 name request.LANGUAGE_CODE %}`.

Caching views

You can cache the output of individual views using the `cache_page` decorator located at `django.views.decorators.cache`. The decorator requires a `timeout` argument (in seconds).

Let's use it in your views. Edit the `urls.py` file of the `students` application and add the following import:

```
from django.views.decorators.cache import cache_page
```

Then, apply the `cache_page` decorator to the `student_course_detail` and `student_course_detail_module` URL patterns, as follows:

```
path(
    'course/<pk>/',
    cache_page(60 * 15)(views.StudentCourseDetailView.as_view()),
    name='student_course_detail'
),
path(
    'course/<pk>/<module_id>/',
    cache_page(60 * 15)(views.StudentCourseDetailView.as_view()),
    name='student_course_detail_module'
),
```

Now, the complete content returned by the `StudentCourseDetailView` is cached for 15 minutes.

> The per-view cache uses the URL to build the cache key. Multiple URLs pointing to the same view will be cached separately.

Using the per-site cache

This is the highest-level cache. It allows you to cache your entire site. To allow the per-site cache, edit the `settings.py` file of your project and add the `UpdateCacheMiddleware` and `FetchFromCacheMiddleware` classes to the `MIDDLEWARE` setting, as follows:

```
MIDDLEWARE = [
    'debug_toolbar.middleware.DebugToolbarMiddleware',
    'django.middleware.security.SecurityMiddleware',
    'django.contrib.sessions.middleware.SessionMiddleware',
    'django.middleware.cache.UpdateCacheMiddleware',
    'django.middleware.common.CommonMiddleware',
    'django.middleware.cache.FetchFromCacheMiddleware',
    'django.middleware.csrf.CsrfViewMiddleware',
    'django.contrib.auth.middleware.AuthenticationMiddleware',
    'django.contrib.messages.middleware.MessageMiddleware',
    'django.middleware.clickjacking.XFrameOptionsMiddleware',
]
```

Remember that middleware is executed in the given order during the request phase, and in reverse order during the response phase. `UpdateCacheMiddleware` is placed before `CommonMiddleware` because it runs during response time, when middleware is executed in reverse order. `FetchFromCacheMiddleware` is placed after `CommonMiddleware` intentionally because it needs to access the request data set by the latter.

Next, add the following settings to the `settings.py` file:

```
CACHE_MIDDLEWARE_ALIAS = 'default'
CACHE_MIDDLEWARE_SECONDS = 60 * 15  # 15 minutes
CACHE_MIDDLEWARE_KEY_PREFIX = 'educa'
```

In these settings, you use the default cache for your cache middleware and set the global cache timeout to `15` minutes. You also specify a prefix for all cache keys to avoid collisions in case you use the same Memcached backend for multiple projects. Your site will now cache and return cached content for all `GET` requests.

You can access the different pages and check the cache requests using Django Debug Toolbar. The per-site cache is not viable for many sites because it affects all views, even the ones that you might not want to cache, like management views where you want data to be returned from the database to reflect the latest changes.

In this project, the best approach is to cache the templates or views that are used to display course contents to students while keeping the content management views for instructors without any cache.

Let's deactivate the per-site cache. Edit the `settings.py` file of your project and comment out the `UpdateCacheMiddleware` and `FetchFromCacheMiddleware` classes in the `MIDDLEWARE` setting, as follows:

```
MIDDLEWARE = [
    'debug_toolbar.middleware.DebugToolbarMiddleware',
    'django.middleware.security.SecurityMiddleware',
    'django.contrib.sessions.middleware.SessionMiddleware',
    # 'django.middleware.cache.UpdateCacheMiddleware',
    'django.middleware.common.CommonMiddleware',
    # 'django.middleware.cache.FetchFromCacheMiddleware',
    'django.middleware.csrf.CsrfViewMiddleware',
    'django.contrib.auth.middleware.AuthenticationMiddleware',
    'django.contrib.messages.middleware.MessageMiddleware',
    'django.middleware.clickjacking.XFrameOptionsMiddleware',
]
```

You have seen an overview of the different methods provided by Django to cache data. You should always define your cache strategy wisely, taking into account expensive QuerySets or calculations, data that won't change frequently, and data that will be accessed concurrently by many users.

Using the Redis cache backend

Django also provides a Redis cache backend. Let's change the settings to use Redis instead of Memcached as the cache backend for the project. Remember that you already used Redis in *Chapter 7, Tracking User Actions*, and in *Chapter 10, Extending Your Shop*.

Install `redis-py` in your environment using the following command:

```
python -m pip install redis==5.0.4
```

Then, edit the `settings.py` file of the `educa` project and modify the `CACHES` setting, as follows:

```
CACHES = {
    'default': {
        'BACKEND': 'django.core.cache.backends.redis.RedisCache',
        'LOCATION': 'redis://127.0.0.1:6379',
    }
}
```

The project will now use the `RedisCache` cache backend. The location is defined in the format `redis://[host]:[port]`. You use `127.0.0.1` to point to the localhost and `6379`, which is the default port for Redis.

You can read more about the Redis cache backend at `https://docs.djangoproject.com/en/5.0/topics/cache/#redis`.

Initialize the Redis Docker container using the following command:

```
docker run -it --rm --name redis -p 6379:6379 redis:7.2.4
```

If you want to run the command in the background (in detached mode), you can use the `-d` option.

Run the development server and open `http://127.0.0.1:8000/` in your browser. Check the cache requests in the **Cache** panel of Django Debug Toolbar. You are now using Redis as your project's cache backend instead of Memcached.

Monitoring Redis with Django Redisboard

You can monitor your Redis server using Django Redisboard. Django Redisboard adds Redis statistics to the Django administration site. You can find more information about Django Redisboard at `https://github.com/ionelmc/django-redisboard`.

Install `django-redisboard` in your environment using the following command:

```
python -m pip install django-redisboard==8.4.0
```

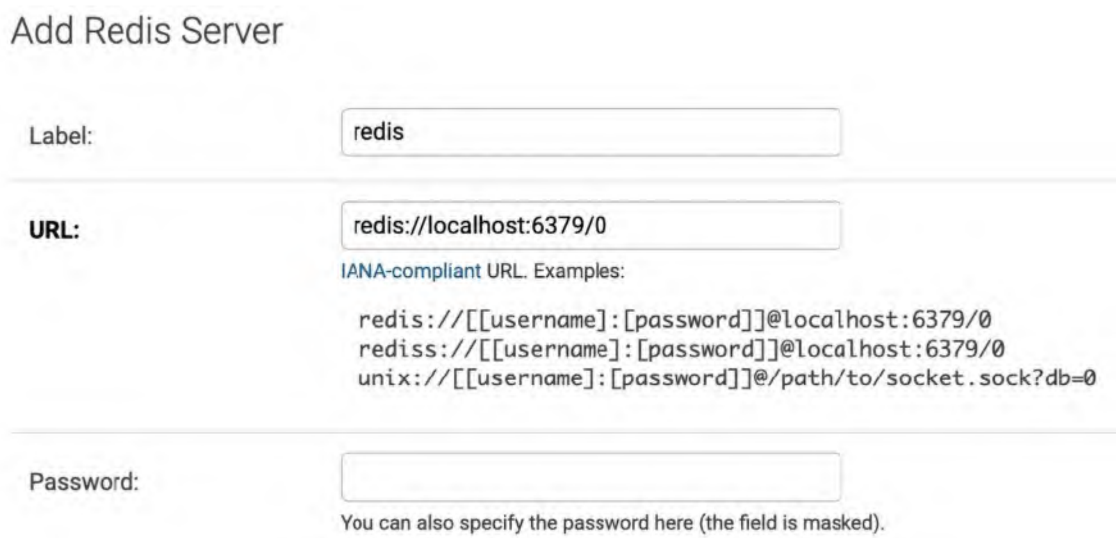
Edit the `settings.py` file of your project and add the application to the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'redisboard',
]
```

Run the following command from your project's directory to run the Django Redisboard migrations:

```
python manage.py migrate redisboard
```

Run the development server and open `http://127.0.0.1:8000/admin/redisboard/redisserver/add/` in your browser to add a Redis server to monitor. For **Label**, enter `redis`, and for **URL**, enter `redis://localhost:6379/0`, as in *Figure 14.11*:



We will monitor the Redis instance running on our localhost, which runs on port `6379` and uses the Redis database numbered `0`. Click on **SAVE**. The information will be saved to the database, and you will be able to see the Redis configuration and metrics on the Django administration site:

Figure 14.12: The Redis monitoring of Django Redisboard on the administration site

Congratulations! You have successfully implemented caching for your project.

Summary

In this chapter, you implemented the public views for the course catalog. You built a system for students to register and enroll in courses. You also created the functionality to render different types of content for the course modules. Finally, you learned how to use the Django cache framework and you used the Memcached and Redis cache backends for your project.

In the next chapter, you will build a RESTful API for your project using Django REST framework and consume it using the Python Requests library.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter14`

- `django-embed-video` documentation: `https://django-embed-video.readthedocs.io/en/latest/`
- Django's cache framework documentation: `https://docs.djangoproject.com/en/5.0/topics/cache/`
- Memcached Docker image: `https://hub.docker.com/_/memcached`
- Memcached downloads: `https://memcached.org/downloads`
- Memcached official website: `https://memcached.org`
- Django's `CACHES` settings documentation: `https://docs.djangoproject.com/en/5.0/ref/settings/#caches`.
- `pymemcache`'s source code: `https://github.com/pinterest/pymemcache`
- Django Redis cache backend: `https://docs.djangoproject.com/en/5.0/topics/cache/#redis`
- Official Redis Docker image: `https://hub.docker.com/_/redis`
- Redis download options: `https://redis.io/download/`
- Django Redisboard source code: `https://github.com/ionelmc/django-redisboard`

15

Building an API

In the previous chapter, you built a system for student registration and enrollment in courses. You created views to display course contents and learned how to use Django's cache framework.

In this chapter, you will create a RESTful API for your e-learning platform. An API is a common programmable interface that can be used on multiple platforms like websites, mobile applications, plugins, and so on. For example, you can create an API to be consumed by a mobile application for your e-learning platform. If you provide an API to third parties, they will be able to consume information and operate with your application programmatically. An API allows developers to automate actions on your platform and integrate your service with other applications or online services. You will build a fully featured API for your e-learning platform.

In this chapter, you will:

- Install Django REST framework
- Create serializers for your models
- Build a RESTful API
- Implement serializer method fields
- Create nested serializers
- Implement ViewSet views and routers
- Build custom API views
- Handle API authentication
- Add permissions to API views
- Create custom permissions
- Use the Requests library to consume the API

Functional overview

Figure 15.1 shows a representation of the views and API endpoints that will be built in this chapter:

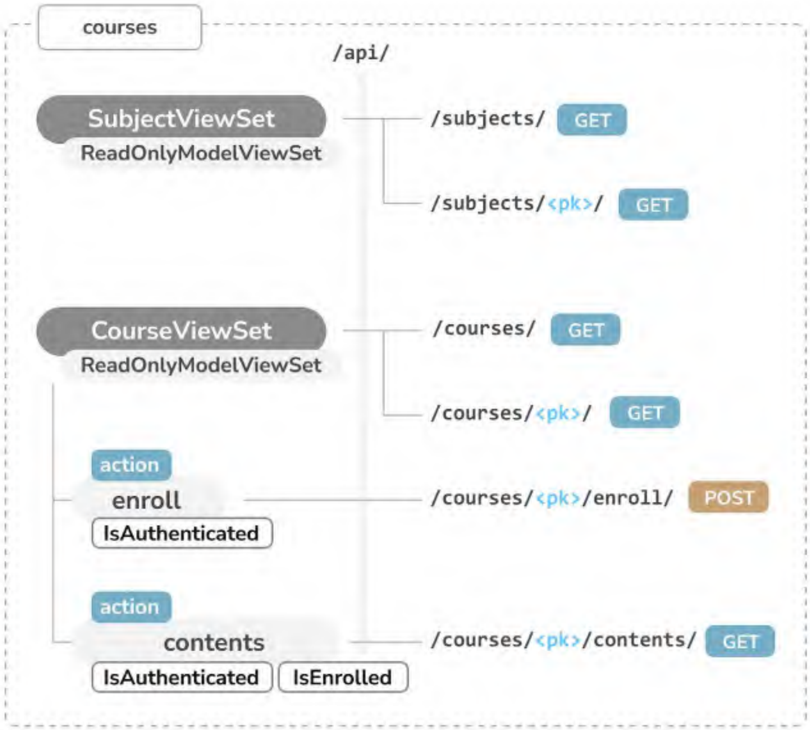


Figure 15.1: Diagram of API views and endpoints to be built in Chapter 15

In this chapter, you will create two different sets of API views, `SubjectViewSet` and `CourseViewSet`. The former will include the list and detail views for subjects. The latter will include the list and detail views for courses. You will also implement the `enroll` action in `CourseViewSet` to enroll students in courses. This action will be only available to authenticated users, by using the `IsAuthenticated` permission. You will create the `contents` action in `CourseViewSet` to access a course's content. To access course contents, users have to be authenticated and enrolled in the given course. You will implement the custom `IsEnrolled` permission to limit access to contents to the users enrolled in the course.

If you are not familiar with API endpoints, you just need to know that they are the specific locations within an API that accept and respond to requests. Each endpoint corresponds to a URL that may accept one or more HTTP methods, like `GET`, `POST`, `PUT`, or `DELETE`.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter15`.

All Python modules used in this chapter are included in the `requirements.txt` file in the source code that accompanies this chapter. You can follow the instructions to install each Python module below, or you can install all requirements at once with the command `python -m pip install -r requirements.txt`.

Building a RESTful API

When building an API, there are several ways you can structure its endpoints and actions, but following REST principles is encouraged.

The **REST** architecture comes from **Representational State Transfer**. RESTful APIs are resource-based; your models represent resources, and HTTP methods such as `GET`, `POST`, `PUT`, or `DELETE` are used to retrieve, create, update, or delete objects. HTTP response codes are also used in this context. Different HTTP response codes are returned to indicate the result of the HTTP request, for example, `2XX` response codes for success, `4XX` for errors, and so on.

The most common formats to exchange data in RESTful APIs are JSON and XML. You will build a RESTful API with JSON serialization for your project. Your API will provide the following functionalities:

- Retrieving subjects
- Retrieving available courses
- Retrieving course contents
- Enrolling in a course

You can build an API from scratch with Django by creating custom views. However, there are several third-party modules that simplify creating an API for your project; the most popular among them is **Django REST framework** (**DRF**).

DRF provides a comprehensive set of tools to build RESTful APIs for your projects. The following are some of the most relevant components that we will use to build our API:

- **Serializers**: To transform data into a standardized format that other programs can understand, or to *deserialize* data, by converting data into a format that your program can process.
- **Parsers and renderers**: To render (or format) serialized data appropriately before it is returned in an HTTP response. Similarly, to parse incoming data to ensure that it's in the correct form.
- **API views**: To implement the application logic.
- **URLs**: To define the API endpoints that will be available.
- **Authentication and permissions**: To define authentication methods for the API and the permissions required for each view.

We will start by installing DRF and, after that, we will learn more about these components to build our first API.

Installing Django REST framework

You can find all the information about **DRF** at `https://www.django-rest-framework.org/`.

Open the shell and install the framework with the following command:

```
python -m pip install djangorestframework==3.15.1
```

Edit the `settings.py` file of the `educa` project and add `rest_framework` to the `INSTALLED_APPS` setting to activate the application, as follows:

```
INSTALLED_APPS = [
    # ...
    'rest_framework',
]
```

Then, add the following code to the `settings.py` file:

```
REST_FRAMEWORK = {
    'DEFAULT_PERMISSION_CLASSES': [
        'rest_framework.permissions.DjangoModelPermissionsOrAnonReadOnly'
    ]
}
```

You can provide a specific configuration for your API using the `REST_FRAMEWORK` setting. DRF offers a wide range of settings to configure default behaviors. The `DEFAULT_PERMISSION_CLASSES` setting specifies the default permissions to read, create, update, or delete objects. You set `DjangoModelPermissionsOrAnonReadOnly` as the only default permission class. This class relies on Django's permissions system to allow users to create, update, or delete objects while providing read-only access for anonymous users. You will learn more about permissions later, in the *Adding permissions to views* section.

For a complete list of available settings for DRF, you can visit `https://www.django-rest-framework.org/api-guide/settings/`.

Defining serializers

After setting up DRF, you need to specify how your data will be serialized. Output data has to be serialized in a specific format, and input data will be deserialized for processing. The framework provides the following classes to build serializers for single objects:

- `Serializer`: Provides serialization for normal Python class instances
- `ModelSerializer`: Provides serialization for model instances
- `HyperlinkedModelSerializer`: The same as `ModelSerializer`, but it represents object relationships with links rather than primary keys

Let's build our first serializer. Create the following file structure inside the `courses` application directory:

```
api/
    __init__.py
    serializers.py
```

You will build all the API functionality inside the `api` directory to keep everything well organized. Edit the `api/serializers.py` file and add the following code:

```python
from rest_framework import serializers
from courses.models import Subject

class SubjectSerializer(serializers.ModelSerializer):
    class Meta:
        model = Subject
        fields = ['id', 'title', 'slug']
```

This is the serializer for the `Subject` model. Serializers are defined in a similar fashion to Django's `Form` and `ModelForm` classes. The `Meta` class allows you to specify the model to serialize and the fields to be included for serialization. All model fields will be included if you don't set a `fields` attribute.

Let's try the serializer. Open the command line and start the Django shell with the following command:

```
python manage.py shell
```

Run the following code:

```python
>>> from courses.models import Subject
>>> from courses.api.serializers import SubjectSerializer
>>> subject = Subject.objects.latest('id')
>>> serializer = SubjectSerializer(subject)
>>> serializer.data
{'id': 4, 'title': 'Programming', 'slug': 'programming'}
```

In this example, you get a `Subject` object, create an instance of `SubjectSerializer`, and access the serialized data. You can see that the model data is translated into Python native data types.

You can read more about serializers at `https://www.django-rest-framework.org/api-guide/serializers/`.

Understanding parsers and renderers

The serialized data has to be rendered in a specific format before you return it in an HTTP response. Likewise, when you get an HTTP request, you have to parse the incoming data and deserialize it before you can operate with it. DRF includes renderers and parsers to handle that.

Let's see how to parse incoming data. Execute the following code in the Python shell:

```python
>>> from io import BytesIO
>>> from rest_framework.parsers import JSONParser
>>> data = b'{"id":4,"title":"Programming","slug":"programming"}'
>>> JSONParser().parse(BytesIO(data))
{'id': 4, 'title': 'Programming', 'slug': 'programming'}
```

Given a JSON string input, you can use the `JSONParser` class provided by DRF to convert it to a Python object.

DRF also includes `Renderer` classes that allow you to format API responses. The framework determines which renderer to use through content negotiation by inspecting the request's `Accept` header to determine the expected content type for the response. Optionally, the renderer is determined by the format suffix of the URL. For example, the URL `http://127.0.0.1:8000/api/data.json` might be an endpoint that triggers the `JSONRenderer` in order to return a JSON response.

Go back to the shell and execute the following code to render the `serializer` object from the previous serializer example:

```
>>> from rest_framework.renderers import JSONRenderer
>>> JSONRenderer().render(serializer.data)
```

You will see the following output:

```
b'{"id":4,"title":"Programming","slug":"programming"}'
```

You use the `JSONRenderer` to render the serialized data into JSON. By default, DRF uses two different renderers: `JSONRenderer` and `BrowsableAPIRenderer`. The latter provides a web interface to easily browse your API. You can change the default renderer classes with the `DEFAULT_RENDERER_CLASSES` option of the `REST_FRAMEWORK` setting.

You can find more information about renderers and parsers at `https://www.django-rest-framework.org/api-guide/renderers/` and `https://www.django-rest-framework.org/api-guide/parsers/`, respectively.

Next, you are going to learn how to build API views and use serializers in views.

Building list and detail views

DRF comes with a set of generic views and mixins that you can use to build your API views. You have been using generic views throughout this book since *Chapter 2*, *Enhancing Your Blog and Adding Social Features*, and you learned about mixins in *Chapter 13*, *Creating a Content Management System*.

The base views and mixins provide the functionality to retrieve, create, update, or delete model objects. You can see all the generic mixins and views provided by DRF at `https://www.django-rest-framework.org/api-guide/generic-views/`.

Let's create list and detail views to retrieve `Subject` objects. Create a new file inside the `courses/api/` directory and name it `views.py`. Add the following code to it:

```
from rest_framework import generics
from courses.api.serializers import SubjectSerializer
from courses.models import Subject


class SubjectListView(generics.ListAPIView):
    queryset = Subject.objects.all()
    serializer_class = SubjectSerializer
```

```
class SubjectDetailView(generics.RetrieveAPIView):
    queryset = Subject.objects.all()
    serializer_class = SubjectSerializer
```

In this code, you use the generic `ListAPIView` and `RetrieveAPIView` views of DRF. Both views have the following attributes:

- `queryset`: The base QuerySet to use to retrieve objects
- `serializer_class`: The class to serialize objects

Let's add URL patterns for your views. Create a new file inside the `courses/api/` directory, name it `urls.py`, and make it look as follows:

```
from django.urls import path
from . import views


app_name = 'courses'

urlpatterns = [
    path(
        'subjects/',
        views.SubjectListView.as_view(),
        name='subject_list'
    ),
    path(
        'subjects/<pk>/',
        views.SubjectDetailView.as_view(),
        name='subject_detail'
    ),
]
```

In the URL pattern for the `SubjectDetailView` view, you include a `pk` URL parameter to retrieve the object with the given primary key of the `Subject` model, which is the `id` field. Edit the main `urls.py` file of the `educa` project and include the API patterns, as follows:

```
urlpatterns = [
    # ...
    path('api/', include('courses.api.urls', namespace='api')),
]
```

You use the `api` namespace for your API URLs. Our initial API endpoints are ready to be used.

Consuming the API

By making our views available via URLs, we have created our first API endpoints. Let's now try our own API. Ensure that your server is running with the following command:

```
python manage.py runserver
```

We are going to use `curl` to consume the API. `curl` is a command-line tool that allows you to transfer data to and from a server. If you are using Linux, macOS, or Windows 10/11, `curl` is very likely included in your system. However, you can download `curl` from `https://curl.se/download.html`.

Open the shell and retrieve the URL `http://127.0.0.1:8000/api/subjects/` with `curl`, as follows:

```
curl http://127.0.0.1:8000/api/subjects/
```

You will get a response similar to the following one:

```
[
    {
        "id":1,
        "title":"Mathematics",
        "slug":"mathematics"
    },
    {
        "id":2,
        "title":"Music",
        "slug":"music"
    },
    {
        "id":3,
        "title":"Physics",
        "slug":"physics"
    },
    {
        "id":4,
        "title":"Programming",
        "slug":"programming"
    }
]
```

To obtain a more readable, well-indented JSON response, you can use `curl` with the `json_pp` utility, as follows:

```
curl http://127.0.0.1:8000/api/subjects/ | json_pp
```

The HTTP response contains a list of `Subject` objects in the JSON format.

Instead of `curl`, you can also use any other tool to send custom HTTP requests, including a browser extension such as Postman, which you can get at `https://www.getpostman.com/`.

Open `http://127.0.0.1:8000/api/subjects/` in your browser. You will see DRF's browsable API, as follows:

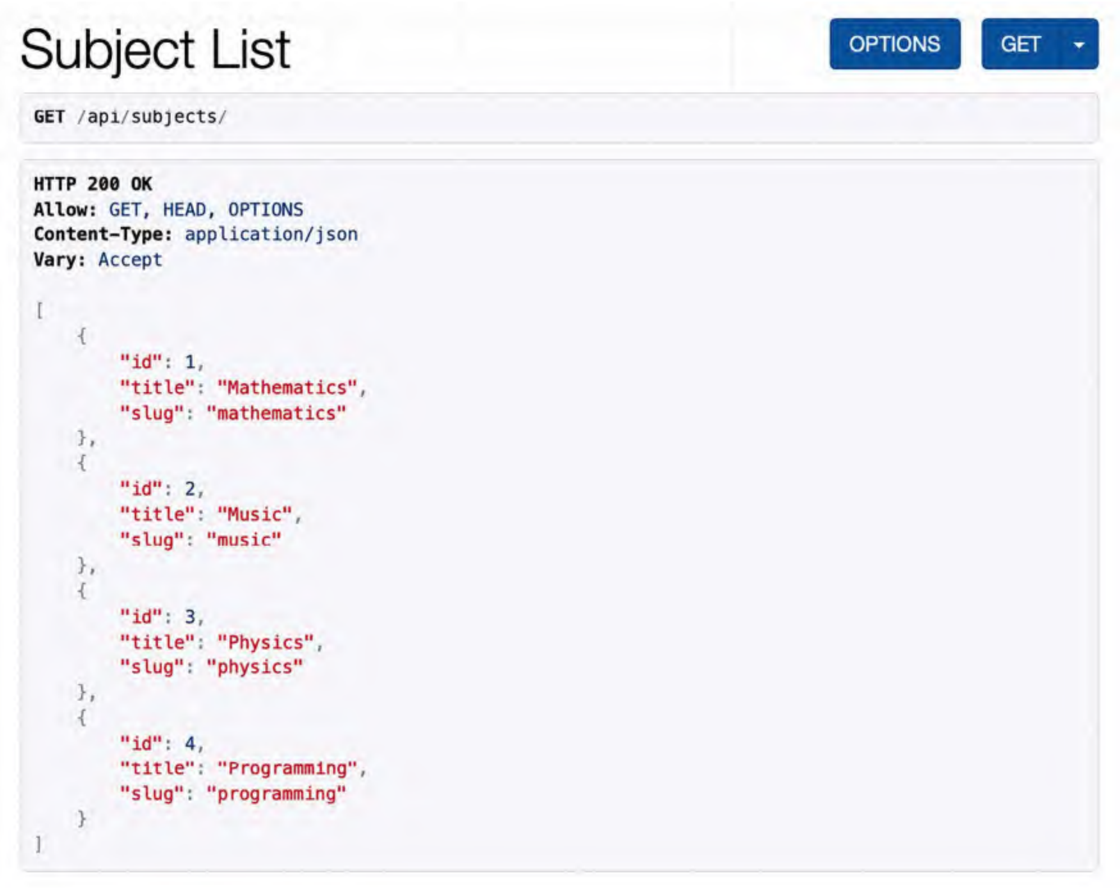


Figure 15.2: The Subject List page in the REST framework browsable API

This HTML interface is provided by the `BrowsableAPIRenderer` renderer. It displays the result headers and content, and it allows you to perform requests. You can also access the API detail view for a `Subject` object by including its ID in the URL.

Open `http://127.0.0.1:8000/api/subjects/1/` in your browser. You will see a single `Subject` object rendered in the JSON format.

Figure 15.3: The Subject Detail page in the REST framework browsable API

This is the response for the `SubjectDetailView`. Let's learn how to enrich the content returned for each subject. In the next section, we are going to dive into extending serializers with additional fields and methods.

Extending serializers

You have learned how to serialize your model objects; however, often, you may want to enrich the response with additional relevant data or calculated fields. Let's take a look at some of the options to extend serializers.

Adding additional fields to serializers

Let's edit the subject views to include the number of courses available for each subject. You will use the Django aggregation functions to annotate the count of related courses for each subject.

Edit the `api/views.py` file of the `courses` application and add the following code highlighted in bold:

```
from django.db.models import Count
# ...

class SubjectListView(generics.ListAPIView):
    queryset = Subject.objects.annotate(total_courses=Count('courses'))
    serializer_class = SubjectSerializer
```

```python
class SubjectDetailView(generics.RetrieveAPIView):
    queryset = Subject.objects.annotate(total_courses=Count('courses'))
    serializer_class = SubjectSerializer
```

You are now using a QuerySet for the `SubjectListView` and `SubjectDetailView` that uses the `Count` aggregation function to annotate the related course count.

Edit the `api/serializers.py` file of the `courses` application and add the following code highlighted in bold:

```python
from rest_framework import serializers
from courses.models import Subject

class SubjectSerializer(serializers.ModelSerializer):
    total_courses = seralizers.IntegerField()

    class Meta:
        model = Subject
        fields = ['id', 'title', 'slug', 'total_courses']
```

You have added the `total_courses` field to the `SubjectSerializer` class. This field is an `IntegerField` to represent integers. This field will automatically get its value from the `total_courses` attribute of the object being serialized. By using `annotate()`, we added the `total_courses` attribute to the resulting objects of the `QuerySet`.

Open `http://127.0.0.1:8000/api/subjects/1/` in your browser. The serialized JSON object now includes the `total_courses` attribute, as shown in *Figure 15.4*:

```
HTTP 200 OK
Allow: GET, HEAD, OPTIONS
Content-Type: application/json
Vary: Accept

{
    "id": 1,
    "title": "Mathematics",
    "slug": "mathematics",
    "total_courses": 4
}
```

Figure 15.4: The Subject Detail page, including the total_courses attribute

You have successfully added the `total_courses` attribute to the subject list and detail views. Now, let's look into adding additional attributes using custom serializer methods.

Implementing serializer method fields

DRF provides SerializerMethodField, which allows you to implement read-only fields that get their value by calling a method of the serializer class. This can be particularly useful when you want to include some custom formatted data in your serialized object or perform complex calculations that are not directly a part of your model instances.

We will create a method that serializes the top 3 popular courses for a subject. We will rank courses by the number of students enrolled in them. Edit the api/serializers.py file of the courses application and add the following code highlighted in bold:

```
from django.db.models import Count
from rest_framework import serializers
from courses.models import Subject


class SubjectSerializer(serializers.ModelSerializer):
    total_courses = serializers.IntegerField()
    popular_courses = seralizers.SerializerMethodField()

    def get_popular_courses(self, obj):
        courses = obj.courses.annotate(
            total_students=Count('students')
        ).order_by('total_students')[:3]
        return [
            f'{c.title} ({c.total_students})' for c in courses
        ]

    class Meta:
        model = Subject
        fields = [
            'id',
            'title',
            'slug',
            'total_courses',
            'popular_courses'
        ]
```

In the new code, you add the new popular_courses serializer method field to SubjectSerializer. The field gets its value from the get_popular_courses() method. You can provide the name of the serializer method to call with the method_field argument of SerializerMethodField. If not included, this defaults to get_<field_name>.

Open http://127.0.0.1:8000/api/subjects/1/ in your browser. The serialized JSON object now includes the total_courses attribute, as shown in *Figure 15.5*:

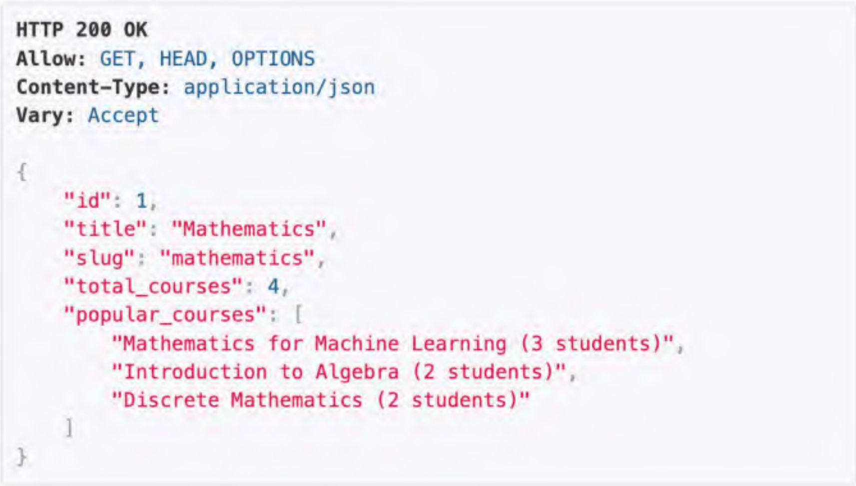


Figure 15.5: The subject detail page, including the popular_courses attribute

You have successfully implemented a `SerializerMethodField`. Note that, now, an additional SQL query is generated for each of the results returned by `SubjectListView`. Next, you are going to learn how to control the number of results returned by adding pagination to `SubjectListView`.

Adding pagination to views

DRF includes built-in pagination capabilities to control how many objects are sent over in your API responses. When the content of your site starts to grow, you might end up with a large number of subjects and courses. Pagination can be particularly useful to improve performance and the user experience when dealing with large datasets.

Let's update the `SubjectListView` view to include pagination. First, we will define a pagination class.

Create a new file inside the `courses/api/` directory and name it `pagination.py`. Add the following code to it:

```
from rest_framework.pagination import PageNumberPagination


class StandardPagination(PageNumberPagination):
    page_size = 10
    page_size_query_param = 'page_size'
    max_page_size = 50
```

In this class, we inherit from `PageNumberPagination`. This class provides support for pagination based on page numbers. We set the following attributes:

- `page_size`: Determines the default page size (the number of items returned per page) when no page size is provided in the request

- `page_size_query_params`: Defines the name for the query parameter to use for the page size
- `max_page_size`: Indicates the maximum requested page size allowed

Now, edit the `api/views.py` file of the `courses` application and add the following lines highlighted in bold:

```
from django.db.models import Count
from rest_framework import generics
from courses.models import Subject
from courses.api.pagination import StandardPagination
from courses.api.serializers import SubjectSerializer


class SubjectListView(generics.ListAPIView):
    queryset = Subject.objects.annotate(total_courses=Count('courses'))
    serializer_class = SubjectSerializer
    pagination_class = StandardPagination

# ...
```

You can now paginate the objects returned by `SubjectListView`. Open `http://127.0.0.1:8000/api/subjects/` in your browser. You can see that the JSON structure returned by the view is now different due to the pagination. You will see the following structure:

```
{
    "count": 4,
    "next": null,
    "previous": null,
    "results": [
        {
            "id": 1,
            "title": "Mathematics",
            ...
        },
        ...
    ]
}
```

The following items are now part of the JSON returned:

- `count`: The total number of results.
- `next`: The URL to retrieve the next page. The value is `null` when there are no following pages.
- `previous`: The URL to retrieve the previous page. The value is `null` when there are no previous pages.

- `results`: A list with the serialized objects returned on this page.

Open `http://127.0.0.1:8000/api/subjects/?page_size=2&page=1` in your browser. This will paginate results by two items per page and retrieve the first page of results, as shown in *Figure 15.6*:

```
GET /api/subjects/?page_size=2&page=1
```

```
HTTP 200 OK
Allow: GET, HEAD, OPTIONS
Content-Type: application/json
Vary: Accept

{
    "count": 4,
    "next": "http://127.0.0.1:8000/api/subjects/?page=2&page_size=2",
    "previous": null,
    "results": [
        {
            "id": 1,
            "title": "Mathematics",
            "slug": "mathematics",
            "total_courses": 4,
            "popular_courses": [
                "Mathematics for Machine Learning (3 students)",
                "Introduction to Algebra (2 students)",
                "Discrete Mathematics (2 students)"
            ]
        },
        {
            "id": 2,
            "title": "Music",
            "slug": "music",
            "total_courses": 2,
            "popular_courses": [
                "Songwriting and Composition (5 students)",
                "Foundations of Music Theory (2 students)"
            ]
        }
    ]
}
```

Figure 15.6: First page of results for the subject list pagination, with a page size of 2

We have implemented pagination based on the page number, but DRF also provides a class to implement limit/offset and cursor-based pagination. You can read more about pagination at `https://www.django-rest-framework.org/api-guide/pagination/`.

You have created the API endpoints for the subject views. Next, you will add course endpoints to your API.

Building the course serializer

We are going to create a serializer for the `Course` model. Edit the `api/serializers.py` file of the `courses` application and add the following code highlighted in bold:

```
# ...
from courses.models import Course, Subject

class CourseSerializer(serializers.ModelSerializer):
    class Meta:
        model = Course
        fields = [
            'id',
            'subject',
            'title',
            'slug',
            'overview',
            'created',
            'owner',
            'modules'
        ]
```

Let's take a look at how a `Course` object is serialized. Open the shell and execute the following command:

```
python manage.py shell
```

Run the following code:

```
>>> from rest_framework.renderers import JSONRenderer
>>> from courses.models import Course
>>> from courses.api.serializers import CourseSerializer
>>> course = Course.objects.latest('id')
>>> serializer = CourseSerializer(course)
>>> JSONRenderer().render(serializer.data)
```

You will get a JSON object with the fields that you included in `CourseSerializer`. You can see that the related objects of the `modules` manager are serialized as a list of primary keys, as follows:

```
"modules": [6, 7, 9, 10]
```

These are the IDs of the related `Module` objects. Next, you are going to learn different methods to serialize related objects.

Serializing relations

DRF comes with different types of related fields to represent model relationships. This works for `ForeignKey`, `ManyToManyField`, and `OneToOneField` relationships, as well as generic model relations.

We are going to use `StringRelatedField` to change how related `Module` objects are serialized. `StringRelatedField` represents the related object using its `__str__()` method.

Edit the `api/serializers.py` file of the `courses` application and add the following code highlighted in bold:

```
# ...

class CourseSerializer(serializers.ModelSerializer):
    modules = serializers.StringRelatedField(many=True, read_only=True)

    class Meta:
        # ...
```

In the new code, you define the `modules` field that provides serialization for the related `Module` objects. You use `many=True` to indicate that you are serializing multiple related objects. The `read_only` parameter indicates that this field is read-only and should not be included in any input to create or update objects.

Open the shell and create an instance of `CourseSerializer` again. Render the serializer's `data` attribute with `JSONRenderer`. This time, the listed modules are serialized using their `__str__()` method, as follows:

```
"modules": ["0. Installing Django", "1. Configuring Django"]
```

Note that DRF does not optimize QuerySets. When serializing a list of courses, a SQL query will be generated for each course result to retrieve the related `Module` objects. You can reduce the number of additional SQL requests by using `prefetch_related()` in your QuerySet, like `Course.objects.prefetch_related('modules')`. We will cover this later in the section *Creating ViewSets and routers*.

You can read more about serializer relations at `https://www.django-rest-framework.org/api-guide/relations/`.

Let's advance further and define the serialization of related objects with a nested serializer.

Creating nested serializers

If we want to include more information about each module, we need to serialize `Module` objects and nest them. Modify the previous code of the `api/serializers.py` file of the `courses` application to make it look as follows:

```
from django.db.models import Count
from rest_framework import serializers
from courses.models import Course, Module, Subject


class ModuleSerializer(serializers.ModelSerializer):
    class Meta:
        model = Module
```

```
        fields = ['order', 'title', 'description']


class CourseSerializer(serializers.ModelSerializer):
    modules = ModuleSerializer(many=True, read_only=True)

    class Meta:
        # ...
```

In the new code, you define `ModuleSerializer` to provide serialization for the `Module` model. Then, you modify the `modules` attribute of `CourseSerializer` to nest the `ModuleSerializer` serializer. You keep `many=True` to indicate that you are serializing multiple objects and `read_only=True` to keep this field read-only.

Open the shell and create an instance of `CourseSerializer` again. Render the serializer's `data` attribute with `JSONRenderer`. This time, the listed modules are serialized with the nested `ModuleSerializer` serializer, as follows:

```
"modules": [
    {
        "order": 0,
        "title": "Introduction to overview",
        "description": "A brief overview about the Web Framework."
    },
    {
        "order": 1,
        "title": "Configuring Django",
        "description": "How to install Django."
    },
    ...
]
```

Creating ViewSets and routers

ViewSets allow you to define the interactions of your API and let DRF build URLs dynamically with a `Router` object. By using ViewSets, you can avoid repeating logic for multiple views. ViewSets include actions for the following standard operations:

- Create operation: `create()`
- Retrieve operation: `list()` and `retrieve()`
- Update operation: `update()` and `partial_update()`
- Delete operation: `destroy()`

Let's create a ViewSet for the `Course` model. Edit the `api/views.py` file and add the following code highlighted in bold:

```
from django.db.models import Count
from rest_framework import generics
from rest_framework import viewsets
from courses.api.pagination import StandardPagination
from courses.api.serializers import CourseSerializer, SubjectSerializer
from courses.models import Course, Subject


class CourseViewSet(viewsets.ReadOnlyModelViewSet):
    queryset = Course.objects.prefetch_related('modules')
    serializer_class = CourseSerializer
    pagination_class = StandardPagination
```

The new `CourseViewSet` class inherits from `ReadOnlyModelViewSet`, which provides the read-only actions `list()` and `retrieve()` to list objects or retrieve a single object, respectively. You specify the base QuerySet to retrieve objects. You use `prefetch_related('modules')` to fetch the related `Module` objects in an efficient manner. This will avoid additional SQL queries when serializing nested modules for each course. In this class, you also define the serializer and pagination classes to use for the ViewSet.

Edit the `api/urls.py` file and create a router for your ViewSet, as follows:

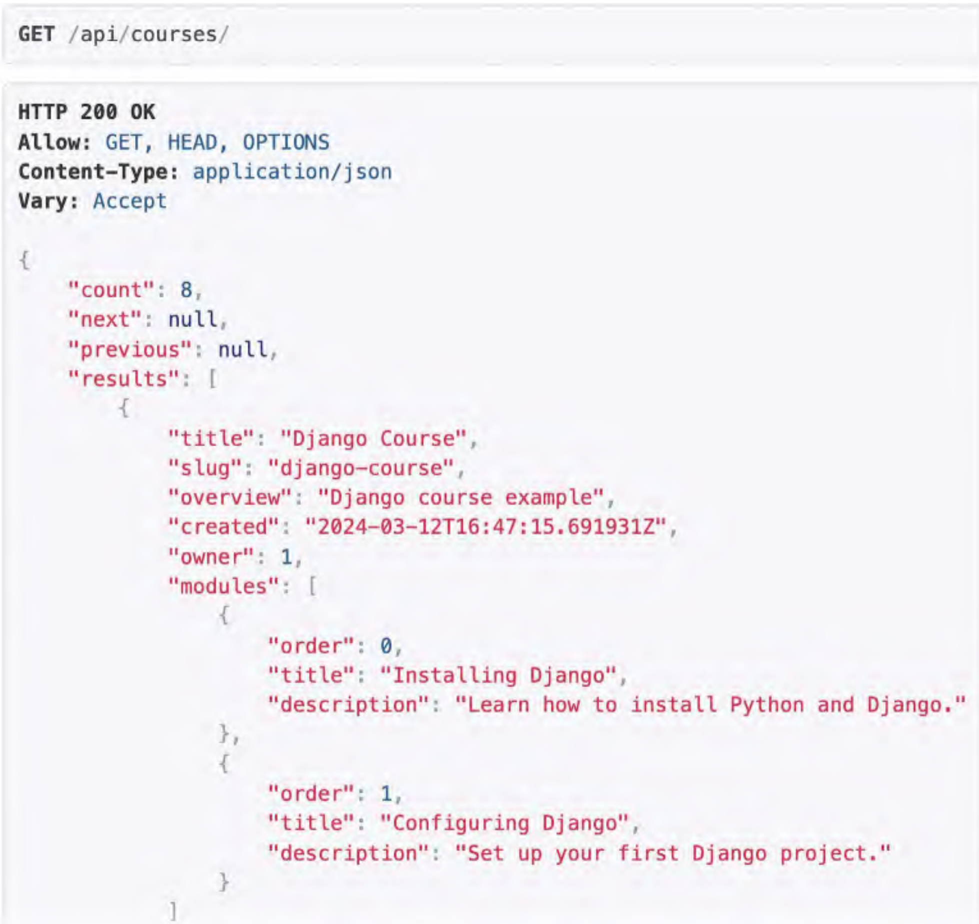
```
from django.urls import include, path
from rest_framework import routers
from . import views


app_name = 'courses'


router = routers.DefaultRouter()
router.register('courses', views.CourseViewSet)

urlpatterns = [
    # ...
    path('', include(router.urls)),
]
```

You create a `DefaultRouter` object and register `CourseViewSet` with the `courses` prefix. The router takes charge of generating URLs automatically for your `ViewSet`.

Open `http://127.0.0.1:8000/api/` in your browser. You will see that the router lists the `courses` ViewSet in its base URL, as shown in *Figure 15.7*:

Figure 15.7: The API Root page of the REST framework browsable API

You can access `http://127.0.0.1:8000/api/courses/` to retrieve the list of courses, as shown in *Figure 15.8*:



Let's convert the `SubjectListView` and `SubjectDetailView` views into a single ViewSet. Edit the `api/views.py` file, and remove or comment out the `SubjectListView` and `SubjectDetailView` classes. Then, add the following code highlighted in bold:

```
# ...
class SubjectViewSet(viewsets.ReadOnlyModelViewSet):
    queryset = Subject.objects.annotate(total_courses=Count('courses'))
    serializer_class = SubjectSerializer
    pagination_class = StandardPagination
```

Edit the `api/urls.py` file and remove or comment out the following URLs, since you don't need them anymore:

```

# path(
#     subjects/',
#     views.SubjectListView.as_view(),
#     name=subject_list'
# ),
# path(
#     subjects/<pk>/ ',
#      views.SubjectDetailView.as_view(),
#      name='subject_detail'
#),
```

In the same file, add the following code highlighted in bold:

```
from django.urls import include, path
from rest_framework import routers
from . import views

app_name = 'courses'

router = routers.DefaultRouter()
router.register('courses', views.CourseViewSet)
router.register('subjects', views.SubjectViewSet)

urlpatterns = [
    path('', include(router.urls)),
]
```

Open `http://127.0.0.1:8000/api/` in your browser. You will see that the router now includes URLs for both the `courses` and `subjects` ViewSets, as shown in *Figure 15.9*:

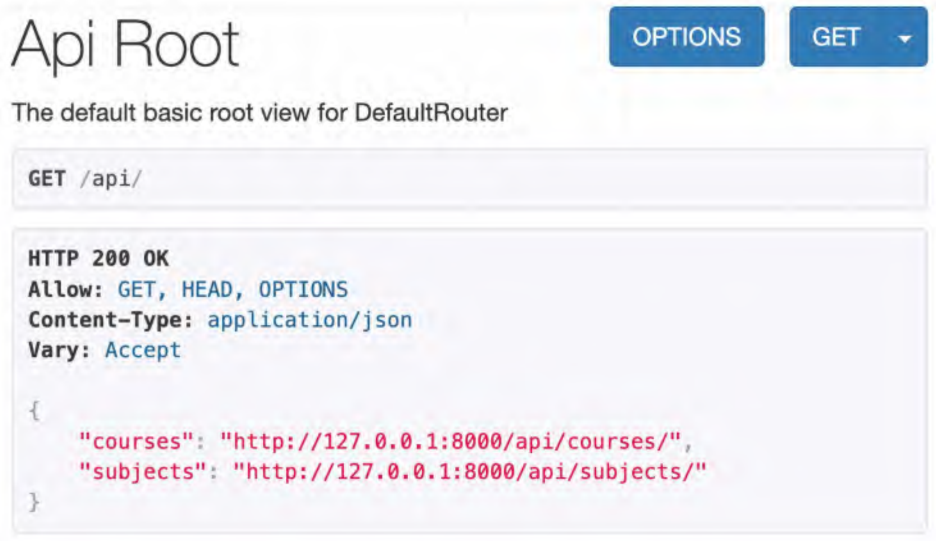


Figure 15.9: The API Root page of the REST framework browsable API

You can learn more about ViewSets at `https://www.django-rest-framework.org/api-guide/viewsets/`. You can also find more information about routers at `https://www.django-rest-framework.org/api-guide/routers/`.

Generic API views and ViewSets are very useful to build REST APIs based on your models and serializers. However, you might also need to implement your own views with custom logic. Let's learn how to create a custom API view.

Building custom API views

DRF provides an `APIView` class that builds API functionality on top of Django's `View` class. The `APIView` class differs from `View` by using DRF's custom `Request` and `Response` objects and handling `APIException` exceptions to return the appropriate HTTP responses. It also has a built-in authentication and authorization system to manage access to views.

You are going to create a view for users to enroll in courses. Edit the `api/views.py` file of the `courses` application and add the following code highlighted in bold:

```
from django.db.models import Count
from django.shortcuts import get_object_or_404
from rest_framework import generics
from rest_framework import viewsets
from rest_framework.response import Response
from rest_framework.views import APIView
from courses.api.pagination import StandardPagination
```

```
from courses.api.serializers import CourseSerializer, SubjectSerializer
from courses.models import Course, Subject

# ...

class CourseEnrollView(APIView):
    def post(self, request, pk, format=None):
        course = get_object_or_404(Course, pk=pk)
        course.students.add(request.user)
        return Response({'enrolled': True})
```

The `CourseEnrollView` view handles user enrollment in courses. The preceding code is as follows:

1. You create a custom view that subclasses `APIView`.
2. You define a `post()` method for `POST` actions. No other HTTP method will be allowed for this view.
3. You expect a `pk` URL parameter containing the ID of a course. You retrieve the course by the given `pk` parameter and raise a `404` exception if it's not found.
4. You add the current user to the `students` many-to-many relationship of the `Course` object and return a successful response.

Edit the `api/urls.py` file and add the following URL pattern to the `CourseEnrollView` view:

```
path(
    'courses/<pk>/enroll/',
    views.CourseEnrollView.as_view(),
    name='course_enroll'
),
```

Theoretically, you could now perform a `POST` request to enroll the current user in a course. However, you need to be able to identify the user and prevent unauthenticated users from accessing this view. Let's see how API authentication and permissions work.

Handling authentication

DRF provides authentication classes to identify the user performing the request. If authentication is successful, the framework sets the authenticated `User` object in `request.user`. If no user is authenticated, an instance of Django's `AnonymousUser` is set instead.

DRF provides the following authentication backends:

- `BasicAuthentication`: This is HTTP basic authentication. The user and password are sent by the client in the `Authorization` HTTP header, encoded with Base64. You can learn more about it at `https://en.wikipedia.org/wiki/Basic_access_authentication`.
- `TokenAuthentication`: This is token-based authentication. A `Token` model is used to store user tokens. Users include the token in the `Authorization` HTTP header for authentication.

- `SessionAuthentication`: This uses Django's session backend for authentication. This backend is useful for performing authenticated AJAX requests to the API from your website's frontend.
- `RemoteUserAuthentication`: This allows you to delegate authentication to your web server, which sets a `REMOTE_USER` environment variable.

You can build a custom authentication backend by subclassing the `BaseAuthentication` class provided by DRF and overriding the `authenticate()` method.

Implementing basic authentication

You can set authentication on a per-view basis or set it globally with the `DEFAULT_AUTHENTICATION_CLASSES` setting.

> Authentication only identifies the user performing the request. It won't allow or deny access to views. You have to use permissions to restrict access to views.

You can find all the information about authentication at `https://www.django-rest-framework.org/api-guide/authentication/`.

Let's add `BasicAuthentication` to your view. Edit the `api/views.py` file of the `courses` application and add an `authentication_classes` attribute to `CourseEnrollView`, as follows:

```
# ...
from rest_framework.authentication import BasicAuthentication


class CourseEnrollView(APIView):
    authentication_classes = [BasicAuthentication]
    # ...
```

Users will be identified by the credentials set in the `Authorization` header of the HTTP request.

Adding permissions to views

DRF includes a permission system to restrict access to views. Some of the built-in permissions of DRF are:

- `AllowAny`: Unrestricted access, regardless of whether a user is authenticated or not.
- `IsAuthenticated`: Allows access to authenticated users only.
- `IsAuthenticatedOrReadOnly`: Complete access to authenticated users. Anonymous users are only allowed to execute read methods such as `GET`, `HEAD`, or `OPTIONS`.
- `DjangoModelPermissions`: Permissions tied to `django.contrib.auth`. The view requires a `queryset` attribute. Only authenticated users with model permissions assigned are granted permission.

- `DjangoObjectPermissions`: Django permissions on a per-object basis.

If users are denied permission, they will usually get one of the following HTTP error codes:

- `HTTP 401`: Unauthorized
- `HTTP 403`: Permission denied

You can read more information about permissions at `https://www.django-rest-framework.org/api-guide/permissions/`.

Edit the `api/views.py` file of the `courses` application and add a `permission_classes` attribute to `CourseEnrollView`, as follows:

```
# ...
from rest_framework.authentication import BasicAuthentication
from rest_framework.permissions import IsAuthenticated

class CourseEnrollView(APIView):
    authentication_classes = [BasicAuthentication]
    permission_classes = [IsAuthenticated]
    # ...
```

You include the `IsAuthenticated` permission. This will prevent anonymous users from accessing the view. Now, you can perform a `POST` request to your new API method.

Make sure the development server is running. Open the shell and run the following command:

```
curl -i -X POST http://127.0.0.1:8000/api/courses/1/enroll/
```

You will get the following response:

```
HTTP/1.1 401 Unauthorized
...
{"detail": "Authentication credentials were not provided."}
```

You got a `401` HTTP code as expected, since you are not authenticated. Let's use basic authentication with one of your users. Run the following command, replacing `student:password` with the credentials of an existing user:

```
curl -i -X POST -u student:password http://127.0.0.1:8000/api/courses/1/enroll/
```

You will get the following response:

```
HTTP/1.1 200 OK
...
{"enrolled": true}
```

You can access the administration site and check that the user is now enrolled in the course.

Adding additional actions to ViewSets

You can add extra actions to `ViewSets`. Let's change the `CourseEnrollView` view into a custom `ViewSet` action. Edit the `api/views.py` file and modify the `CourseViewSet` class to look as follows:

```
# ...
from rest_framework.decorators import action

class CourseViewSet(viewsets.ReadOnlyModelViewSet):
    queryset = Course.objects.prefetch_related('modules')
    serializer_class = CourseSerializer

    @action(
        detail=True,
        methods=['post'],
        authentication_classes=[BasicAuthentication],
        permission_classes=[IsAuthenticated]
    )
    def enroll(self, request, *args, **kwargs):
        course = self.get_object()
        course.students.add(request.user)
        return Response({'enrolled': True})
```

In the preceding code, you add a custom `enroll()` method that represents an additional action for this `ViewSet`. The preceding code is as follows:

1. You use the `action` decorator of the framework with the parameter `detail=True` to specify that this is an action to be performed on a single object.
2. The decorator allows you to add custom attributes for the action. You specify that only the `post()` method is allowed for this view and set the authentication and permission classes.
3. You use `self.get_object()` to retrieve the `Course` object.
4. You add the current user to the `students` many-to-many relationship and return a custom success response.

Edit the `api/urls.py` file and remove or comment out the following URL, since you don't need it anymore:

```
path(
    'courses/<pk>/enroll/',
    views.CourseEnrollView.as_view(),
    name='course_enroll'
),
```

Then, edit the `api/views.py` file and remove or comment out the `CourseEnrollView` class.

The URL to enroll on courses is now automatically generated by the router. The URL remains the same, since it's built dynamically using the action name `enroll`.

After students are enrolled in a course, they need to access the course's content. Next, you are going to learn how to ensure only students who have enrolled can access the course.

Creating custom permissions

You want students to be able to access the contents of the courses they are enrolled on. Only students enrolled on a course should be able to access its contents. The best way to do this is with a custom permission class. DRF provides a `BasePermission` class that allows you to define the following methods:

- `has_permission()`: A view-level permission check
- `has_object_permission()`: An instance-level permission check

These methods should return `True` to grant access, or `False` otherwise.

Create a new file inside the `courses/api/` directory and name it `permissions.py`. Add the following code to it:

```
from rest_framework.permissions import BasePermission


class IsEnrolled(BasePermission):
    def has_object_permission(self, request, view, obj):
        return obj.students.filter(id=request.user.id).exists()
```

You subclass the `BasePermission` class and override the `has_object_permission()`. You check that the user performing the request is present in the `students` relationship of the `Course` object. You are going to use the `IsEnrolled` permission next.

Serializing course contents

You need to serialize course contents. The `Content` model includes a generic foreign key that allows you to associate objects of different content models. Yet, you added a common `render()` method for all content models in the previous chapter. You can use this method to provide rendered content to your API.

Edit the `api/serializers.py` file of the `courses` application and add the following code to it:

```
from courses.models import Content, Course, Module, Subject


class ItemRelatedField(serializers.RelatedField):
    def to_representation(self, value):
        return value.render()
```

```
class ContentSerializer(serializers.ModelSerializer):
    item = ItemRelatedField(read_only=True)
    class Meta:
        model = Content
        fields = ['order', 'item']
```

In this code, you define a custom field by subclassing the `RelatedField` serializer field provided by DRF and overriding the `to_representation()` method. You define the `ContentSerializer` serializer for the `Content` model and use the custom field for the `item` generic foreign key.

You need an alternative serializer for the `Module` model that includes its contents, as well as an extended `Course` serializer. Edit the `api/serializers.py` file and add the following code to it:

```
class ModuleWithContentsSerializer(serializers.ModelSerializer):
    contents = ContentSerializer(many=True)
    class Meta:
        model = Module
        fields = ['order', 'title', 'description', 'contents']


class CourseWithContentsSerializer(serializers.ModelSerializer):
    modules = ModuleWithContentsSerializer(many=True)
    class Meta:
        model = Course
        fields = [
            'id',
            'subject',
            'title',
            'slug',
            'overview',
            'created',
            'owner',
            'modules'
        ]
```

Let's create a view that mimics the behavior of the `retrieve()` action but includes the course contents. Edit the `api/views.py` file and add the following method to the `CourseViewSet` class:

```
# ...

from courses.api.permissions import IsEnrolled
from courses.api.serializers import CourseWithContentsSerializer

class CourseViewSet(viewsets.ReadOnlyModelViewSet):
```

```
    # ...
    @action(
        detail=True,
        methods=['get'],
        serializer_class=CourseWithContentsSerializer,
        authentication_classes=[BasicAuthentication],
        permission_classes=[IsAuthenticated, IsEnrolled]
    )
    def contents(self, request, *args, **kwargs):
        return self.retrieve(request, *args, **kwargs)
```

The description of this method is as follows:

1. You use the `action` decorator with the parameter `detail=True` to specify an action that is performed on a single object.
2. You specify that only the `GET` method is allowed for this action.
3. You use the new `CourseWithContentsSerializer` serializer class that includes rendered course contents.
4. You use both `IsAuthenticated` and your custom `IsEnrolled` permissions. By doing so, you make sure that only users enrolled in the course are able to access its contents.
5. You use the existing `retrieve()` action to return the `Course` object.

Open `http://127.0.0.1:8000/api/courses/1/contents/` in your browser. If you access the view with the right credentials, you will see that each module of the course includes the rendered HTML for course contents, as follows:

```
{
    "order": 0,
    "title": "Introduction to Django",
    "description": "Brief introduction to the Django Web Framework.",
    "contents": [
        {
            "order": 0,
            "item": "<p>Meet Django. Django is a high-level
            Python Web framework
            ...</p>"
        },
        {
            "order": 1,
            "item": "\n<iframe width=\"480\" height=\"360\"
            src=\"http://www.youtube.com/embed/bgV39DlmZ2U?
            wmode=opaque\"
```

```
            frameborder=\"0\" allowfullscreen></iframe>\n"
        }
    ]
}
```

You have built a simple API that allows other services to access the course application programmatically. DRF also allows you to handle creating and editing objects with the `ModelViewSet` class. We have covered the main aspects of DRF, but you will find further information about its features in its extensive documentation at `https://www.django-rest-framework.org/`.

Consuming the RESTful API

Now that you have implemented an API, you can consume it in a programmatic manner from other applications. You can interact with the API using the JavaScript Fetch API in the frontend of your application, in a similar fashion to the functionalities you built in *Chapter 6*, *Sharing Content on Your Website*. You can also consume the API from applications built with Python or any other programming language.

You are going to create a simple Python application that uses the RESTful API to retrieve all available courses and then enroll a student in all of them. You will learn how to authenticate against the API using HTTP basic authentication and perform `GET` and `POST` requests.

We will use the Python Requests library to consume the API. We used Requests in *Chapter 6*, *Sharing Content on Your Website*, to retrieve images by their URL. Requests abstracts the complexity of dealing with HTTP requests and provides a very simple interface to consume HTTP services. You can find the documentation for the Requests library at `https://requests.readthedocs.io/en/master/`.

Open the shell and install the Requests library with the following command:

```
python -m pip install requests==2.31.0
```

Create a new directory next to the `educa` project directory and name it `api_examples`. Create a new file inside the `api_examples/` directory and name it `enroll_all.py`. The file structure should now look like this:

```
api_examples/
    enroll_all.py
educa/
    ...
```

Edit the `enroll_all.py` file and add the following code to it:

```
import requests

base_url = 'http://127.0.0.1:8000/api/'
url = f'{base_url}courses/'
available_courses = []
```

```
while url is not None:
    print(f'Loading courses from {url}')
    r = requests.get(url)
    response = r.json()
    url = response['next']
    courses = response['results']
    available_courses += [course['title'] for course in courses]
print(f'Available courses: {", ".join(available_courses)}')
```

In this code, you perform the following actions:

1. You import the Requests library and define the base URL for the API and the URL for the course list API endpoint.
2. You define the `available_courses` empty list.
3. You use a `while` statement to paginate over all result pages.
4. You use `requests.get()` to retrieve data from the API by sending a `GET` request to the URL `http://127.0.0.1:8000/api/courses/`. This API endpoint is publicly accessible, so it does not require any authentication.
5. You use the `json()` method of the response object to decode the JSON data returned by the API.
6. You store the `next` attribute in the `url` variable to retrieve the next page of results in the `while` statement.
7. You add the `title` attribute of each course to the `available_courses` list.
8. When the `url` variable is `None`, you go to the latest page of results and you don't retrieve any additional pages.
9. You print the list of available courses.

Start the development server from the `educa` project directory with the following command:

```
python manage.py runserver
```

In another shell, run the following command from the `api_examples/` directory:

```
python enroll_all.py
```

You will see output with a list of all course titles, like this:

```
Available courses: Introduction to Django, Python for beginners, Algebra basics
```

This is the first automated call to your API.

Edit the `enroll_all.py` file and add the following lines highlighted in bold:

```
import requests

username = ''
password = ''
```

```
base_url = 'http://127.0.0.1:8000/api/'
url = f'{base_url}courses/'
available_courses = []

while url is not None:
    print(f'Loading courses from {url}')
    r = requests.get(url)
    response = r.json()
    url = response['next']
    courses = response['results']
    available_courses += [course['title'] for course in courses]
print(f'Available courses: {", ".join(available_courses)}')

for course in courses:
    course_id = course['id']
    course_title = course['title']
    r = requests.post(
        f'{base_url}courses/{course_id}/enroll/',
        auth=(username, password)
    )
    if r.status_code == 200:
        # successful request
        print(f'Successfully enrolled in {course_title}')
```

Replace the values for the `username` and `password` variables with the credentials of an existing user, or load the values from environment variables. You can use `python-decouple`, as we did in the *Working with environment variables* section in *Chapter 2*, *Enhancing Your Blog and Adding Social Features*, to load credentials from environment variables.

With the new code, you perform the following actions:

1. You define the username and password of the student you want to enroll in courses.
2. You iterate over the available courses retrieved from the API.
3. You store the course ID attribute in the `course_id` variable and the `title` attribute in the `course_title` variable.
4. You use `requests.post()` to send a `POST` request to the URL `http://127.0.0.1:8000/api/courses/[id]/enroll/` for each course. This URL corresponds to the `CourseEnrollView` API view, which allows you to enroll a user in a course. You build the URL for each course using the `course_id` variable. The `CourseEnrollView` view requires authentication. It uses the `IsAuthenticated` permission and the `BasicAuthentication` authentication class. The Requests library supports HTTP basic authentication out of the box. You use the `auth` parameter to pass a tuple with the username and password to authenticate the user, using HTTP basic authentication.

5. If the status code of the response is `200 OK`, you print a message to indicate that the user has been successfully enrolled in the course.

You can use different kinds of authentication with Requests. You can find more information on authentication with Requests at `https://requests.readthedocs.io/en/master/user/authentication/`.

Run the following command from the `api_examples/` directory:

```
python enroll_all.py
```

You will now see output like this:

```
Available courses: Introduction to Django, Python for beginners, Algebra basics
Successfully enrolled in Introduction to Django
Successfully enrolled in Python for beginners
Successfully enrolled in Algebra basics
```

Great! You have successfully enrolled the user in all available courses using the API. You will see a `Successfully enrolled` message for each course on the platform. As you can see, it's very easy to consume the API from any other application.

Summary

In this chapter, you learned how to use DRF to build a RESTful API for your project. You created serializers and views for models, and you built custom API views. You also added authentication to your API and restricted access to API views using permissions. Next, you discovered how to create custom permissions, and you implemented `ViewSets` and routers. Finally, you used the Requests library to consume the API from an external Python script.

The next chapter will teach you how to build a chat server using Django Channels. You will implement asynchronous communication using WebSockets, and you will use Redis to set up a channel layer.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter15`
- REST framework website: `https://www.django-rest-framework.org/`
- REST framework settings: `https://www.django-rest-framework.org/api-guide/settings/`
- REST framework serializers: `https://www.django-rest-framework.org/api-guide/serializers/`
- REST framework renderers: `https://www.django-rest-framework.org/api-guide/renderers/`
- REST framework parsers: `https://www.django-rest-framework.org/api-guide/parsers/`
- REST framework generic mixins and views – `https://www.django-rest-framework.org/api-guide/generic-views/`

- Download `curl`: `https://curl.se/download.html`
- Postman API platform: `https://www.getpostman.com/`
- REST framework pagination: `https://www.django-rest-framework.org/api-guide/pagination/`
- REST framework serializer relations: `https://www.django-rest-framework.org/api-guide/relations/`
- HTTP basic authentication: `https://en.wikipedia.org/wiki/Basic_access_authentication`
- REST framework authentication: `https://www.django-rest-framework.org/api-guide/authentication/`
- REST framework permissions: `https://www.django-rest-framework.org/api-guide/permissions/`
- REST framework `ViewSets`: `https://www.django-rest-framework.org/api-guide/viewsets/`
- REST framework routers: `https://www.django-rest-framework.org/api-guide/routers/`
- Python Requests library documentation: `https://requests.readthedocs.io/en/master/`
- Authentication with the Requests library: `https://requests.readthedocs.io/en/master/user/authentication/`

16

Building a Chat Server

In the previous chapter, you created a RESTful API for your project that provides a programmable interface for your application.

In this chapter, you will develop a chat server for students using Django Channels, enabling students to engage in real-time messaging within course chat rooms. You will learn how to build real-time applications through asynchronous programming with Django Channels. By serving your Django project through **Asynchronous Server Gateway Interface** (**ASGI**), and implementing asynchronous communication, you will enhance the responsiveness and scalability of your server. Additionally, you will persist chat messages into the database, building a comprehensive chat history and enriching the user experience and functionality of the chat application.

In this chapter, you will:

- Add Channels to your project
- Build a WebSocket consumer and appropriate routing
- Implement a WebSocket client
- Enable a channel layer with Redis
- Make your consumer fully asynchronous
- Persist chat messages into the database

Functional overview

Figure 16.1 shows a representation of the views, templates, and functionalities that will be built in this chapter:

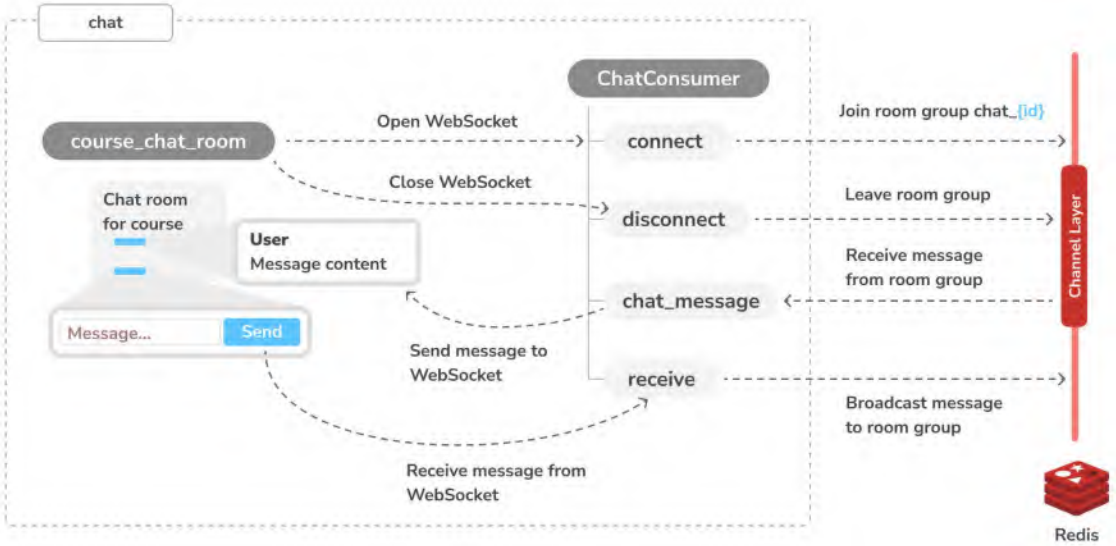


Figure 16.1: Diagram of functionalities built in this chapter

In this chapter, you will implement the `course_chat_room` view in the `chat` application. This view will serve the template that displays the chat room for a given course. The latest chat messages will be displayed when a user joins a chat room. You will use JavaScript to establish a WebSocket connection in the browser, and you will build the `ChatConsumer` WebSocket consumer to handle WebSocket connections and to exchange messages. You will use Redis to implement the channel layer that allows broadcasting messages to all users in the chat room.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter16`.

All Python modules used in this chapter are included in the `requirements.txt` file in the source code that comes along with this chapter. You can follow the instructions to install each Python module below or you can install all requirements at once with the command `python -m pip install -r requirements.txt`.

Creating a chat application

You are going to implement a chat server to provide students with a chat room for each course. Students enrolled in a course will be able to access the course chat room and exchange messages in real time. You will use Channels to build this functionality. Channels is a Django application that extends Django to handle protocols that require long-running connections, such as WebSockets, chatbots, or MQTT (a lightweight publish/subscribe message transport commonly used in **Internet of Things** (**IoT**) projects).

Using Channels, you can easily implement real-time or asynchronous functionalities into your project in addition to your standard HTTP synchronous views. You will start by adding a new application to your project. The new application will contain the logic for the chat server.

You can the documentation for Django Channels at `https://channels.readthedocs.io/`.

Let's start implementing the chat server. Run the following command from the project's `educa` directory to create the new application file structure:

```
django-admin startapp chat
```

Edit the `settings.py` file of the `educa` project and activate the `chat` application in your project by editing the `INSTALLED_APPS` setting, as follows:

```
INSTALLED_APPS = [
    # ...
    'chat.apps.ChatConfig',
]
```

The new `chat` application is now active in your project. Next, you are going to build a view for course chat rooms.

Implementing the chat room view

You will provide students with a different chat room for each course. You need to create a view for students to join the chat room of a given course. Only students who are enrolled in a course will be able to access the course chat room.

Edit the `views.py` file of the new `chat` application and add the following code to it:

```
from django.contrib.auth.decorators import login_required
from django.http import HttpResponseForbidden
from django.shortcuts import render
from courses.models import Course


@login_required
def course_chat_room(request, course_id):
    try:
        # retrieve course with given id joined by the current user
        course = request.user.courses_joined.get(id=course_id)
    except Course.DoesNotExist:
        # user is not a student of the course or course does not exist
        return HttpResponseForbidden()
    return render(request, 'chat/room.html', {'course': course})
```

This is the `course_chat_room` view. In this view, you use the `@login_required` decorator to prevent any non-authenticated user from accessing the view. The view works as follows:

1. The view receives a required `course_id` parameter that is used to retrieve the course with the given `id`.
2. The courses that the user is enrolled in are retrieved through the `courses_joined` relationship and the course with the given `id` is obtained from that subset of courses. If the course with the given `id` does not exist or the user is not enrolled in it, an `HttpResponseForbidden` response is returned, which translates to an HTTP response with status `403`.
3. If the course with the given `id` exists and the user is enrolled in it, the `chat/room.html` template is rendered, passing the `course` object to the template context.

You need to add a URL pattern for this view. Create a new file inside the `chat` application directory and name it `urls.py`. Add the following code to it:

```
from django.urls import path
from . import views


app_name = 'chat'

urlpatterns = [
    path(
        'room/<int:course_id>/',
        views.course_chat_room,
        name='course_chat_room'),
]
```

This is the initial URL patterns file for the `chat` application. You define the `course_chat_room` URL pattern, including the `course_id` parameter with the `int` prefix, as you only expect an integer value here.

Include the new URL patterns of the `chat` application in the main URL patterns of the project. Edit the main `urls.py` file of the `educa` project and add the following line to it:

```
urlpatterns = [
    # ...
    path('chat/', include('chat.urls', namespace='chat')),
]
```

URL patterns for the `chat` application are added to the project under the `chat/` path.

You need to create a template for the `course_chat_room` view. This template will contain an area to visualize the messages that are exchanged in the chat, and a text input with a submit button to send text messages to the chat.

Create the following file structure within the `chat` application directory:

```
templates/
    chat/
        room.html
```

Edit the `chat/room.html` template and add the following code to it:

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

{% block title %}Chat room for "{{ course.title }}"{% endblock %}

{% block content %}
  <div id="chat">
  </div>
  <div id="chat-input">
    <input id="chat-message-input" type="text">
    <input id="chat-message-submit" type="submit" value="Send">
  </div>
{% endblock %}

{% block include_js %}
{% endblock %}

{% block domready %}
{% endblock %}
```

This is the template for the course chat room. In this template, you perform the following actions:

1. You extend the `base.html` template of your project and fill its `content` block.
2. You define a `<div>` HTML element with the `chat` ID that you will use to display the chat messages sent by the user and by other students.
3. You also define a second `<div>` element with a `text` input and a submit button that will allow the user to send messages.
4. You add the `include_js` and `domready` blocks defined in the `base.html` template, which you are going to implement later, to establish a connection with a WebSocket and send or receive messages.

Run the development server and open `http://127.0.0.1:8000/chat/room/1/` in your browser, replacing `1` with the `id` of an existing course in the database.

Access the chat room with a logged-in user who is enrolled in the course. You will see the following screen:

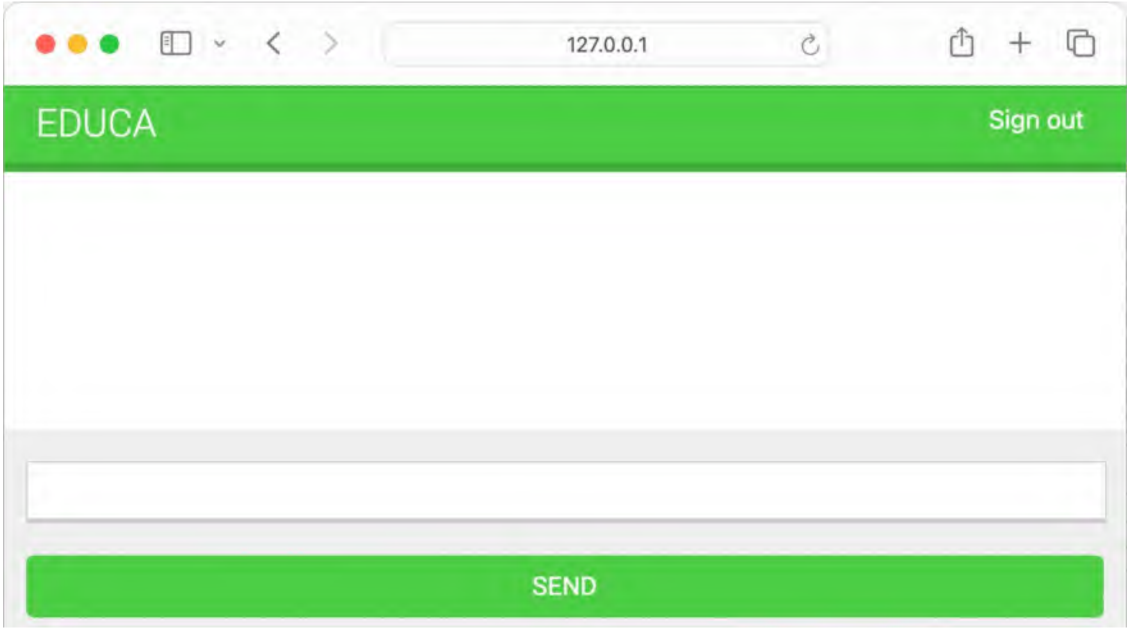


Figure 16.2: The course chat room page

This is the course chat room screen that students will use to discuss topics within a course.

You have created the base view for the course chat room. Now you need to handle messages between students. The next section will introduce asynchronous support with Channels for real-time communication.

Real-time Django with Channels

You are building a chat server to provide students with a chat room for each course. Students enrolled in a course will be able to access the course chat room and exchange messages. This functionality requires real-time communication between the server and the client.

A standard HTTP request/response model doesn't work here because you need the browser to receive notifications as soon as new messages arrive. There are several ways you could implement this feature, using AJAX polling or long polling in combination with storing the messages in your database or Redis. However, there is no efficient way to implement real-time communication using a standard synchronous web application.

You need asynchronous communication, which allows real-time interactions, where the server can push updates to the client as soon as new messages arrive without the client needing to request updates periodically. Asynchronous communication also comes with other advantages, such as reduced latency, improved performance under load, and a better overall user experience. You are going to build a chat server using asynchronous communication through ASGI.

Asynchronous applications using ASGI

Django is usually deployed using **Web Server Gateway Interface** (**WSGI**), which is the standard interface for Python applications to handle HTTP requests. However, to work with asynchronous applications, you need to use another interface called ASGI, which can handle WebSocket requests as well. ASGI is the emerging Python standard for asynchronous web servers and applications. By using ASGI, we will enable Django to handle each message independently and in real time, creating a smooth and live chat experience for students.

You can find an introduction to ASGI at `https://asgi.readthedocs.io/en/latest/introduction.html`.

Django comes with support for running asynchronous Python through ASGI. Writing asynchronous views has been supported since Django 3.1, and Django 4.1 introduced asynchronous handlers for class-based views. Django 5.0 adds handling for disconnect events in asynchronous views before the response is generated. It also adds asynchronous functions to the authentication framework, provides support for asynchronous signal dispatching, and adds async support to multiple built-in decorators.

Channels builds upon the native ASGI support available in Django and provides additional functionalities to handle protocols that require long-running connections, such as WebSockets, IoT protocols, and chat protocols.

WebSockets provide full-duplex communication by establishing a persistent, open, bidirectional **Transmission Control Protocol** (**TCP**) connection between servers and clients. Instead of sending HTTP requests to the server, you establish a connection with the server; once the channel is open, messages can be exchanged in both directions without needing to establish a new connection each time. You are going to use WebSockets to implement your chat server.

You can read more about WebSockets at `https://en.wikipedia.org/wiki/WebSocket`.

You can find more information about deploying Django with ASGI at `https://docs.djangoproject.com/en/5.0/howto/deployment/asgi/`.

You can find more information about Django's support for writing asynchronous views at `https://docs.djangoproject.com/en/5.0/topics/async/` and Django's support for asynchronous class-based views at `https://docs.djangoproject.com/en/5.0/topics/class-based-views/#async-class-based-views`.

Next, we are going to learn how the Django request/response cycle is altered by using Channels.

The request/response cycle using Channels

It's important to understand the differences in a request cycle between a standard synchronous request cycle and a Channels implementation. The following schema shows the request cycle of a synchronous Django setup:

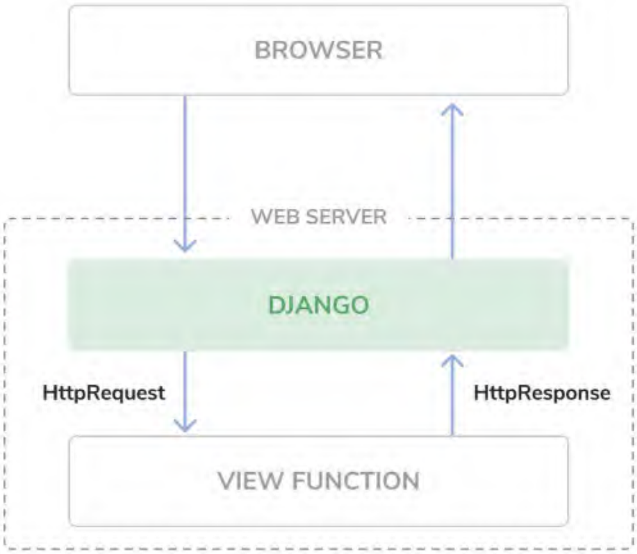


Figure 16.3: The Django request/response cycle

When an HTTP request is sent by the browser to the web server, Django handles the request and passes the `HttpRequest` object to the corresponding view. The view processes the request and returns an `HttpResponse` object that is sent back to the browser as an HTTP response. There is no mechanism to maintain an open connection or send data to the browser without an associated HTTP request.

The following schema shows the request cycle of a Django project using Channels with WebSockets:

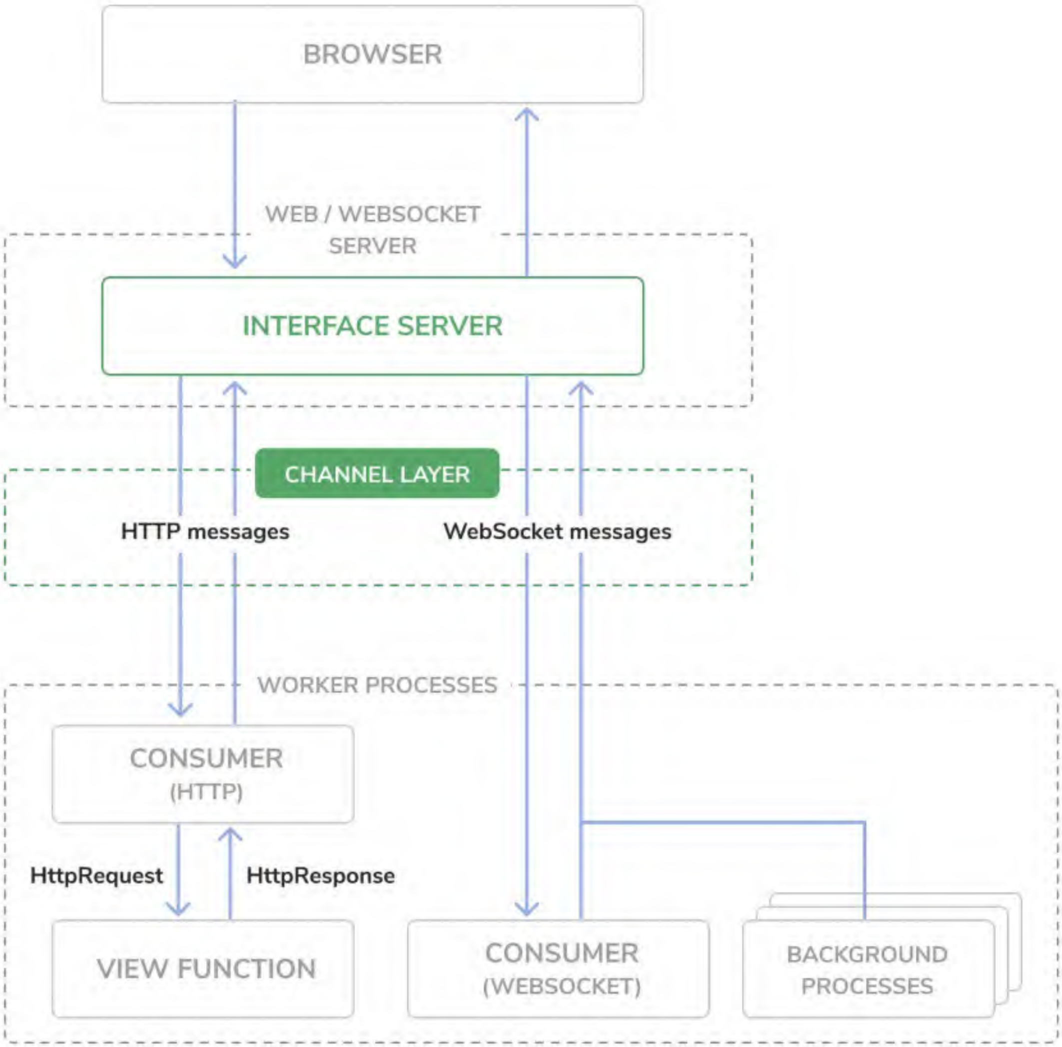


Figure 16.4: The Django Channels request/response cycle

Channels replaces Django's request/response cycle with messages that are sent across channels. HTTP requests are still routed to view functions using Django, but they get routed over channels. This allows WebSocket message handling as well, where you have producers and consumers that exchange messages across a channel layer. Channels preserves Django's synchronous architecture, allowing you to choose between writing synchronous code and asynchronous code, or a combination of both.

Your existing synchronous views will co-exist with the WebSocket functionality that we will implement with Daphne, and you will serve both HTTP and WebSocket requests.

Next, you are going to install Channels and add it to your project.

Installing Channels and Daphne

You are going to add Channels to your project and set up the required basic ASGI application routing for it to manage HTTP requests.

Install Channels in your virtual environment with the following command:

```
python -m pip install -U 'channels[daphne]==4.1.0'
```

This will simultaneously install Channels along with the Daphne ASGI application server. An ASGI server is necessary for handling asynchronous requests, and we choose Daphne for its simplicity and compatibility, as it comes bundled with Channels.

Edit the `settings.py` file of the `educa` project and add `daphne` to the beginning of the `INSTALLED_APPS` setting as follows:

```
INSTALLED_APPS = [
    'daphne',
    # ...
]
```

When `daphne` is added to the `INSTALLED_APPS` setting, it takes control over the `runserver` command, replacing the standard Django development server. This will allow you to serve asynchronous requests during development. Besides handling URL routing to Django views for synchronous requests, Daphne also manages routes to WebSocket consumers. You can find more information about Daphne at `https://github.com/django/daphne`.

Channels expects you to define a single root application that will be executed for all requests. You can define the root application by adding the `ASGI_APPLICATION` setting to your project. This is similar to the `ROOT_URLCONF` setting that points to the base URL patterns of your project. You can place the root application anywhere in your project, but it is recommended to put it in a project-level file. You can add your root routing configuration to the `asgi.py` file directly, where the ASGI application will be defined.

Edit the `asgi.py` file in the `educa` project directory and add the following code highlighted in bold:

```
import os
from channels.routing import ProtocolTypeRouter
from django.core.asgi import get_asgi_application

os.environ.setdefault('DJANGO_SETTINGS_MODULE', 'educa.settings')

django_asgi_app = get_asgi_application()
```

```
application = ProtocolTypeRouter({
    'http': django_asgi_app,
})
```

In the previous code, you define the main ASGI application that will be executed when serving the Django project through ASGI. You use the `ProtocolTypeRouter` class provided by Channels as the main entry point of your routing system. `ProtocolTypeRouter` takes a dictionary that maps communication types like `http` or `websocket` to ASGI applications. You instantiate this class with the default application for the HTTP protocol. Later, you will add a protocol for the WebSocket.

Add the following line to the `settings.py` file of your project:

```
ASGI_APPLICATION = 'educa.asgi.application'
```

The `ASGI_APPLICATION` setting is used by Channels to locate the root routing configuration.

Start the development server using the following command:

```
python manage.py runserver
```

You will see output similar to the following:

```
Watching for file changes with StatReloader
Performing system checks...
System check identified no issues (0 silenced).
April 14, 2024 - 08:02:57
Django version 5.0.4, using settings 'educa.settings'
Starting ASGI/Daphne version 4.1.0 development server at http://127.0.0.1:8000/
Quit the server with CONTROL-C.
```

Check that the output contains the line `Starting ASGI/Daphne version 4.1.0 development server`. This line confirms that you are using the Daphne development server, which is capable of managing synchronous and asynchronous requests, instead of the standard Django development server. HTTP requests continue to behave the same as before, but they get routed over Channels.

Now that Channels is installed in your project, you can build the chat server for courses. To implement the chat server for your project, you will need to take the following steps:

1. **Set up a consumer:** Consumers are individual pieces of code that can handle WebSockets in a very similar way to traditional HTTP views. You will build a consumer to read and write messages to a communication channel.
2. **Configure routing:** Channels provides routing classes that allow you to combine and stack your consumers. You will configure URL routing for your chat consumer.
3. **Implement a WebSocket client**: When the student accesses the chat room, you will connect to the WebSocket from the browser and send or receive messages using JavaScript.

4. **Enable a channel layer:** Channel layers allow you to talk between different instances of an application. They're a useful part of making a distributed real-time application. You will set up a channel layer using Redis.

Let's start by writing your own consumer to handle connecting to a WebSocket, receiving and sending messages, and disconnecting.

Writing a consumer

Consumers are the equivalent of Django views for asynchronous applications. As mentioned, they handle WebSockets in a very similar way to how traditional views handle HTTP requests. Consumers are ASGI applications that can handle messages, notifications, and other things. Unlike Django views, consumers are built for long-running communication. URLs are mapped to consumers through routing classes that allow you to combine and stack consumers.

Let's implement a basic consumer that can accept WebSocket connections and echoes every message it receives from the WebSocket back to it. This initial functionality will allow the student to send messages to the consumer and receive back the messages it sends.

Create a new file inside the `chat` application directory and name it `consumers.py`. Add the following code to it:

```
import json
from channels.generic.websocket import WebsocketConsumer


class ChatConsumer(WebsocketConsumer):
    def connect(self):
        # accept connection
        self.accept()

    def disconnect(self, close_code):
        pass

    # receive message from WebSocket
    def receive(self, text_data):
        text_data_json = json.loads(text_data)
        message = text_data_json['message']
        # send message to WebSocket
        self.send(text_data=json.dumps({'message': message}))
```

This is the `ChatConsumer` consumer. This class inherits from the Channels `WebsocketConsumer` class to implement a basic WebSocket consumer. In this consumer, you implement the following methods:

- `connect()`: Called when a new connection is received. You accept any connection with `self.accept()`. You can also reject a connection by calling `self.close()`.

- `disconnect()`: Called when the socket closes. You use `pass` because you don't need to implement any action when a client closes the connection.
- `receive()`: Called whenever data is received from the WebSocket. You expect text to be received as `text_data` (this could also be `binary_data` for binary data). You treat the text data received as JSON. Therefore, you use `json.loads()` to load the received JSON data into a Python dictionary. You access the `message` key, which you expect to be present in the JSON structure received. To echo the message, you send the message back to the WebSocket with `self.send()`, transforming it into JSON format again through `json.dumps()`.

The initial version of your `ChatConsumer` consumer accepts any WebSocket connection and echoes to the WebSocket client every message it receives. Note that the consumer does not broadcast messages to other clients yet. You will build this functionality by implementing a channel layer later.

First, let's expose our consumer by adding it to the URLs of the project.

Routing

You need to define a URL to route connections to the `ChatConsumer` consumer you have implemented. Channels provides routing classes that allow you to combine and stack consumers to dispatch based on what the connection is. You can think of them as the URL routing system of Django for asynchronous applications.

Create a new file inside the `chat` application directory and name it `routing.py`. Add the following code to it:

```
from django.urls import re_path
from . import consumers


websocket_urlpatterns = [
    re_path(
        r'ws/chat/room/(?P<course_id>\d+)/$',
        consumers.ChatConsumer.as_asgi()
    ),
]
```

In this code, you map a URL pattern with the `ChatConsumer` class that you defined in the `chat/consumers.py` file. There are some details that are worth reviewing:

- You use Django's `re_path()` to define the path with a regular expression instead of `path()`. Channels' URL routing may not function correctly with `path()` routes if inner routers are wrapped by additional middleware, so this approach helps avoid any issues.
- The URL includes an integer parameter called `course_id`. This parameter will be available in the scope of the consumer and will allow you to identify the course chat room that the user is connecting to.

- You call the `as_asgi()` method of the `consumer` class in order to get an ASGI application that will instantiate an instance of the consumer for each user connection. This behavior is similar to Django's `as_view()` method for class-based views.

It is a good practice to prepend WebSocket URLs with `/ws/` to differentiate them from URLs used for standard synchronous HTTP requests. This also simplifies the production setup when an HTTP server routes requests based on the path.

Edit the global `asgi.py` file located next to the `settings.py` file so that it looks like this:

```
import os
from channels.auth import AuthMiddlewareStack
from channels.routing import ProtocolTypeRouter, URLRouter
from django.core.asgi import get_asgi_application

os.environ.setdefault('DJANGO_SETTINGS_MODULE', 'educa.settings')

django_asgi_app = get_asgi_application()

from chat.routing import websocket_urlpatterns

application = ProtocolTypeRouter({
    'http': django_asgi_app,
    'websocket': AuthMiddlewareStack(
        URLRouter(websocket_urlpatterns)
    ),
})
```

In this code, you have added:

- A new route for the `websocket` protocol. You use `URLRouter` to map `websocket` connections to the URL patterns defined in the `websocket_urlpatterns` list of the `chat.routing` module.
- `AuthMiddlewareStack` as a wrapper function for the URL router. The `AuthMiddlewareStack` class provided by Channels supports standard Django authentication, where the user details are stored in the session. Later, you will access the user instance in the scope of the consumer to identify the user who sends a message.

Note that the `websocket_urlpatterns` import is below the `get_asgi_application()` function call. This is needed to ensure the application registry is populated before importing code that may import ORM models.

Now that we have a functioning WebSocket consumer that is available through a URL, we can implement the WebSocket client.

Implementing the WebSocket client

So far, you have created the `course_chat_room` view and its corresponding template for students to access the course chat room. You have implemented a WebSocket consumer for the chat server and tied it with URL routing. Now, you need to build a WebSocket client to establish a connection with the WebSocket in the course chat room template and be able to send/receive messages.

You are going to implement the WebSocket client with JavaScript to open and maintain a connection in the browser, and you will interact with the **Document Object Model** (**DOM**) using JavaScript.

You will perform the following tasks related to the WebSocket client:

1. Open a WebSocket connection with the server when the page is loaded.
2. Add messages to an HTML container when data is received through the WebSocket.
3. Attach a listener to the submit button to send messages through the WebSocket when the user clicks the **SEND** button or presses the *Enter* key.

Let's start by opening the WebSocket connection.

Edit the `chat/room.html` template of the `chat` application and modify the `include_js` and `domready` blocks, as follows:

```
{% block include_js %}
  {{ course.id|json_script:"course-id" }}
{% endblock %}

{% block domready %}
  const courseId = JSON.parse(
    document.getElementById('course-id').textContent
  );
  const url = 'ws://' + window.location.host +
              '/ws/chat/room/' + courseId + '/';
  const chatSocket = new WebSocket(url);
{% endblock %}
```

In the `include_js` block, you use the `json_script` template filter to securely use the value of `course.id` with JavaScript. The `json_script` template filter provided by Django outputs a Python object as JSON, wrapped in a `<script>` tag, so that you can safely use it with JavaScript. The code `{{ course.id|json_script:"course-id" }}` is rendered as `<script id="course-id" type="application/json">6</script>`. This value is then retrieved in the `domready` block by parsing the content of the element with `id="course-id"` using `JSON.parse()`. This is the safe way to use Python objects in JavaScript.

> The `json_script` template filter securely encodes Python objects as JSON and safely embeds them in a `<script>` HTML tag, protecting against **cross-site scripting** (**XSS**) attacks by escaping potentially harmful characters.

You can find more information about the `json_script` template filter at `https://docs.djangoproject.com/en/5.0/ref/templates/builtins/#json-script`.

In the `domready` block, you define an URL with the WebSocket protocol, which looks like `ws://` (or `wss://` for secure WebSockets, just like `https://`). You build the URL using the current location of the browser, which you obtain from `window.location.host`. The rest of the URL is built with the path for the chat room URL pattern that you defined in the `routing.py` file of the `chat` application.

You write the URL instead of building it with a resolver because Channels does not provide a way to reverse URLs. You use the current course `ID` to generate the URL for the current course and store the URL in a new constant named `url`.

You then open a WebSocket connection to the stored URL using `new WebSocket(url)`. You assign the instantiated WebSocket client object to the new constant `chatSocket`.

You have created a WebSocket consumer, you have included routing for it, and you have implemented a basic WebSocket client. Let's try the initial version of your chat.

Start the development server using the following command:

```
python manage.py runserver
```

Open the URL `http://127.0.0.1:8000/chat/room/1/` in your browser, replacing `1` with the `id` of an existing course in the database. Take a look at the console output. Besides the HTTP `GET` requests for the page and its static files, you should see two lines, including `WebSocket HANDSHAKING` and `WebSocket CONNECT`, like the following output:

```
HTTP GET /chat/room/1/ 200 [0.02, 127.0.0.1:57141]
WebSocket HANDSHAKING /ws/chat/room/1/ [127.0.0.1:57144]
WebSocket CONNECT /ws/chat/room/1/ [127.0.0.1:57144]
```

The Daphne server listens for incoming socket connections using a standard TCP socket. The handshake is the bridge from HTTP to WebSockets. In the handshake, details of the connection are negotiated and either party can close the connection before completion. Remember that you are using `self.accept()` to accept any connection in the `connect()` method of the `ChatConsumer` class, implemented in the `consumers.py` file of the `chat` application. The connection is accepted, and therefore, you see the `WebSocket CONNECT` message in the console.

If you use the browser developer tools to track network connections, you can also see information for the WebSocket connection that has been established.

It should look like *Figure 16.5*:

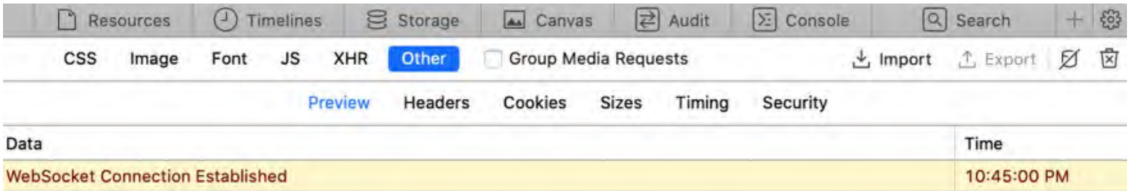


Figure 16.5: The browser developer tools showing that the WebSocket connection has been established

Now that you can connect to the WebSocket, it's time to interact with it. You will implement the methods to handle common events, such as receiving a message and closing the connection. Edit the `chat/room.html` template of the `chat` application and modify the `domready` block, as follows:

```
{% block domready %}
  const courseId = JSON.parse(
    document.getElementById('course-id').textContent
  );
  const url = 'ws://' + window.location.host +
              '/ws/chat/room/' + courseId + '/';
  const chatSocket = new WebSocket(url);

  chatSocket.onmessage = function(event) {
    const data = JSON.parse(event.data);
    const chat = document.getElementById('chat');

    chat.innerHTML += '<div class="message">' +
                      data.message + '</div>';
    chat.scrollTop = chat.scrollHeight;
  };

  chatSocket.onclose = function(event) {
    console.error('Chat socket closed unexpectedly');
  };
{% endblock %}
```

In this code, you define the following events for the WebSocket client:

- `onmessage`: Fired when data is received through the WebSocket. You parse the message, which you expect in JSON format, and access its `message` attribute. You then append a new `<div>` element with the message received to the HTML element with the `chat` ID. This will add new messages to the chat log, while keeping all previous messages that have been added to the log. You scroll the chat log `<div>` to the bottom to ensure that the new message gets visibility. You achieve this by scrolling to the total scrollable height of the chat log, which can be obtained by accessing its `scrollHeight` attribute.

- `onclose`: Fired when the connection with the WebSocket is closed. You don't expect to close the connection, and therefore, you write the error `Chat socket closed unexpectedly` to the console log if this happens.

You have implemented the action to display the message when a new message is received. You need to implement the functionality to send messages to the socket as well.

Edit the `chat/room.html` template of the `chat` application and add the following JavaScript code to the bottom of the `domready` block:

```
const input = document.getElementById('chat-message-input');
const submitButton = document.getElementById('chat-message-submit');

submitButton.addEventListener('click', function(event) {
  const message = input.value;
  if(message) {
    // send message in JSON format
    chatSocket.send(JSON.stringify({'message': message}));
    // clear input
    input.value = '';
    input.focus();
  }
});
```

In this code, you define an event listener for the `click` event of the submit button, which you select by its ID `chat-message-submit`. When the button is clicked, you perform the following actions:

1. You read the message entered by the user from the value of the text input element with the ID `chat-message-input`.
2. You check whether the message has any content with `if(message)`.
3. If the user has entered a message, you form JSON content such as `{'message': 'string entered by the user'}` by using `JSON.stringify()`.
4. You send the JSON content through the WebSocket, calling the `send()` method of `chatSocket` client.
5. You clear the contents of the text input by setting its value to an empty string with `input.value = ''`.
6. You return the focus to the text input with `input.focus()` so that the user can write a new message straight away.

The user is now able to send messages using the text input and by clicking the submit button.

To improve the user experience, you will give focus to the text input when the page loads, allowing users to begin typing immediately without needing to click on it first. You will also capture keyboard keypress events to identify the *Enter* key and fire the `click` event on the submit button. Users will be able to either click the button or press the *Enter* key to send a message.

Edit the `chat/room.html` template of the `chat` application and add the following JavaScript code to the bottom of the `domready` block:

```
input.addEventListener('keypress', function(event) {
    if (event.key === 'Enter') {
      // cancel the default action, if needed
      event.preventDefault();
      // trigger click event on button
      submitButton.click();
    }
  });

input.focus();
```

In this code, you also define a function for the `keypress` event of the `input` element. For any key that the user presses, you perform the following actions:

1. You check whether its key is *Enter*.
2. If the *Enter* key is pressed:
    a. You prevent the default behavior for this key with `event.preventDefault()`.
    b. Then you fire the `click` event on the submit button to send the message to the WebSocket.

Outside of the event handler, in the main JavaScript code for the `domready` block, you give the focus to the text input with `input.focus()`. By doing so, when the DOM is loaded, the focus will be set on the `input` element for the user to type a message.

The `domready` block of the `chat/room.html` template should now look as follows:

```
{% block domready %}
  const courseId = JSON.parse(
    document.getElementById('course-id').textContent
  );
  const url = 'ws://' + window.location.host +
              '/ws/chat/room/' + courseId + '/';
  const chatSocket = new WebSocket(url);

  chatSocket.onmessage = function(event) {
    const data = JSON.parse(event.data);
    const chat = document.getElementById('chat');

    chat.innerHTML += '<div class="message">' +
                      data.message + '</div>';
    chat.scrollTop = chat.scrollHeight;
```

```
  };

  chatSocket.onclose = function(event) {
    console.error('Chat socket closed unexpectedly');
  };

  const input = document.getElementById('chat-message-input');
  const submitButton = document.getElementById('chat-message-submit');

  submitButton.addEventListener('click', function(event) {
    const message = input.value;
    if(message) {
      // send message in JSON format
      chatSocket.send(JSON.stringify({'message': message}));
      // clear input
      input.value = '';
      input.focus();
    }
  });

  input.addEventListener('keypress', function(event) {
    if (event.key === 'Enter') {
      // cancel the default action, if needed
      event.preventDefault();
      // trigger click event on button
      submitButton.click();
    }
  });

  input.focus();
{% endblock %}
```

Open the URL `http://127.0.0.1:8000/chat/room/1/` in your browser, replacing `1` with the `id` of an existing course in the database. With a logged-in user who is enrolled in the course, write some text in the input field and click the **SEND** button or press the *Enter* key.

You will see that your message appears in the chat log:

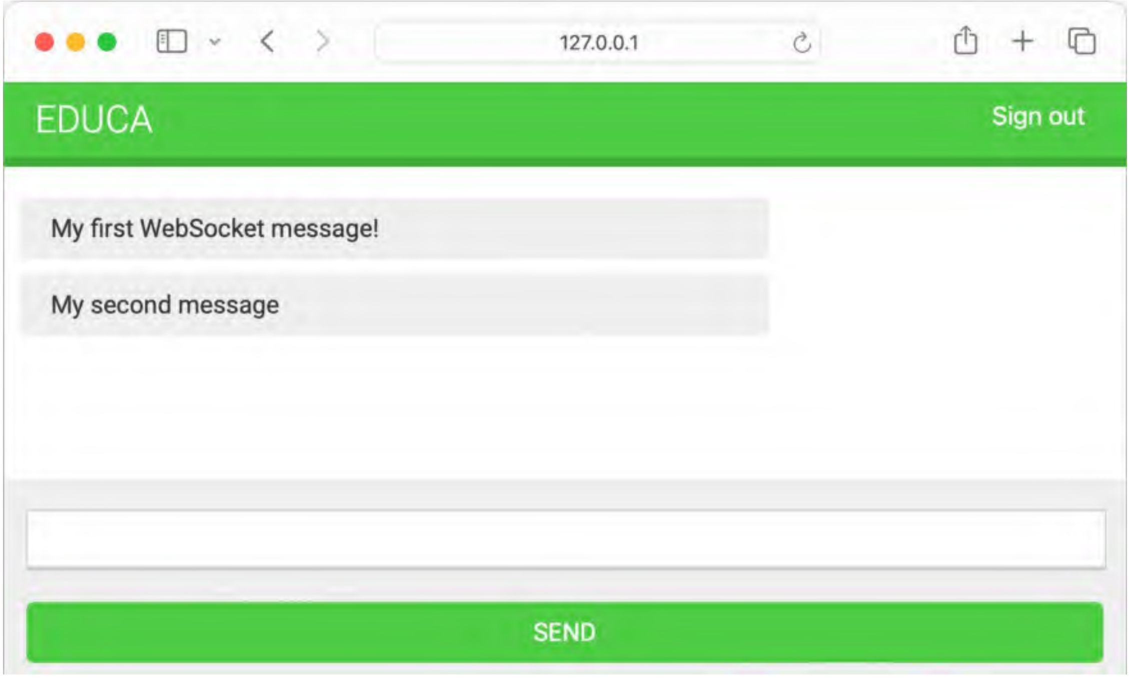


Figure 16.6: The chat room page, including messages sent through the WebSocket

Great! The message has been sent through the WebSocket and the `ChatConsumer` consumer has received the message and has sent it back through the WebSocket. The `chatSocket` client has received a message event and the `onmessage` function has been fired, adding the message to the chat log.

You have implemented the functionality with a WebSocket consumer and a WebSocket client to establish client/server communication and can send or receive events. However, the chat server is not able to broadcast messages to other clients. If you open a second browser tab and enter a message, the message will not appear on the first tab. In order to build communication between consumers, you have to enable a channel layer.

Enabling a channel layer

Channel layers allow you to communicate between different instances of an application. A channel layer is the transport mechanism that allows multiple consumer instances to communicate with each other and with other parts of Django.

In your chat server, you plan to have multiple instances of the `ChatConsumer` consumer for the same course chat room. Each student who joins the chat room will instantiate the WebSocket client in their browser, and that will open a connection with an instance of the WebSocket consumer. You need a common channel layer to distribute messages between consumers.

Channels and groups

Channel layers provide two abstractions to manage communications: channels and groups:

- **Channel**: You can think of a channel as an inbox where messages can be sent or as a task queue. Each channel has a name. Messages are sent to a channel by anyone who knows the channel name and then given to consumers listening on that channel.
- **Group**: Multiple channels can be grouped into a group. Each group has a name. A channel can be added or removed from a group by anyone who knows the group name. Using the group name, you can also send a message to all channels in the group.

You will work with channel groups to implement the chat server. By creating a channel group for each course chat room, the `ChatConsumer` instances will be able to communicate with each other.

Let's add a channel layer to our project.

Setting up a channel layer with Redis

Redis is the preferred option for a channel layer, though Channels has support for other types of channel layers. Redis works as the communication store for the channel layer. Remember that you already used Redis in *Chapter 7*, *Tracking User Actions*, *Chapter 10*, *Extending Your Shop*, and *Chapter 14*, *Rendering and Caching Content*.

If you haven't installed Redis yet, you can find installation instructions in *Chapter 7*, *Tracking User Actions*.

To use Redis as a channel layer, you have to install the `channels-redis` package. Install `channels-redis` in your virtual environment with the following command:

```
python -m pip install channels-redis==4.2.0
```

Edit the `settings.py` file of the `educa` project and add the following code to it:

```
CHANNEL_LAYERS = {
    'default': {
        'BACKEND': 'channels_redis.core.RedisChannelLayer',
        'CONFIG': {
            'hosts': [('127.0.0.1', 6379)],
        },
    },
}
```

The `CHANNEL_LAYERS` setting defines the configuration for the channel layers available to the project. You define a default channel layer using the `RedisChannelLayer` backend provided by `channels-redis` and specify the host `127.0.0.1` and the port `6379`, on which Redis is running.

Let's try the channel layer. Initialize the Redis Docker container using the following command:

```
docker run -it --rm --name redis -p 6379:6379 redis:7.2.4
```

If you want to run the command in the background (in detached mode) you can use the `-d` option.

Open the Django shell using the following command from the project directory:

```
python manage.py shell
```

To verify that the channel layer can communicate with Redis, write the following code to send a message to a test channel named `test_channel` and receive it back:

```
>>> import channels.layers
>>> from asgiref.sync import async_to_sync
>>> channel_layer = channels.layers.get_channel_layer()
>>> async_to_sync(channel_layer.send)('test_channel', {'message': 'hello'})
>>> async_to_sync(channel_layer.receive)('test_channel')
```

You should get the following output:

```
{'message': 'hello'}
```

In the previous code, you send a message to a test channel through the channel layer, and then you retrieve it from the channel layer. The channel layer is communicating successfully with Redis.

Next, we will add the channel layer to our project.

Updating the consumer to broadcast messages

Let's edit the `ChatConsumer` consumer to use the channel layer we have implemented with Redis. You will use a channel group for each course chat room. Therefore, you will use the course `id` to build the group name. `ChatConsumer` instances will know the group name and will be able to communicate with each other.

Edit the `consumers.py` file of the `chat` application, import the `async_to_sync()` function, and modify the `connect()` method of the `ChatConsumer` class, as follows:

```
import json
from asgiref.sync import async_to_sync
from channels.generic.websocket import WebsocketConsumer


class ChatConsumer(WebsocketConsumer):
    def connect(self):
        self.id = self.scope['url_route']['kwargs']['course_id']
        self.room_group_name = f'chat_{self.id}'
        # join room group
        async_to_sync(self.channel_layer.group_add)(
            self.room_group_name, self.channel_name
        )
        # accept connection
        self.accept()
    # ...
```

In this code, you import the `async_to_sync()` helper function to wrap calls to asynchronous channel layer methods. `ChatConsumer` is a synchronous `WebsocketConsumer` consumer, but it needs to call asynchronous methods of the channel layer.

In the new `connect()` method, you perform the following tasks:

1. You retrieve the course `id` from the scope to know the course that the chat room is associated with. You access `self.scope['url_route']['kwargs']['course_id']` to retrieve the `course_id` parameter from the URL. Every consumer has a scope with information about its connection, arguments passed by the URL, and the authenticated user, if any.
2. You build the group name with the `id` of the course that the group corresponds to. Remember that you will have a channel group for each course chat room. You store the group name in the `room_group_name` attribute of the consumer.
3. You join the group by adding the current channel to the group. You obtain the channel name from the `channel_name` attribute of the consumer. You use the `group_add` method of the channel layer to add the channel to the group. You use the `async_to_sync()` wrapper to use the channel layer asynchronous method.
4. You keep the `self.accept()` call to accept the WebSocket connection.

When the `ChatConsumer` consumer receives a new WebSocket connection, it adds the channel to the group associated with the course in its scope. The consumer is now able to receive any messages sent to the group.

In the same `consumers.py` file, modify the `disconnect()` method of the `ChatConsumer` class, as follows:

```
class ChatConsumer(WebsocketConsumer):
    # ...
    def disconnect(self, close_code):
        # leave room group
        async_to_sync(self.channel_layer.group_discard)(
            self.room_group_name, self.channel_name
        )
    # ...
```

When the connection is closed, you call the `group_discard()` method of the channel layer to leave the group. You use the `async_to_sync()` wrapper to use the channel layer asynchronous method.

In the same `consumers.py` file, modify the `receive()` method of the `ChatConsumer` class, as follows:

```
class ChatConsumer(WebsocketConsumer):
    # ...
    # receive message from WebSocket
    def receive(self, text_data):
        text_data_json = json.loads(text_data)
        message = text_data_json['message']
        # send message to room group
```

```
        async_to_sync(self.channel_layer.group_send)(
            self.room_group_name,
            {
                'type': 'chat_message',
                'message': message,
            }
        )
```

When you receive a message from the WebSocket connection, instead of sending the message to the associated channel, you send the message to the group. You do this by calling the `group_send()` method of the channel layer. You use the `async_to_sync()` wrapper to use the channel layer asynchronous method. You pass the following information in the event sent to the group:

- `type`: The event type. This is a special key that corresponds to the name of the method that should be invoked on consumers that receive the event. You can implement a method in the consumer named the same as the message type so that it gets executed every time a message with that specific type is received.
- `message`: The actual message you are sending.

In the same `consumers.py` file, add a new `chat_message()` method in the `ChatConsumer` class, as follows:

```
class ChatConsumer(WebsocketConsumer):
    # ...
    # receive message from room group
    def chat_message(self, event):
        # send message to WebSocket
        self.send(text_data=json.dumps(event))
```

You name this method `chat_message()` to match the `type` key that is sent to the channel group when a message is received from the WebSocket. When a message with type `chat_message` is sent to the group, all consumers subscribed to the group will receive the message and will execute the `chat_message()` method. In the `chat_message()` method, you send the event message received to the WebSocket.

The complete `consumers.py` file should now look like this:

```
import json
from asgiref.sync import async_to_sync
from channels.generic.websocket import WebsocketConsumer


class ChatConsumer(WebsocketConsumer):
    def connect(self):
        self.id = self.scope['url_route']['kwargs']['course_id']
        self.room_group_name = f'chat_{self.id}'
        # join room group
        async_to_sync(self.channel_layer.group_add)(
```

```
            self.room_group_name, self.channel_name
        )
        # accept connection
        self.accept()

    def disconnect(self, close_code):
        # leave room group
        async_to_sync(self.channel_layer.group_discard)(
            self.room_group_name, self.channel_name
        )

    # receive message from WebSocket
    def receive(self, text_data):
        text_data_json = json.loads(text_data)
        message = text_data_json['message']
        # send message to room group
        async_to_sync(self.channel_layer.group_send)(
            self.room_group_name,
            {
                'type': 'chat_message',
                'message': message,
            }
        )

    # receive message from room group
    def chat_message(self, event):
        # send message to WebSocket
        self.send(text_data=json.dumps(event))
```

You have implemented a channel layer in `ChatConsumer`, allowing consumers to broadcast messages and communicate with each other.

Run the development server with the following command:

```
python manage.py runserver
```

Open the URL `http://127.0.0.1:8000/chat/room/1/` in your browser, replacing `1` with the `id` of an existing course in the database. Write a message and send it. Then, open a second browser window and access the same URL. Send a message from each browser window.

The result should look like this:

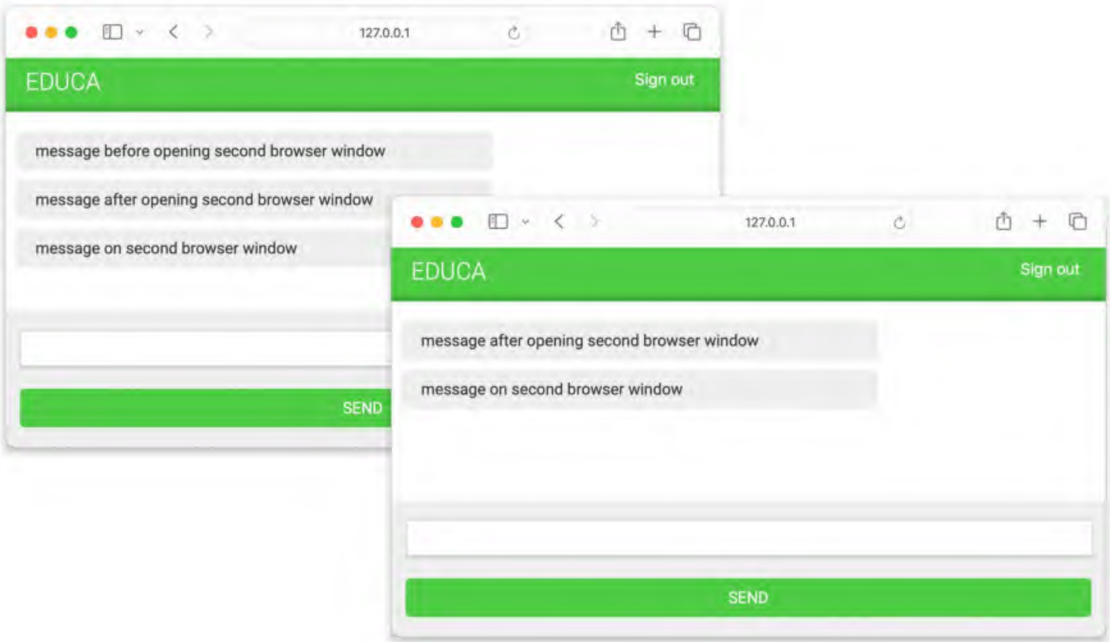


Figure 16.7: The chat room page with messages sent from different browser windows

You will see that the first message is only displayed in the first browser window. When you open a second browser window, messages sent in any of the browser windows are displayed in both of them. When you open a new browser window and access the chat room URL, a new WebSocket connection is established between the JavaScript WebSocket client in the browser and the WebSocket consumer in the server. Each channel gets added to the group associated with the course ID and passed through the URL to the consumer. Messages are sent to the group and received by all consumers.

Next, we are going to enrich messages with additional context.

Adding context to the messages

Now that messages can be exchanged between all users in a chat room, you probably want to display who sent which message and when it was sent. Let's add some context to the messages.

Edit the `consumers.py` file of the `chat` application and implement the following changes:

```
import json
from asgiref.sync import async_to_sync
from channels.generic.websocket import WebsocketConsumer
from django.utils import timezone


class ChatConsumer(WebsocketConsumer):
```

```
    def connect(self):
        self.user = self.scope['user']
        self.id = self.scope['url_route']['kwargs']['course_id']
        self.room_group_name = f'chat_{self.id}'
        # join room group
        async_to_sync(self.channel_layer.group_add)(
            self.room_group_name, self.channel_name
        )
        # accept connection
        self.accept()

    def disconnect(self, close_code):
        # leave room group
        async_to_sync(self.channel_layer.group_discard)(
            self.room_group_name, self.channel_name
        )

    # receive message from WebSocket
    def receive(self, text_data):
        text_data_json = json.loads(text_data)
        message = text_data_json['message']
        now = timezone.now()
        # send message to room group
        async_to_sync(self.channel_layer.group_send)(
            self.room_group_name,
            {
                'type': 'chat_message',
                'message': message,
                'user': self.user.username,
                'datetime': now.isoformat(),
            }
        )

    # receive message from room group
    def chat_message(self, event):
        # send message to WebSocket
        self.send(text_data=json.dumps(event))
```

You now import the `timezone` module provided by Django. In the `connect()` method of the consumer, you retrieve the current user from the scope with `self.scope['user']` and store them in a new `user` attribute of the consumer.

When the consumer receives a message through the WebSocket, it gets the current time using `timezone.now()` and passes the current `user` and `datetime` in ISO 8601 format along with the message in the event sent to the channel group.

Edit the `chat/room.html` template of the `chat` application and add the following line highlighted in bold to the `include_js` block:

```
{% block include_js %}
  {{ course.id|json_script:"course-id" }}
  {{ request.user.username|json_script:"request-user" }}
{% endblock %}
```

Using the `json_script` template, you safely print the username of the request user to use it with JavaScript.

In the `domready` block of the `chat/room.html` template, add the following lines highlighted in bold:

```
{% block domready %}
  const courseId = JSON.parse(
    document.getElementById('course-id').textContent
  );
  const requestUser = JSON.parse(
    document.getElementById('request-user').textContent
  );
  # ...

{% endblock %}
```

In the new code, you safely parse the data of the element with the ID `request-user` and store it in the `requestUser` constant.

Then, in the `domready` block, find the following lines:

```
const data = JSON.parse(event.data);
const chat = document.getElementById('chat');

chat.innerHTML += '<div class="message">' +
                  data.message + '</div>';
chat.scrollTop = chat.scrollHeight;
```

Replace those lines with the following code:

```
const data = JSON.parse(event.data);
const chat = document.getElementById('chat');

const dateOptions = {hour: 'numeric', minute: 'numeric', hour12: true};
const datetime = new Date(data.datetime).toLocaleString('en', dateOptions);
```

```
const isMe = data.user === requestUser;
const source = isMe ? 'me' : 'other';
const name = isMe ? 'Me' : data.user;

chat.innerHTML += '<div class="message ' + source + '">' +
                  '<strong>' + name + '</strong> ' +
                  '<span class="date">' + datetime + '</span><br>' +
                  data.message + '</div>';
chat.scrollTop = chat.scrollHeight;
```

In this code, you implement the following changes:

1. You convert the `datetime` received in the message to a JavaScript `Date` object and format it with a specific locale.
2. You compare the username received in the message with two different constants as helpers to identify the user.
3. The constant `source` gets the value `me` if the user sending the message is the current user, or `other` otherwise.
4. The constant `name` gets the value `Me` if the user sending the message is the current user or the name of the user sending the message otherwise. You use it to display the name of the user sending the message.
5. You use the `source` value as a `class` of the main `<div>` message element to differentiate messages sent by the current user from messages sent by others. Different CSS styles are applied based on the `class` attribute. These CSS styles are declared in the `css/base.css` static file.
6. You use the username and the `datetime` in the message that you append to the chat log.

Open the URL `http://127.0.0.1:8000/chat/room/1/` in your browser, replacing `1` with the `id` of an existing course in the database. With a logged-in user who is enrolled in the course, write a message and send it.

Then, open a second browser window in incognito mode to prevent the use of the same session. Log in with a different user, also enrolled in the same course, and send a message.

You will be able to exchange messages using the two different users and see the user and time, with a clear distinction between messages sent by the user and messages sent by others. The conversation between two users should look similar to the following one:

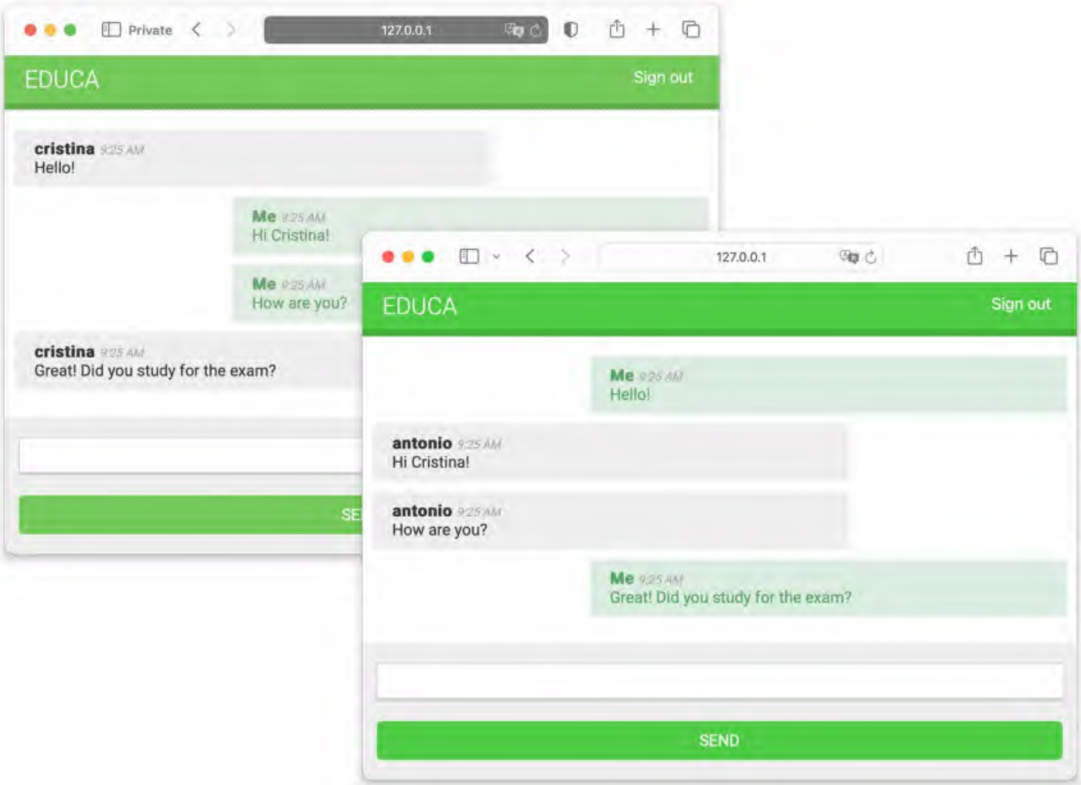


Figure 16.8: The chat room page with messages from two different user sessions

Great! You have built a functional real-time chat application using Channels. Next, you will learn how to improve the chat consumer by making it fully asynchronous.

Modifying the consumer to be fully asynchronous

The `ChatConsumer` you have implemented inherits from the synchronous base class `WebsocketConsumer`. Synchronous consumers operate in a way that each request must be processed in sequence, one after the other. Synchronous consumers are convenient for accessing Django models and calling regular synchronous I/O functions. However, asynchronous consumers perform better because of their ability to perform non-blocking operations, moving to another task without waiting for the first operation to complete. They don't require additional threads when handling requests, thus reducing wait times and increasing the ability to scale to more users and requests simultaneously.

Given that you are already using the asynchronous channel layer functions, you can seamlessly rewrite the `ChatConsumer` class to make it asynchronous.

Edit the `consumers.py` file of the `chat` application and implement the following changes:

```
import json
from channels.generic.websocket import AsyncWebsocketConsumer
from django.utils import timezone


class ChatConsumer(AsyncWebsocketConsumer):
    async def connect(self):
        self.user = self.scope['user']
        self.id = self.scope['url_route']['kwargs']['course_id']
        self.room_group_name = 'chat_%s' % self.id
        # join room group
        await self.channel_layer.group_add(
            self.room_group_name, self.channel_name
        )
        # accept connection
        await self.accept()

    async def disconnect(self, close_code):
        # leave room group
        await self.channel_layer.group_discard(
            self.room_group_name, self.channel_name
        )

    # receive message from WebSocket
    async def receive(self, text_data):
        text_data_json = json.loads(text_data)
        message = text_data_json['message']
        now = timezone.now()
        # send message to room group
        await self.channel_layer.group_send(
            self.room_group_name,
            {
                'type': 'chat_message',
                'message': message,
                'user': self.user.username,
                'datetime': now.isoformat(),
            }
        )
```

```
    # receive message from room group
    async def chat_message(self, event):
        # send message to WebSocket
        await self.send(text_data=json.dumps(event))
```

You have implemented the following changes:

1. The `ChatConsumer` consumer now inherits from the `AsyncWebsocketConsumer` class to implement asynchronous calls.
2. You have changed the definition of all methods from `def` to `async def`.
3. You use `await` to call asynchronous functions that perform I/O operations.
4. You no longer use the `async_to_sync()` helper function when calling methods on the channel layer.

Open the URL `http://127.0.0.1:8000/chat/room/1/` with two different browser windows again and verify that the chat server still works. The chat server is now fully asynchronous!

Next, we are going to implement a chat history by storing messages in the database.

Persisting messages into the database

Let's enhance the chat application by adding message persistence. We will develop functionality to store messages in the database, allowing us to present a chat history to users when they join a chat room. This feature is essential for real-time applications, where it's necessary to display both current and previously generated data. For example, consider a stock trading application: upon logging in, users should see not only the current stock values but also the historical values from the time the stock market opened.

To implement the chat history functionality, we will follow these steps:

1. We will create Django model to store chat messages and add it to the administration site.
2. We will modify the WebSocket consumer to persist messages.
3. We will retrieve the chat history to display the latest messages when users enter a chat room.

Let's start by creating the message model.

Creating a model for chat messages

Edit the `models.py` file of the `chat` application and add the following lines highlighted in bold:

```
from django.conf import settings
from django.db import models


class Message(models.Model):
    user = models.ForeignKey(
        settings.AUTH_USER_MODEL,
```

```
        on_delete=models.PROTECT,
        related_name='chat_messages'
    )
    course = models.ForeignKey(
        'courses.Course',
        on_delete=models.PROTECT,
        related_name='chat_messages'
    )
    content = models.TextField()
    sent_on = models.DateTimeField(auto_now_add=True)

    def __str__(self):
        return f'{self.user} on {self.course} at {self.sent_on}'
```

This is the data model to persist chat messages. Let's take a look at the fields of the `Message` model:

- `user`: The `User` object that wrote the message. This is a foreign key field because it specifies a many-to-one relationship: a user can send multiple messages, but each message is sent by a single user. By using `PROTECT` for the `on_delete` parameter, a `User` object cannot be deleted if related messages exist.
- `course`: A relationship with the `Course` object. Each message belongs to the chat room of a course. By using `PROTECT` for the `on_delete` parameter, a `Course` object cannot be deleted if related messages exist.
- `content`: A `TextField` to store the content of the message.
- `sent_on`: A `DateTimeField` to store the date and time when the message object is saved the first time.

Run the following command in the shell prompt to generate the database migrations for the `chat` application:

```
python manage.py makemigrations chat
```

You should get the following output:

```
Migrations for 'chat':
    chat/migrations/0001_initial.py
        - Create model Message
```

Apply the newly created migration to your database with the following command:

```
python manage.py migrate
```

You will get an output that ends with the following line:

```
Applying chat.0001_initial... OK
```

The database is now in sync with the new model. Let's add the `Message` model to the administration site.

Adding the message model to the administration site

Edit the `admin.py` file of the `chat` application and register the `Message` model into the administration site, as follows. The new code is highlighted in bold:

```
from django.contrib import admin
from chat.models import Message

@admin.register(Message)
class MessageAdmin(admin.ModelAdmin):
    list_display = ['sent_on', 'user', 'course', 'content']
    list_filter = ['sent_on', 'course']
    search_fields = ['content']
    raw_id_fields = ['user', 'content']
```

Run the development server and open `http://127.0.0.1:8000/admin/` in your browser. You should see the **CHAT** block and the **Messages** section on the administration site:

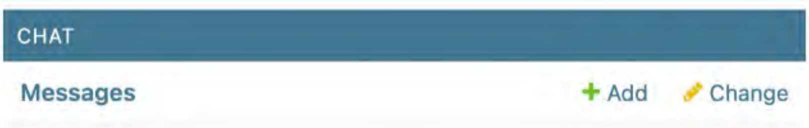


Figure 16.9: The Chat application and Messages section on the administration site

We will continue by saving messages to the database when they are sent by users.

Storing messages in the database

We will modify the WebSocket consumer to persist each message that is received through the WebSocket. Edit the `consumers.py` file of the `chat` application, and add the following code highlighted in bold:

```
import json
from channels.generic.websocket import AsyncWebsocketConsumer
from django.utils import timezone
from chat.models import Message

class ChatConsumer(AsyncWebsocketConsumer):
    # ...
    async def persist_message(self, message):
        # send message to WebSocket
        await Message.objects.acreate(
            user=self.user, course_id=self.id, content=message
        )

    # receive message from WebSocket
```

```
    async def receive(self, text_data):
        text_data_json = json.loads(text_data)
        message = text_data_json['message']
        now = timezone.now()
        # send message to room group
        await self.channel_layer.group_send(
            self.room_group_name,
            {
                'type': 'chat_message',
                'message': message,
                'user': self.user.username,
                'datetime': now.isoformat(),
            },
        )
        # persist message
        await self.persist_message(message)
    # ...
```

In this code, we add the asynchronous `persist_message()` method to the `ChatConsumer` class. This method takes a `message` parameter and creates a `Message` object in the database with the given message, the related authenticated `user`, and the `id` of the `Course` object that the group chat room belongs to. Since the is `ChatConsumer` is fully asynchronous, we use the `acreate()` QuerySet method, which is the asynchronous version of `create()`. You can read more about how to write asynchronous queries with the Django ORM at `https://docs.djangoproject.com/en/5.0/topics/db/queries/#asynchronous-queries`.

We call the `persist_message()` method asynchronously in the `receive()` method that is executed when a message is received by the consumer through the WebSocket.

Run the development server and open `http://127.0.0.1:8000/chat/room/1/` in your browser, replacing `1` with the `id` of an existing course in the database. With a logged-in user who is enrolled in the course, write a message and send it.

Then, open a second browser window in incognito mode to prevent the use of the same session. Log in with a different user, also enrolled in the same course, and send a few messages as well.

Figure 16.10 shows an example of messages sent by two different users:

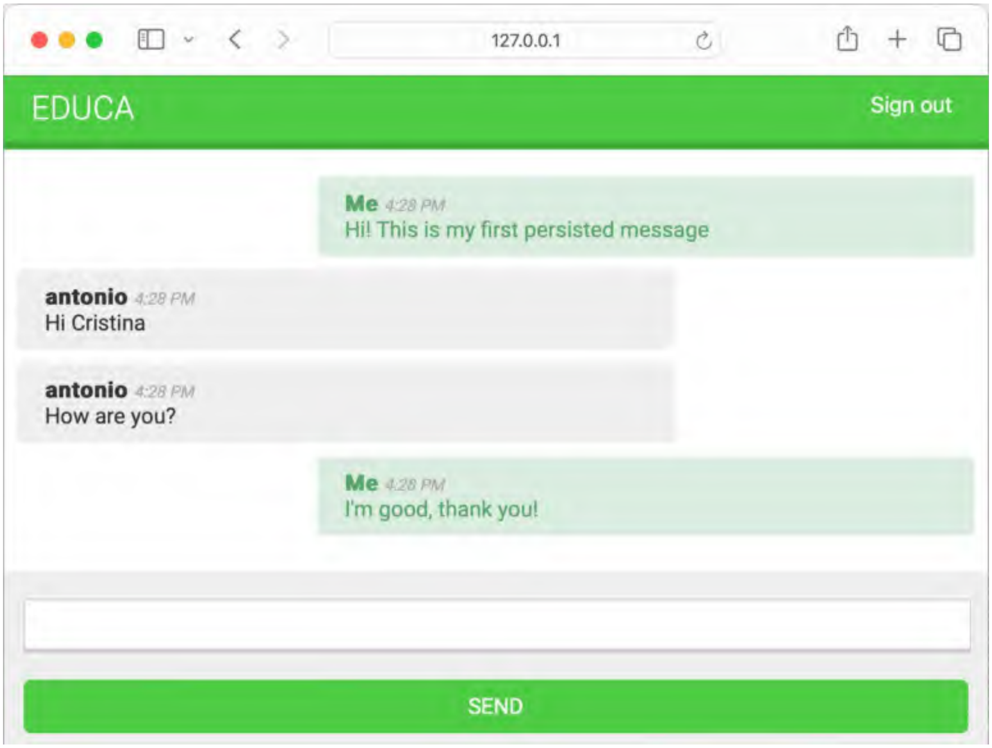


Figure 16.10: Chat room example with messages sent by two different users

Open `http://127.0.0.1:8000/admin/chat/message/` in your browser. The messages sent should appear on the administration site, as in *Figure 16.11*:

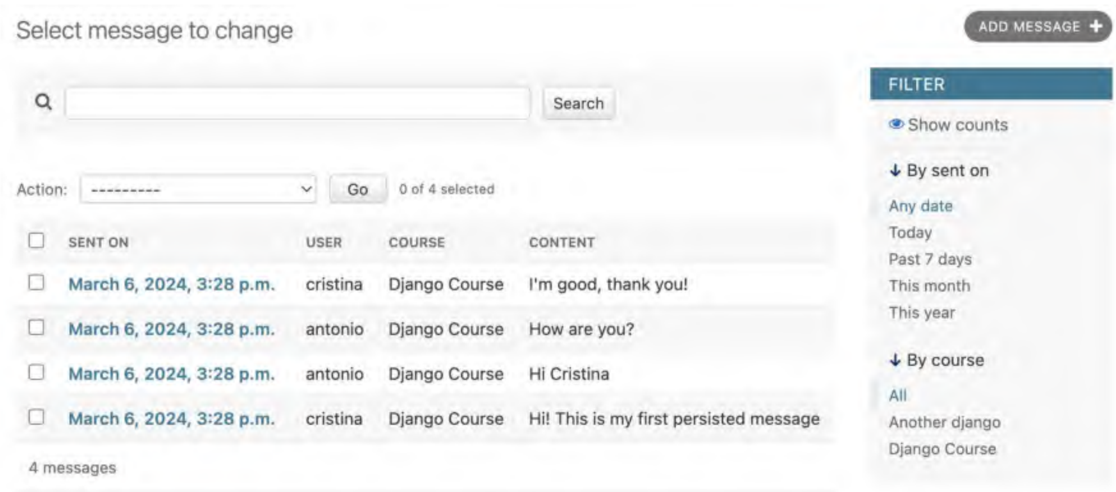


Figure 16.11: Admin list display view of messages stored in the database

All messages are now persisted in the database.

Note that messages could contain malicious code, for example, JavaScript fragments. We do not mark the messages as safe in our template, providing an initial layer of protection against malicious content. However, to further enhance security, consider sanitizing the messages before storing them in the database. A reliable option for sanitizing content is the `nh3` package. You can read more about `nh3` at `https://nh3.readthedocs.io/en/latest/`. Additionally, `django-nh3` is a Django integration available that offers custom `nh3` model fields and form fields. More information is available at `https://github.com/marksweb/django-nh3`.

Now that you are storing the complete chat history in your database, let's learn how to present the latest messages in the chat history to users when they join a chat room.

Displaying the chat history

When users join a course chat room, we will display the latest five messages of the chat history. This will ensure that users gain immediate context for ongoing conversations.

Edit the `views.py` file of the `chat` application and add the following code highlighted in bold to the `course_chat_room` view:

```
@login_required
def course_chat_room(request, course_id):
    try:
        # retrieve course with given id joined by the current user
        course = request.user.courses_joined.get(id=course_id)
    except Course.DoesNotExist:
        # user is not a student of the course or course does not exist
        return HttpResponseForbidden()
    # retrieve chat history
    latest_messages = course.chat_messages.select_related(
        'user'
    ).order_by('-id')[:5]
    latest_messages = reversed(latest_messages)
    return render(
        request,
        'chat/room.html',
        {'course': course, 'latest_messages': latest_messages}
    )
```

We retrieve the chat messages related to the course and use `select_related()` to fetch the related user in the same query. This will prevent the generation of additional SQL queries when accessing the username to display it alongside each message. Django's ORM doesn't support negative indexing, so we retrieve the first five messages in reverse chronological order, and we utilize the `reversed()` function to reorder them back into chronological sequence.

Now, we will add the chat history to the chat room template. Edit the `chat/room.html` template and add the following lines highlighted in bold:

```
# ...
{% block content %}
  <div id="chat">
    {% for message in latest_messages %}
      <div class="message {% if message.user == request.user %}me{% else %}
other{% endif %}">
        <strong>{{ message.user.username }}</strong>
        <span class="date">
          {{ message.sent_on|date:"Y.m.d H:i A" }}
        </span>
        <br>
        {{ message.content }}
      </div>
    {% endfor %}
  </div>
  <div id="chat-input">
    <input id="chat-message-input" type="text">
    <input id="chat-message-submit" type="submit" value="Send">
  </div>
{% endblock %}
# ...
```

Open `http://127.0.0.1:8000/chat/room/1/` in your browser, replacing `1` with the `id` of an existing course in the database. You should now see the latest messages, as shown in *Figure 16.12*:

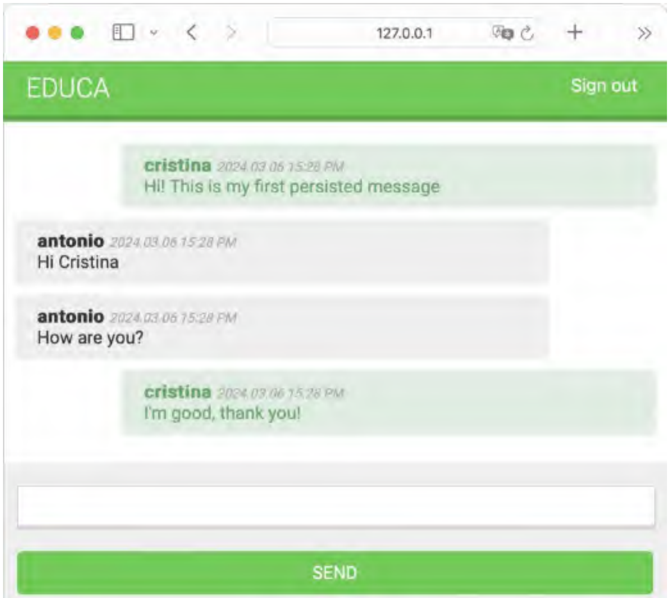


Figure 16.12: Chat room initially displaying the latest messages

Users can now see the latest messages in the chat history upon joining a chat room. Next, we are going to add a link to the menu so that users can enter the course chat room.

Integrating the chat application with existing views

The chat server is now fully implemented, and students enrolled in a course can communicate with each other. Let's add a link for students to join the chat room for each course.

Edit the `students/course/detail.html` template of the `students` application and add the following `<h3>` HTML element code at the bottom of the `<div class="contents">` element:

```
<div class="contents">
  ...
  <h3>
    <a href="{% url "chat:course_chat_room" object.id %}">
      Course chat room
    </a>
  </h3>
</div>
```

Open the browser and access any course that the student is enrolled in to view the course contents. The sidebar will now contain a **Course chat room** link that points to the course chat room view. If you click on it, you will enter the chat room:

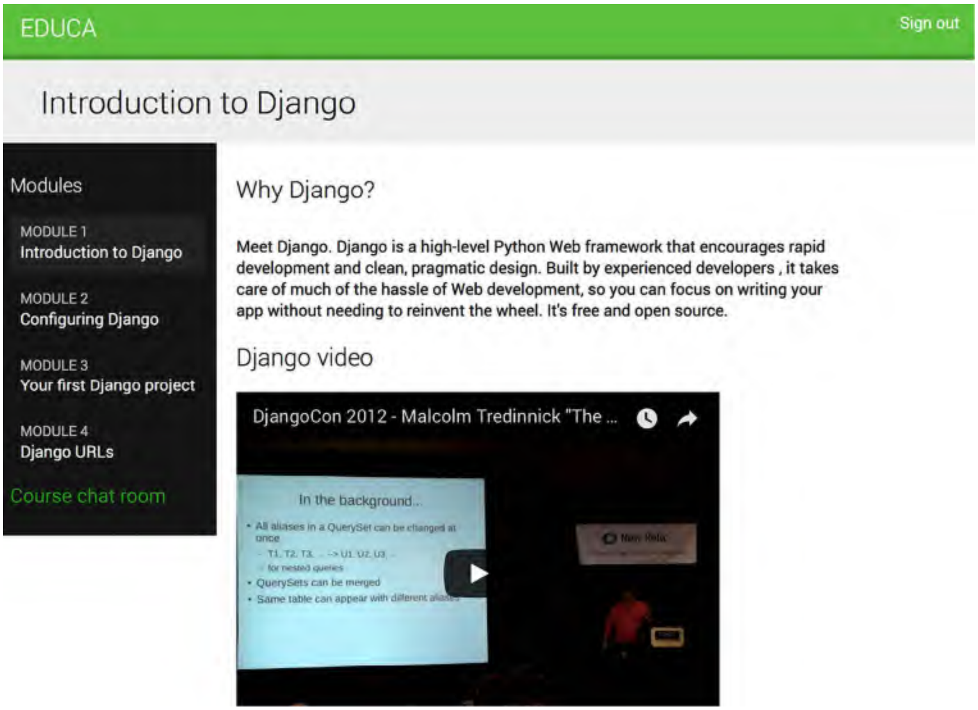


Figure 16.13: The course detail page, including a link to the course chat room

Congratulations! You successfully built your first asynchronous application using Django Channels.

Summary

In this chapter, you learned how to create a chat server using Channels. You implemented both a WebSocket consumer and a client. By enabling communication through a channel layer with Redis and modifying the consumer to be fully asynchronous, you improved the responsiveness and scalability of your application. Additionally, you implemented chat message persistence, providing a robust and user-friendly experience and maintaining chat history for users over time. The skills you learned in this chapter will help you in any future implementations of asynchronous real-time functionalities.

The next chapter will teach you how to build a production environment for your Django project using NGINX, uWSGI, and Daphne with Docker Compose. You will also learn how to implement custom middleware for request/response processing across your entire application, and how to develop custom management commands, which enable you to automate tasks and execute them via the command line.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter16`
- Introduction to ASGI: `https://asgi.readthedocs.io/en/latest/introduction.html`
- Django support for asynchronous views: `https://docs.djangoproject.com/en/5.0/topics/async/`
- Django support for asynchronous class-based views: `https://docs.djangoproject.com/en/5.0/topics/class-based-views/#async-class-based-views`
- Daphne ASGI server: `https://github.com/django/daphne`
- Django Channels documentation: `https://channels.readthedocs.io/`
- Deploying Django with ASGI: `https://docs.djangoproject.com/en/5.0/howto/deployment/asgi/`
- Introduction to WebSockets: `https://en.wikipedia.org/wiki/WebSocket`.
- `json_script` template filter usage: `https://docs.djangoproject.com/en/5.0/ref/templates/builtins/#json-script`
- Django ORM asynchronous queries: `https://docs.djangoproject.com/en/5.0/topics/db/queries/#asynchronous-queries`
- `nh3` documentation: `https://nh3.readthedocs.io/en/latest/`
- `django-nh3` project: `https://github.com/marksweb/django-nh3`

17

Going Live

In the previous chapter, you built a real-time chat server for students using Django Channels. Now that you have created a fully functional e-learning platform, you need to set up a production environment so that it can be accessed over the internet. Until now, you have been working in a development environment, using the Django development server to run your site. In this chapter, you will learn how to set up a production environment that is able to serve your Django project in a secure and efficient manner.

This chapter will cover the following topics:

- Configuring Django settings for multiple environments
- Using Docker Compose to run multiple services
- Setting up a web server with uWSGI and Django
- Serving PostgreSQL and Redis with Docker Compose
- Using the Django system check framework
- Serving NGINX with Docker
- Serving static assets through NGINX
- Securing connections through **Transport Layer Security** (**TLS**) / **Secure Sockets Layer** (**SSL**)
- Using the Daphne **Asynchronous Server Gateway Interface** (**ASGI**) server for Django Channels
- Creating a custom Django middleware
- Implementing custom Django management commands

In previous chapters, diagrams at the start represented views, templates, and end-to-end functionalities. This chapter, however, shifts focus to setting up a production environment. Instead, you will find specific diagrams to illustrate the environment setup throughout the chapter.

The source code for this chapter can be found at `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter17`.

All Python modules used in this chapter are included in the `requirements.txt` file in the source code that comes along with this chapter. You can follow the instructions to install each Python module below or you can install all requirements at once with the `python -m pip install -r requirements.txt` command.

Creating a production environment

It's time to deploy your Django project in a production environment. You will start by configuring Django settings for multiple environments, and then you will set up a production environment.

Managing settings for multiple environments

In real-world projects, you will have to deal with multiple environments. You will usually have at least a local environment for development and a production environment for serving your application. You could have other environments as well, such as testing or staging environments.

Some project settings will be common to all environments, but others will be specific to each environment. Usually, you will use a base file that defines common settings, and a settings file per environment that overrides any necessary settings and defines additional ones.

We will manage the following environments:

- `local`: The local environment to run the project on your machine
- `prod`: The environment for deploying your project on a production server

Create a `settings/` directory next to the `settings.py` file of the `educa` project. Rename the `settings.py` file to `base.py` and move it into the new `settings/` directory.

Create the following additional files inside the `settings/` folder so that the new directory looks as follows:

```
settings/
    __init__.py
    base.py
    local.py
    prod.py
```

These files are as follows:

- `base.py`: The base settings file, which contains common settings (previously `settings.py`)
- `local.py`: Custom settings for your local environment
- `prod.py`: Custom settings for the production environment

You have moved the settings files to a directory one level below, so you need to update the `BASE_DIR` setting in the `settings/base.py` file to point to the main project directory.

When handling multiple environments, create a base settings file and a settings file for each environment. Environment settings files should inherit the common settings and override environment-specific settings.

Edit the `settings/base.py` file and replace the following line:

```
BASE_DIR = Path(__file__).resolve().parent.parent
```

Replace the preceding line with the following one:

```
BASE_DIR = Path(__file__).resolve().parent.parent.parent
```

You point to one directory above by adding `.parent` to the `BASE_DIR` path. Let's configure the settings for the local environment.

Local environment settings

Instead of using a default configuration for the `DEBUG` and `DATABASES` settings, you will define them for each environment explicitly. These settings will be environment specific. Edit the `educa/settings/local.py` file and add the following lines:

```
from .base import *

DEBUG = True

DATABASES = {
    'default': {
        'ENGINE': 'django.db.backends.sqlite3',
        'NAME': BASE_DIR / 'db.sqlite3',
    }
}
```

This is the settings file for your local environment. In this file, you import all settings defined in the `base.py` file, and you define the `DEBUG` and `DATABASES` settings for this environment. The `DEBUG` and `DATABASES` settings remain the same as you have been using for development.

Now, remove the `DATABASES` and `DEBUG` settings from the `base.py` settings file.

Django management commands won't automatically detect the settings file to use because the project settings file is not the default `settings.py` file. When running management commands, you need to indicate the settings module that you want to use by adding a `--settings` option, as follows:

```
python manage.py runserver --settings=educa.settings.local
```

Next, we are going to validate the project and the local environment configuration.

Running the local environment

Let's run the local environment using the new settings structure. Make sure Redis is running or start the Redis Docker container in a shell with the following command:

```
docker run -it --rm --name redis -p 6379:6379 redis:7.2.4
```

Run the following management command in another shell, from the project directory:

```
python manage.py runserver --settings=educa.settings.local
```

Open `http://127.0.0.1:8000/` in your browser and check that the site loads correctly. You are now serving your site using the settings for the `local` environment.

If don't want to pass the `--settings` option every time you run a management command, you can define the `DJANGO_SETTINGS_MODULE` environment variable. Django will use it to identify the settings module to use. If you are using Linux or macOS, you can define the environment variable by executing the following command in the shell:

```
export DJANGO_SETTINGS_MODULE=educa.settings.local
```

If you are using Windows, you can execute the following command in the shell:

```
set DJANGO_SETTINGS_MODULE=educa.settings.local
```

Any management command you execute after this will use the settings defined in the `DJANGO_SETTINGS_MODULE` environment variable.

Stop the Django development server from the shell by pressing the *Ctrl* + *C* keys and stop the Redis Docker container from the shell by also pressing the *Ctrl* + *C* keys.

The local environment works well. Let's prepare the settings for the production environment.

Production environment settings

Let's start by adding initial settings for the production environment. Edit the `educa/settings/prod.py` file and make it look as follows:

```
from .base import *

DEBUG = False

ADMINS = [
    ('Antonio M', 'email@mydomain.com'),
]

ALLOWED_HOSTS = ['*']

DATABASES = {
    'default': {
        'ENGINE': 'django.db.backends.sqlite3',
        NAME: BASE_DIR / 'db.sqlite3',
    }
}
```

These are the settings for the production environment:

- `DEBUG`: Setting `DEBUG` to `False` is necessary for any production environment. Failing to do so will result in the traceback information and sensitive configuration data being exposed to everyone.

- `ADMINS`: When `DEBUG` is `False` and a view raises an exception, all information will be sent by email to the people listed in the `ADMINS` setting. Make sure that you replace the name/email tuple with your own information.
- `ALLOWED_HOSTS`: For security reasons, Django will only allow the hosts included in this list to serve the project. For now, you allow all hosts by using the asterisk symbol, `*`. You will limit the hosts that can be used for serving the project later.
- `DATABASES`: You keep the `default` database settings pointing to the SQLite database of your local environment. You will configure the production database later.

Over the next sections of this chapter, you will complete the settings file for your production environment.

You have successfully organized settings for handling multiple environments. Now, you will build a complete production environment by setting up different services with Docker.

Using Docker Compose

You initially used Docker in *Chapter 3*, *Extending Your Blog Application*, and you have been using Docker throughout this book to run containers for different services, such as PostgreSQL, Redis, and RabbitMQ.

Each Docker container combines application source code with operating system libraries and dependencies required to run the application. By using application containers, you can improve your application portability. For the production environment, we will use Docker Compose to build and run multiple Docker containers.

Docker Compose is a tool for defining and running multi-container applications. You can create a configuration file to define the different services and use a single command to start all services from your configuration. You can find information about Docker Compose at `https://docs.docker.com/compose/`.

For the production environment, you will create a distributed application that runs across multiple Docker containers. Each Docker container will run a different service. You will initially define the following three services and you will add additional services in the next sections:

- **Web service**: A web server to serve the Django project
- **Database service**: A database service to run PostgreSQL
- **Cache service**: A service to run Redis

Let's start by installing Docker Compose.

Installing Docker Compose via Docker Desktop

You can run Docker Compose on macOS, 64-bit Linux, and Windows. The fastest way to install Docker Compose is by installing Docker Desktop. The installation includes Docker Engine, the command-line interface, and Docker Compose.

Install Docker Desktop by following the instructions at `https://docs.docker.com/compose/install/compose-desktop/`.

Open the Docker Desktop application and click on **Containers**. It will look as follows:

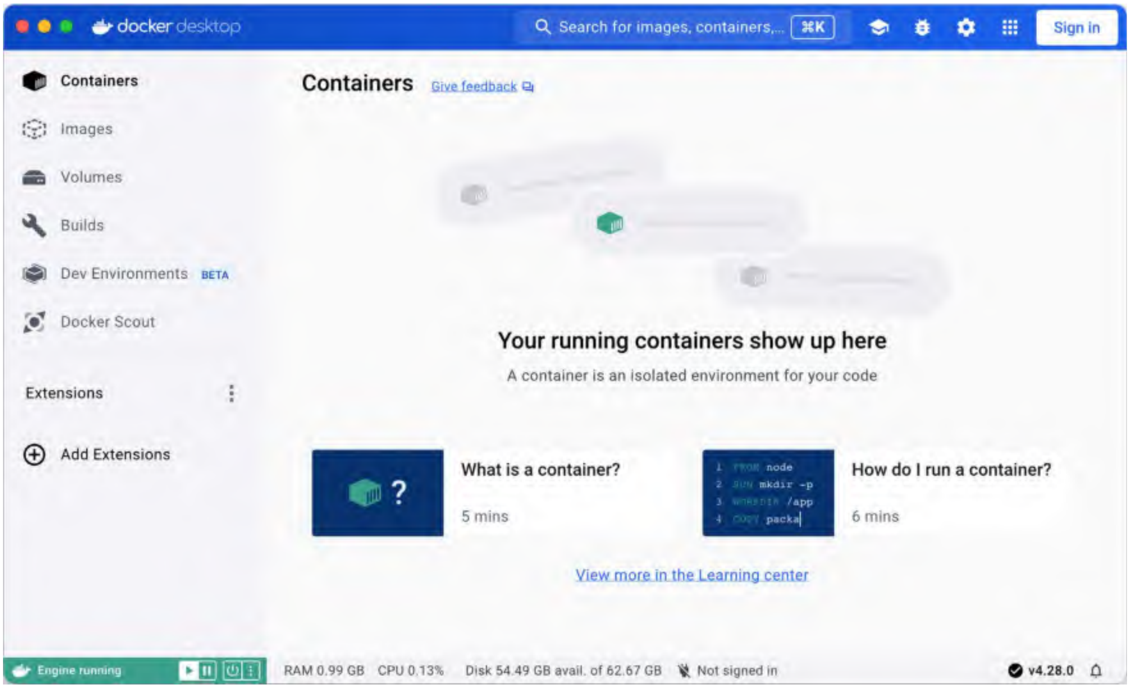


Figure 17.1: The Docker Desktop interface

After installing Docker Compose, you need to create a Docker image for your Django project.

Creating a Dockerfile

You need to create a Docker image to run the Django project. A `Dockerfile` is a text file that contains the commands for Docker to assemble a Docker image. You will prepare a `Dockerfile` with the commands for building the Docker image for the Django project.

Next to the `educa` project directory, create a new file and name it `Dockerfile`. Add the following code to the new file:

```
# Pull official base Python Docker image
FROM python:3.12.3

# Set environment variables
ENV PYTHONDONTWRITEBYTECODE=1
ENV PYTHONUNBUFFERED=1

# Set work directory
WORKDIR /code

# Install dependencies
```

```
RUN pip install --upgrade pip
COPY requirements.txt .
RUN pip install -r requirements.txt

# Copy the Django project
COPY . .
```

This code performs the following tasks:

1. The Python `3.12.3` parent Docker image is used. You can find the official Python Docker image at `https://hub.docker.com/_/python`.
2. The following environment variables are set:
    a. `PYTHONDONTWRITEBYTECODE`: This prevents Python from writing out `pyc` files.
    b. `PYTHONUNBUFFERED`: This ensures that the Python `stdout` and `stderr` streams are sent straight to the terminal without first being buffered.
3. The `WORKDIR` command is used to define the working directory of the image.
4. The `pip` package of the image is upgraded.
5. The `requirements.txt` file is copied to the working directory (`.`) of the parent Python image.
6. The Python packages in `requirements.txt` are installed in the image using `pip`.
7. The Django project source code is copied from the local directory to the working directory (`.`) directory of the image.

With this `Dockerfile`, you have defined how the Docker image that will serve Django will be assembled. You can find the `Dockerfile` reference at `https://docs.docker.com/reference/dockerfile/`.

Adding the Python requirements

A `requirements.txt` file is used in the `Dockerfile` you created to install all of the necessary Python packages for the project.

Next to the `educa` project directory, create a new file and name it `requirements.txt`. You may have already created this file before and copied the content for the `requirements.txt` file from `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter17/requirements.txt`. If you haven't done so, add the following lines to the newly created `requirements.txt` file:

```
asgiref==3.8.1
Django~=5.0.4
Pillow==10.3.0
sqlparse==0.5.0
django-braces==1.15.0
django-embed-video==1.4.9
pymemcache==4.0.0
django-debug-toolbar==4.3.0
redis==5.0.4
```

```
django-redisboard==8.4.0
djangorestframework==3.15.1
requests==2.31.0
channels[daphne]==4.1.0
channels-redis==4.2.0
psycopg==3.1.18
uwsgi==2.0.25.1
python-decouple==3.8
```

In addition to the Python packages that you installed in the previous chapters, the `requirements.txt` file includes the following packages:

- `psycopg`: This is the PostgreSQL adapter. You will use PostgreSQL for the production environment.
- `uwsgi`: A WSGI web server. You will configure this web server later to serve Django in the production environment.
- `python-decouple`: Package to load environment variables easily.

Let's start by setting up the Docker application in Docker Compose. We will create a Docker Compose file with the definition for the web server, database, and Redis services.

Creating a Docker Compose file

To define the services that will run in different Docker containers, we will use a Docker Compose file. The Compose file is a text file in YAML format, defining services, networks, and data volumes for a Docker application. YAML is a human-readable data-serialization language. You can see an example of a YAML file at `https://yaml.org/`.

Next to the `educa` project directory, create a new file and name it `docker-compose.yml`. Add the following code to it:

```
services:

  web:
    build: .
    command: python /code/educa/manage.py runserver 0.0.0.0:8000
    restart: always
    volumes:
      - .:/code
    ports:
      - "8000:8000"
    environment:
      - DJANGO_SETTINGS_MODULE=educa.settings.prod
```

In this file, you define a `web` service. The sections to define this service are as follows:

- `build`: This defines the build requirements for a service container image. This can be a single string defining a context path, or a detailed build definition. You provide a relative path with a single dot (`.`) to point to the same directory where the Compose file is located. Docker Compose will look for a `Dockerfile` at this location. You can read more about the `build` section at `https://docs.docker.com/compose/compose-file/build/`.
- `command`: This overrides the default command of the container. You run the Django development server using the `runserver` management command. The project is served on host `0.0.0.0`, which is the default Docker IP, on port `8000`.
- `restart`: This defines the restart policy for the container. Using `always`, the container is always restarted if it stops. This is useful for a production environment where you want to minimize downtime. You can read more about the restart policy at `https://docs.docker.com/config/containers/start-containers-automatically/`.
- `volumes`: Data in Docker containers is not permanent. Each Docker container has a virtual filesystem that is populated with the files of the image and that is destroyed when the container is stopped. Volumes are the preferred method to persist data generated and used by Docker containers. In this section, you mount the local `.` directory to the `/code` directory of the image. You can read more about Docker volumes at `https://docs.docker.com/storage/volumes/`.
- `ports`: This exposes container ports. Host port `8000` is mapped to container port `8000`, on which the Django development server is running.
- `environment`: This defines environment variables. You set the `DJANGO_SETTINGS_MODULE` environment variable to use the production Django settings file `educa.settings.prod`.

Note that in the Docker Compose file definition, you are using the Django development server to serve the application. The Django development server is not suitable for production use, so you will replace it later with a WSGI Python web server.

You can find information about the Docker Compose specification at `https://docs.docker.com/compose/compose-file/`.

At this point, assuming your parent directory is named `Chapter17`, the file structure should look as follows:

```
Chapter17/
    Dockerfile
    docker-compose.yml
    educa/
        manage.py
        ...
    requirements.txt
```

Open a shell in the parent directory, where the `docker-compose.yml` file is located, and run the following command:

```
docker compose up
```

This will start the Docker app defined in the Docker Compose file. You will see an output that includes the following lines:

```
chapter17-web-1  | Performing system checks...
chapter17-web-1  |
chapter17-web-1  | System check identified no issues (0 silenced).
chapter17-web-1  | March 10, 2024 - 12:03:28
chapter17-web-1  | Django version 5.0.4, using settings 'educa.settings.prod'
chapter17-web-1  | Starting ASGI/Daphne version 4.1.0 development server at
http://0.0.0.0:8000/
chapter17-web-1  | Quit the server with CONTROL-C.
```

The Docker container for your Django project is running!

Open `http://0.0.0.0:8000/admin/` with your browser. You should see the Django administration site login form. It should look like *Figure 17.2*:

Figure 17.2: The Django administration site login form with no CSS styles applied

CSS styles are not loaded. You are using `DEBUG=False`, so URL patterns for serving static files are not being included in the main `urls.py` file of the project. Remember that the Django development server is not suitable for serving static files. You will configure a server for serving static files later in this chapter.

If you access any other URL of your site, you might get an HTTP `500` error because you haven't configured a database for the production environment yet.

Take a look at the Docker Desktop app. You will see the following containers:

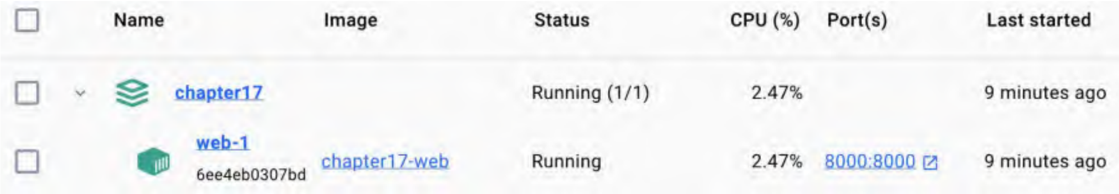


Figure 17.3: The chapter17 application and the web-1 container in Docker Desktop

The `chapter17` Docker application is running and it has a single container named `web-1`, which is running on port `8000`. The name for the Docker application is generated dynamically using the name of the directory where the Docker Compose file is located, in this case, `chapter17`.

Under **Images**, you will see the image built for the `web` service, as in *Figure 17.4*:

Figure 17.4: The chapter17 application and the web-1 container in Docker Desktop

The `chapter17-web` image has been built using the `Dockerfile` you defined earlier and is used by the `web-1` container.

Next, you are going to add a PostgreSQL service and a Redis service to your Docker application.

Configuring the PostgreSQL service

Throughout this book, you have mostly used the SQLite database. SQLite is simple and quick to set up, but for a production environment, you will need a more powerful database, such as PostgreSQL, MySQL, or Oracle. You used Docker to install PostgreSQL in *Chapter 3*, *Extending Your Blog Application*. You can find information about the official PostgreSQL Docker image at `https://hub.docker.com/_/postgres`.

Edit the `docker-compose.yml` file and add the following lines highlighted in bold:

```
services:

  db:
    image: postgres:16.2
    restart: always
    volumes:
      - ./data/db:/var/lib/postgresql/data
    environment:
      - POSTGRES_DB=postgres
      - POSTGRES_USER=postgres
```

```
      - POSTGRES_PASSWORD=postgres

  web:
    build: .
    command: python /code/educa/manage.py runserver 0.0.0.0:8000
    restart: always
    volumes:
      - .:/code
    ports:
      - "8000:8000"
    environment:
      - DJANGO_SETTINGS_MODULE=educa.settings.prod
      - POSTGRES_DB=postgres
      - POSTGRES_USER=postgres
      - POSTGRES_PASSWORD=postgres
    depends_on:
      - db
```

With these changes, you define a service named `db` with the following subsections:

- `image`: The service uses the base `postgres` Docker image.
- `restart`: The restart policy is set to `always`.
- `volumes`: You mount the `./data/db` directory to the image directory `/var/lib/postgresql/data` to persist the database so that data stored in the database is maintained after the Docker application is stopped. This will create the local `data/db/` path.
- `environment`: You use the `POSTGRES_DB` (database name), `POSTGRES_USER`, and `POSTGRES_PASSWORD` variables with default values.

The definition for the `web` service now includes the PostgreSQL environment variables for Django. You create a service dependency using `depends_on` so that the `web` service is started after the `db` service. This will guarantee the order of the container initialization, but it won't guarantee that PostgreSQL is fully initiated before the Django web server is started. To solve this, you need to use a script that will wait on the availability of the database host and its TCP port. Docker recommends that you use the `wait-for-it` tool to control container initialization.

Download the `wait-for-it.sh` bash script from `https://github.com/vishnubob/wait-for-it/blob/master/wait-for-it.sh` and save the file next to the `docker-compose.yml` file. Then, edit the `docker-compose.yml` file and modify the `web` service definition as follows. The new code is highlighted in bold:

```
web:
  build: .
  command: ["./wait-for-it.sh", "db:5432", "--",
            "python", "/code/educa/manage.py", "runserver",
            "0.0.0.0:8000"]
```

```
  restart: always
  volumes:
      - .:/code
    environment:
      - DJANGO_SETTINGS_MODULE=educa.settings.prod
      - POSTGRES_DB=postgres
      - POSTGRES_USER=postgres
      - POSTGRES_PASSWORD=postgres
    depends_on:
      - db
```

In this service definition, you use the `wait-for-it.sh` bash script to wait for the `db` host to be ready and accept connections on port `5432`, the default port for PostgreSQL, before starting the Django development server. You can read more about the service startup order in Compose at `https://docs.docker.com/compose/startup-order/`.

Let's edit the Django settings. Edit the `educa/settings/prod.py` file and add the following code highlighted in bold:

```
from decouple import config
from .base import *

DEBUG = False

ADMINS = [
    ('Antonio M', 'email@mydomain.com'),
]

ALLOWED_HOSTS = ['*']

DATABASES = {
    'default': {
        'ENGINE': 'django.db.backends.postgresql',
        'NAME': config('POSTGRES_DB'),
        'USER': config('POSTGRES_USER'),
        'PASSWORD': config('POSTGRES_PASSWORD'),
        'HOST': 'db',
        'PORT': 5432,
    }
}
```

In the production settings file, you use the following settings:

- `ENGINE`: You use the Django database backend for PostgreSQL.

- `NAME`, `USER`, and `PASSWORD`: You use the `config()` function of `python-decouple` to retrieve the `POSTGRES_DB` (database name), `POSTGRES_USER`, and `POSTGRES_PASSWORD` environment variables. You have set these environment variables in the Docker Compose file.
- `HOST`: You use `db`, which is the container hostname for the database service defined in the Docker Compose file. A container hostname defaults to the container's ID in Docker. That's why you use the `db` hostname.
- `PORT`: You use the `5432` value, which is the default port for PostgreSQL.

Stop the Docker application from the shell by pressing the *Ctrl* + *C* keys or using the stop button in the Docker Desktop app. Then, start Compose again with the following command:

```
docker compose up
```

The first execution after adding the `db` service to the Docker Compose file will take longer because PostgreSQL needs to initialize the database. The output will contain the following two lines:

```
db-1   | ... database system is ready to accept connections
...
web-1  | Starting ASGI/Daphne version 4.1.0 development server at
http://0.0.0.0:8000/
```

Both the PostgreSQL database and the Django application are ready. The production database is empty, so you need to apply database migrations.

Applying database migrations and creating a superuser

Open a different shell in the parent directory, where the `docker-compose.yml` file is located, and run the following command:

```
docker compose exec web python /code/educa/manage.py migrate
```

The `docker compose exec` command allows you to execute commands in the container. You use this command to execute the `migrate` management command in the `web` Docker container.

Finally, create a superuser with the following command:

```
docker compose exec web python /code/educa/manage.py createsuperuser
```

Migrations have been applied to the database and you have created a superuser. You can access `http://localhost:8000/admin/` with the superuser credentials. CSS styles still won't load because you haven't configured serving static files yet.

You have defined services to serve Django and PostgreSQL using Docker Compose. Next, you will add a service to serve Redis in the production environment.

Configuring the Redis service

Let's add a Redis service to the Docker Compose file. For this purpose, you will use the official Redis Docker image. You can find information about the official Redis Docker image at `https://hub.docker.com/_/redis`.

Edit the `docker-compose.yml` file and add the following lines highlighted in bold:

```
services:

  db:
    # ...

  cache:
    image: redis:7.2.4
    restart: always
    volumes:
      - ./data/cache:/data

  web:
    # ...
    depends_on:
      - db
      - cache
```

In the previous code, you define the `cache` service with the following subsections:

- `image`: The service uses the base `redis` Docker image.
- `restart`: The restart policy is set to `always`.
- `volumes`: You mount the `./data/cache` directory to the `/data` image directory where any Redis writes will be persisted. This will create the local `data/cache/` path.

In the `web` service definition, you add the `cache` service as a dependency, so that the `web` service is started after the `cache` service. The Redis server initializes fast, so you don't need to use the `wait-for-it` tool in this case.

Edit the `educa/settings/prod.py` file and add the following lines:

```
REDIS_URL = 'redis://cache:6379'
CACHES['default']['LOCATION'] = REDIS_URL
CHANNEL_LAYERS['default']['CONFIG']['hosts'] = [REDIS_URL]
```

In these settings, you use the `cache` hostname that is automatically generated by Docker Compose using the name of the `cache` service and port `6379` used by Redis. You modify the Django `CACHE` setting and the `CHANNEL_LAYERS` setting used by Channels to use the production Redis URL.

Stop the Docker application from the shell by pressing the *Ctrl* + *C* keys or using the stop button in the Docker Desktop app. Then, start Compose again with the following command:

```
docker compose up
cache-1    | ... Ready to accept connections tcp
```

Open the Docker Desktop application. You should see now the `chapter17` Docker application running a container for each service defined in the Docker Compose file: `db`, `cache`, and `web`, as in *Figure 17.4*:

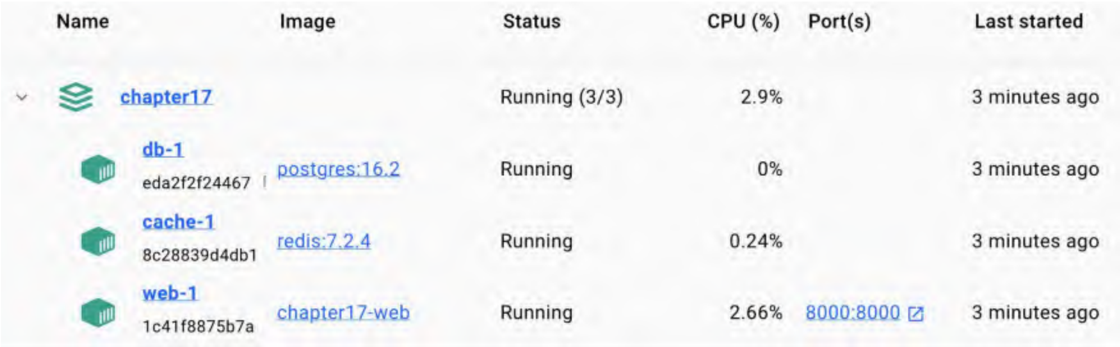


Figure 17.5: The chapter17 application with the db-1, web-1, and cache-1 containers in Docker Desktop

You are still serving Django with the Django development server, which, as you know, is meant for development only and not optimized for production use. Let's replace it with the WSGI Python web server.

Serving Django through WSGI and NGINX

Django's primary deployment platform is WSGI. **WSGI** stands for **Web Server Gateway Interface** , and it is the standard for serving Python applications on the web.

When you generate a new project using the `startproject` command, Django creates a `wsgi.py` file inside your project directory. This file contains a WSGI application callable, which is an access point to your application.

WSGI is used for both running your project with the Django development server and deploying your application with the server of your choice in a production environment. You can learn more about WSGI at `https://wsgi.readthedocs.io/en/latest/`.

In the following sections we will use **uWSGI**, an open source web server that implements the WSGI specification.

Using uWSGI

Throughout this book, you have been using the Django development server to run projects in your local environment. However, the development server is not designed for production use, and deploying your application in a production environment will require a standard web server.

uWSGI is an extremely fast Python application server. It communicates with your Python application using the WSGI specification. uWSGI translates web requests into a format that your Django project can process.

Let's configure uWSGI to serve the Django project. You already added `uwsgi==2.0.20` to the `requirements.txt` file of the project, so uWSGI is already being installed in the Docker image of the `web` service.

Edit the `docker-compose.yml` file and modify the `web` service definition as follows. The new code is highlighted in bold:

```
web:
    build: .
    command: ["./wait-for-it.sh", "db:5432", "--",
              "uwsgi", "--ini", "/code/config/uwsgi/uwsgi.ini"]
    restart: always
    volumes:
      - .:/code
    environment:
      - DJANGO_SETTINGS_MODULE=educa.settings.prod
      - POSTGRES_DB=postgres
      - POSTGRES_USER=postgres
      - POSTGRES_PASSWORD=postgres
    depends_on:
      - db
      - cache
```

Make sure to remove the `ports` section. uWSGI will be reachable with a socket, so you don't need to expose a port in the container.

The new `command` for the image runs `uwsgi` and passes the `/code/config/uwsgi/uwsgi.ini` configuration file to it. Let's create the configuration file for uWSGI.

Configuring uWSGI

uWSGI allows you to define a custom configuration in an `.ini` file. Next to the `docker-compose.yml` file, create the `config/uwsgi/uwsgi.ini` file path. Assuming your parent directory is named `Chapter17`, the file structure should look as follows:

```
Chapter17/
    config/
        uwsgi/
            uwsgi.ini
    Dockerfile
    docker-compose.yml
    educa/
        manage.py
        ...
    requirements.txt
```

Edit the `config/uwsgi/uwsgi.ini` file and add the following code to it:

```
[uwsgi]
```

```
socket=/code/educa/uwsgi_app.sock
chdir = /code/educa/
module=educa.wsgi:application
master=true
chmod-socket=666
uid=www-data
gid=www-data
vacuum=true
```

In the `uwsgi.ini` file, you define the following options:

- `socket`: This is the Unix/TCP socket to bind the server.
- `chdir`: This is the path to your project directory, so that uWSGI changes to that directory before loading the Python application.
- `module`: This is the WSGI module to use. You set this to the `application` callable contained in the `wsgi` module of your project.
- `master`: This enables the master process.
- `chmod-socket`: These are the file permissions to apply to the socket file. In this case, you use `666` so that NGINX can read/write the socket.
- `uid`: This is the user ID of the process once it's started.
- `gid`: This is the group ID of the process once it's started.
- `vacuum`: Using `true` instructs uWSGI to clean up any temporary files or UNIX sockets it creates.

The `socket` option is intended for communication with some kind of third-party router, such as NGINX. You are going to run uWSGI using a socket and you are going to configure NGINX as your web server, which will communicate with uWSGI through the socket.

You can find the list of available uWSGI options at `https://uwsgi-docs.readthedocs.io/en/latest/Options.html`.

You will not be able to access your uWSGI instance from your browser now, since it's running through a socket. To complete the environment, we will use NGINX in front of uWSGI, to manage HTTP requests and pass application requests to uWSGI through the socket. Let's complete the production environment.

Using NGINX

When you are serving a website, you have to serve dynamic content, but you also need to serve static files, such as CSS style sheets, JavaScript files, and images. While uWSGI is capable of serving static files, it adds unnecessary overhead to HTTP requests and, therefore, it is encouraged to set up a web server, such as NGINX, in front of it.

NGINX is a web server focused on high concurrency, performance, and low memory usage. NGINX also acts as a reverse proxy, receiving HTTP and WebSocket requests and routing them to different backends.

Generally, you will use a web server, such as NGINX, in front of uWSGI for serving static files efficiently, and you will forward dynamic requests to uWSGI workers. By using NGINX, you can also apply different rules and benefit from its reverse proxy capabilities.

We will add the NGINX service to the Docker Compose file using the official NGINX Docker image. You can find information about the official NGINX Docker image at `https://hub.docker.com/_/nginx`.

Edit the `docker-compose.yml` file and add the following lines highlighted in bold:

```
services:
  db:
    # ...
  cache:
    # ...
  web:
    # ...

  nginx:
    image: nginx:1.25.5
    restart: always
    volumes:
      - ./config/nginx:/etc/nginx/templates
      - .:/code
    ports:
      - "80:80"
```

You have added the definition for the `nginx` service with the following subsections:

- `image`: The service uses the base `nginx` Docker image.
- `restart`: The restart policy is set to `always`.
- `volumes`: You mount the `./config/nginx` volume to the `/etc/nginx/templates` directory of the Docker image. This is where NGINX will look for a default configuration template. You also mount the local directory `.` to the `/code` directory of the image, so that NGINX can have access to static files.
- `ports`: You expose port `80`, which is mapped to container port `80`. This is the default port for HTTP.

Let's configure the NGINX web server.

Configuring NGINX

Create the following file path highlighted in bold under the `config/` directory:

```
config/
    uwsgi/
      uwsgi.ini
```

```
    nginx/
        default.conf.template
```

Edit the `nginx/default.conf.template` file and add the following code to it:

```
# upstream for uWSGI
upstream uwsgi_app {
    server unix:/code/educa/uwsgi_app.sock;
}

server {
    listen       80;
    server_name  www.educaproject.com educaproject.com;
    error_log    stderr warn;
    access_log   /dev/stdout main;

    location / {
        include      /etc/nginx/uwsgi_params;
        uwsgi_pass   uwsgi_app;
    }
}
```

This is the basic configuration for NGINX. In this configuration, you set up an `upstream` component named `uwsgi_app`, which points to the socket created by uWSGI. You use the `server` block with the following configuration:

- You tell NGINX to listen on port `80`.
- You set the server name to both `www.educaproject.com` and `educaproject.com`. NGINX will serve incoming requests for both domains.
- You use `stderr` for the `error_log` directive to get error logs written to the standard error file. The second parameter determines the logging level. You use `warn` to get warnings and errors of higher severity.
- You point `access_log` to the standard output with `/dev/stdout`.
- You specify that any request under the `/` path has to be routed with the `uwsgi_app` socket to uWSGI.
- You include the default uWSGI configuration parameters that come with NGINX. These are located at `/etc/nginx/uwsgi_params`.

NGINX is now configured. You can find the NGINX documentation at `https://nginx.org/en/docs/`.

Stop the Docker application from the shell by pressing the *Ctrl* + *C* keys or using the stop button in the Docker Desktop app. Then, start Compose again with the following command:

```
docker compose up
```

Open the `http://localhost/` URL in your browser. It's not necessary to add a port to the URL because you are accessing the host through the standard HTTP port `80`. You should see the course list page with no CSS styles, like *Figure 17.6*:

Figure 17.6: The course list page served with NGINX and uWSGI

The following diagram shows the request/response cycle of the production environment that you have set up:

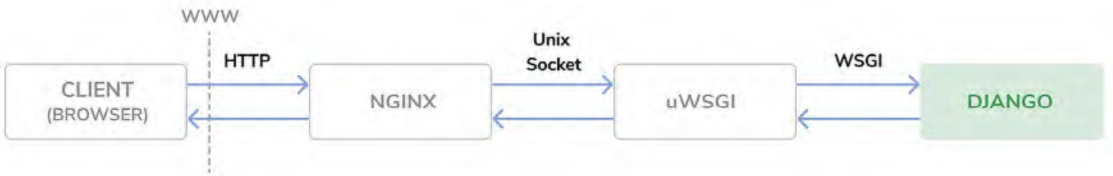


Figure 17.7: The production environment request/response cycle

The following happens when the client browser sends an HTTP request:

1. NGINX receives the HTTP request.
2. NGINX delegates the request to uWSGI through a socket.
3. uWSGI passes the request to Django for processing.
4. Django returns an HTTP response that is passed back to NGINX, which in turn passes it back to the client browser.

If you check the Docker Desktop application, you should see that there are four containers running:

- The `db` service is running PostgreSQL
- The `cache` service is running Redis
- The `web` service is running uWSGI and Django
- The `nginx` service is running NGINX

Let's continue with the production environment setup. Instead of accessing our project using `localhost`, we will configure the project to use the `educaproject.com` hostname.

Using a hostname

You will use the `educaproject.com` hostname for your site. Since you are using a sample domain name, you need to redirect it to your local host.

If you are using Linux or macOS, edit the `/etc/hosts` file and add the following line to it:

```
127.0.0.1 educaproject.com www.educaproject.com
```

If you are using Windows, edit the `C:\Windows\System32\drivers\etc` file and add the same line.

By doing so, you are routing the `educaproject.com` and `www.educaproject.com` hostnames to your local server. In a production server, you won't need to do this, since you will have a fixed IP address and you will point your hostname to your server in your domain's DNS configuration.

Open `http://educaproject.com/` in your browser. You should be able to see your site, still without any static assets loaded. Your production environment is almost ready.

Now, you can restrict the hosts that can serve your Django project. Edit the `educa/settings/prod.py` production settings file of your project and change the `ALLOWED_HOSTS` setting, as follows:

```
ALLOWED_HOSTS = ['educaproject.com', 'www.educaproject.com']
```

Django will only serve your application if it's running under any of these hostnames. You can read more about the `ALLOWED_HOSTS` setting at `https://docs.djangoproject.com/en/5.0/ref/settings/#allowed-hosts`.

The production environment is almost ready. Let's continue by configuring NGINX to serve static files.

Serving static and media assets

uWSGI is capable of serving static files flawlessly, but it is not as fast and effective as NGINX. For the best performance, you will use NGINX to serve static files in your production environment. You will set up NGINX to serve both the static files of your application (CSS style sheets, JavaScript files, and images) and media files uploaded by instructors for the course contents.

Edit the `settings/base.py` file and add the following line just below the `STATIC_URL` setting:

```
STATIC_ROOT = BASE_DIR / 'static'
```

This is the root directory for all static files of the project. Next, you are going to collect the static files from the different Django applications into the common directory.

Collecting static files

Each application in your Django project may contain static files in a `static/` directory. Django provides a command to collect static files from all applications into a single location. This simplifies the setup for serving static files in production. The `collectstatic` command collects the static files from all applications of the project into the path defined with the `STATIC_ROOT` setting.

Stop the Docker application from the shell by pressing the *Ctrl* + *C* keys or using the stop button in the Docker Desktop app. Then, start Compose again with the following command:

```
docker compose up
```

Open another shell in the parent directory, where the `docker-compose.yml` file is located, and run the following command:

```
docker compose exec web python /code/educa/manage.py collectstatic
```

Note that you can alternatively run the following command in the shell, from the `educa/` project directory:

```
python manage.py collectstatic --settings=educa.settings.local
```

Both commands will have the same effect since the base local directory is mounted to the Docker image. Django will ask whether you want to override any existing files in the root directory. Type `yes` and press *Enter*. You will see the following output:

```
171 static files copied to '/code/educa/static'.
```

Files located under the `static/` directory of each application present in the `INSTALLED_APPS` setting have been copied to the global `/educa/static/` project directory.

Serving static files with NGINX

Edit the `config/nginx/default.conf.template` file and add the following lines highlighted in bold to the `server` block:

```
server {
    # ...
    location / {
        include      /etc/nginx/uwsgi_params;
        uwsgi_pass   uwsgi_app;
    }

    location /static/ {
        alias /code/educa/static/;
    }

    location /media/ {
        alias /code/educa/media/;
    }
}
```

These directives tell NGINX to serve static files located under the `/static/` and `/media/` paths directly. These paths are as follows:

- `/static/`: This corresponds to the path of the `STATIC_URL` setting. The target path corresponds to the value of the `STATIC_ROOT` setting. You use it to serve the static files of your application from the directory mounted to the NGINX Docker image.

- `/media/`: This corresponds to the path of the `MEDIA_URL` setting, and its target path corresponds to the value of the `MEDIA_ROOT` setting. You use it to serve the media files uploaded to the course contents from the directory mounted to the NGINX Docker image.

Figure 17.8 shows the current setup of the production environment:

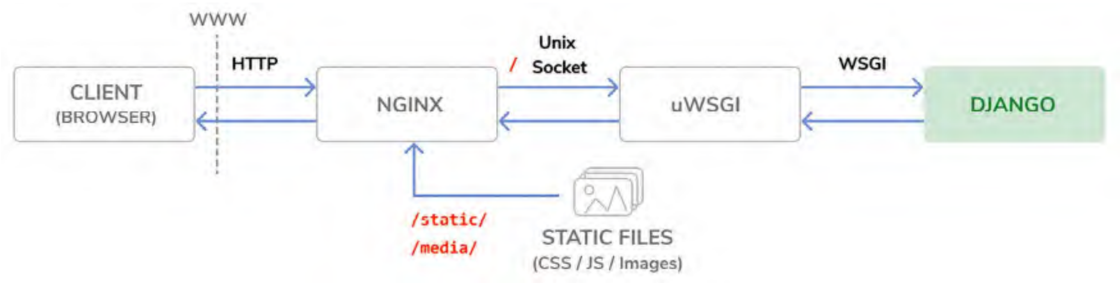


Figure 17.8: The production environment request/response cycle, including static files

Files under the `/static/` and `/media/` paths are now served by NGINX directly, instead of being forwarded to uWSGI. Requests to any other path are still passed by NGINX to uWSGI through the UNIX socket.

Stop the Docker application from the shell by pressing the *Ctrl* + *C* keys or using the stop button in the Docker Desktop app. Then, start Compose again with the following command:

```
docker compose up
```

Open `http://educaproject.com/` in your browser. You should see the following screen:

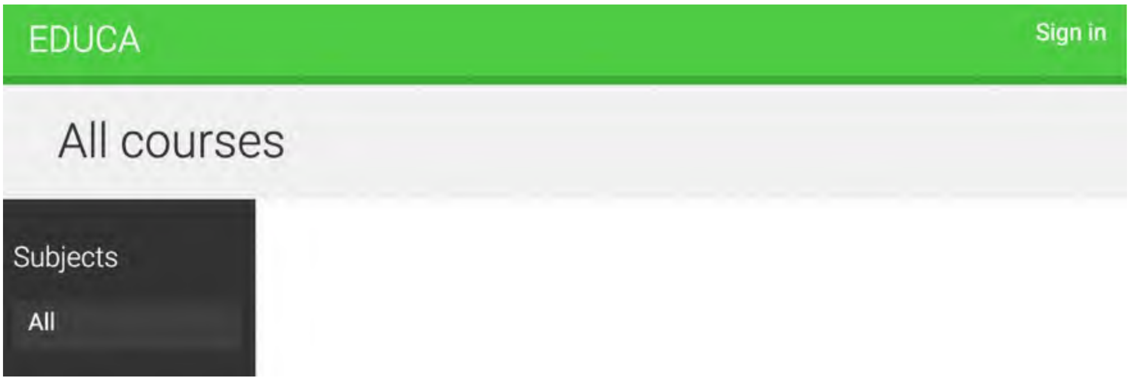


Figure 17.9: The course list page served with NGINX and uWSGI

Static resources, such as CSS style sheets and images, are now loaded correctly. HTTP requests for static files are now being served by NGINX directly, instead of being forwarded to uWSGI.

You have successfully configured NGINX for serving static files. Next, you are going to perform some checks on your Django project to validate it for a production environment and you are going to serve your site under HTTPS.

Securing your site with SSL/TLS

The **TLS** protocol is the standard for serving websites through a secure connection. The TLS predecessor is SSL. Although SSL is now deprecated, in multiple libraries and online documentation, you will find references to both the terms TLS and SSL. It's strongly encouraged that you serve your websites over HTTPS.

In this section, you are going to check your Django project for any issues and validate it for a production deployment. You will also prepare the project to be served over HTTPS. Then, you are going to configure an SSL/TLS certificate in NGINX to serve your site securely.

Checking your project for production

Django includes a system check framework for validating your project at any time. The check framework inspects the applications installed in your Django project and detects common problems. Checks are triggered implicitly when you run management commands like `runserver` and `migrate`. However, you can trigger checks explicitly with the `check` management command.

You can read more about Django's system check framework at `https://docs.djangoproject.com/en/5.0/topics/checks/`.

Let's confirm that the check framework does not raise any issues for your project. Open the shell in the `educa` project directory and run the following command to check your project:

```
python manage.py check --settings=educa.settings.prod
```

You will see the following output:

```
System check identified no issues (0 silenced).
```

The system check framework didn't identify any issues. If you use the `--deploy` option, the system check framework will perform additional checks that are relevant for a production deployment.

Run the following command from the `educa` project directory:

```
python manage.py check --deploy --settings=educa.settings.prod
```

You will see an output like the following:

```
System check identified some issues:
WARNINGS:
(security.W004) You have not set a value for the SECURE_HSTS_SECONDS setting.
...
(security.W008) Your SECURE_SSL_REDIRECT setting is not set to True...
(security.W009) Your SECRET_KEY has less than 50 characters, less than 5 unique
characters, or it's prefixed with 'django-insecure-'...
(security.W012) SESSION_COOKIE_SECURE is not set to True. ...
```

```
(security.W016) You have 'django.middleware.csrf.CsrfViewMiddleware' in your
MIDDLEWARE, but you have not set CSRF_COOKIE_SECURE ...
System check identified 5 issues (0 silenced).
```

The check framework has identified five issues (zero errors and five warnings). All warnings are related to security-related settings.

Let's address the `security.W009` issue. Edit the `educa/settings/base.py` file and modify the `SECRET_KEY` setting by removing the `django-insecure-` prefix and adding additional random characters to generate a string with at least 50 characters.

Run the `check` command again and verify that the `security.W009` issue is not raised anymore. The rest of the warnings are related to SSL/TLS configuration. We will address them next.

Configuring your Django project for SSL/TLS

Django comes with specific settings for SSL/TLS support. You are going to edit the production settings to serve your site over HTTPS.

Edit the `educa/settings/prod.py` settings file and add the following settings to it:

```python
# Security
CSRF_COOKIE_SECURE = True
SESSION_COOKIE_SECURE = True
SECURE_SSL_REDIRECT = True
```

These settings are as follows:

- `CSRF_COOKIE_SECURE`: Use a secure cookie for **cross-site request forgery** (**CSRF**) protection. With `True`, browsers will only transfer the cookie over HTTPS.
- `SESSION_COOKIE_SECURE`: Use a secure session cookie. With `True`, browsers will only transfer the cookie over HTTPS.
- `SECURE_SSL_REDIRECT`: This indicates whether HTTP requests have to be redirected to HTTPS.

Django will now redirect HTTP requests to HTTPS; session and CSRF cookies will be sent only over HTTPS.

Run the following command from the main directory of your project:

```
python manage.py check --deploy --settings=educa.settings.prod
```

Only one warning remains, `security.W004`:

```
(security.W004) You have not set a value for the SECURE_HSTS_SECONDS setting.
...
```

This warning is related to the **HTTP Strict Transport Security** (**HSTS**) policy. The HSTS policy prevents users from bypassing warnings and connecting to a site with an expired, self-signed, or otherwise invalid SSL certificate. In the next section, we will use a self-signed certificate for our site, so we will ignore this warning.

When you own a real domain, you can apply for a trusted **Certificate Authority** (**CA**) to issue an SSL/TLS certificate for it, so that browsers can verify its identity. In that case, you can give a value to `SECURE_HSTS_SECONDS` higher than `0`, which is the default value. You can learn more about the HSTS policy at `https://docs.djangoproject.com/en/5.0/ref/middleware/#http-strict-transport-security`.

You have successfully fixed the rest of the issues raised by the check framework. You can read more about the Django deployment checklist at `https://docs.djangoproject.com/en/5.0/howto/deployment/checklist/`.

Creating an SSL/TLS certificate

Create a new directory inside the `educa` project directory and name it `ssl`. Then, generate an SSL/TLS certificate from the command line with the following command:

```
openssl req -x509 -newkey rsa:2048 -sha256 -days 3650 -nodes \
  -keyout ssl/educa.key -out ssl/educa.crt \
  -subj '/CN=*.educaproject.com' \
  -addext 'subjectAltName=DNS:*.educaproject.com'
```

This will generate a private key and a 2048-bit SSL/TLS certificate that is valid for 10 years. This certificate is issued for the `*.educaproject.com` hostname. This is a wildcard certificate; by using the * wildcard character in the domain name, the certificate can be used for any subdomain of `educaproject.com`, such as `www.educaproject.com` or `django.educaproject.com`. After generating the certificate, the `educa/ssl/` directory will contain two files: `educa.key` (the private key) and `educa.crt` (the certificate).

You will need at least OpenSSL 1.1.1 or LibreSSL 3.1.0 to use the `-addext` option. You can check the OpenSSL location in your machine with the `which openssl` command and you can check the version with the `openssl version` command.

Alternatively, you can use the SSL/TLS certificate provided in the source code for this chapter. You will find the certificate at `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter17/educa/ssl/`. Note that you should generate a private key and not use this certificate in production.

Configuring NGINX to use SSL/TLS

Edit the `docker-compose.yml` file and add the following line highlighted in bold:

```
services:
  # ...

  nginx:
    #...
    ports:
      - "80:80"
      - "443:443"
```

The NGINX container host will be accessible through port `80` (HTTP) and port `443` (HTTPS). The host port `443` is mapped to the container port `443`.

Edit the `config/nginx/default.conf.template` file of the `educa` project and edit the `server` block to include SSL/TLS, as follows:

```
server {
   listen                  80;
   listen                  443 ssl;
   ssl_certificate         /code/educa/ssl/educa.crt;
   ssl_certificate_key     /code/educa/ssl/educa.key;
   server_name             www.educaproject.com educaproject.com;
   # ...
}
```

With the preceding code, NGINX now listens both to HTTP over port `80` and HTTPS over port `443`. You indicate the path to the SSL/TLS certificate with `ssl_certificate` and the certificate key with `ssl_certificate_key`.

Stop the Docker application from the shell by pressing the *Ctrl* + *C* keys or using the stop button in the Docker Desktop app. Then, start Compose again with the following command:

```
docker compose up
```

Open `https://educaproject.com/` with your browser. You should see a warning message similar to the following one:

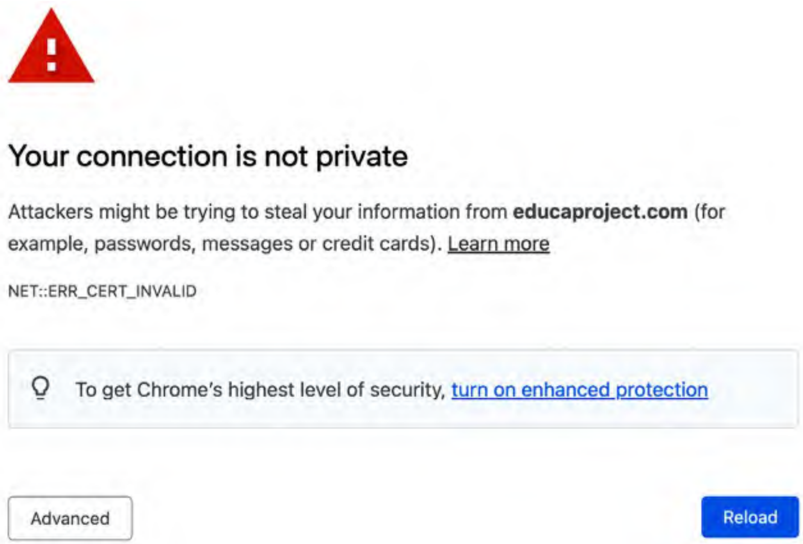


Figure 17.10: An invalid certificate warning

This screen might vary depending on your browser. It alerts you that your site is not using a trusted or valid certificate; the browser can't verify the identity of your site. This is because you signed your own certificate instead of obtaining one from a trusted CA. When you own a real domain, you can apply for a trusted CA to issue an SSL/TLS certificate for it, so that browsers can verify its identity. If you want to obtain a trusted certificate for a real domain, you can refer to the Let's Encrypt project created by the Linux Foundation. It is a nonprofit CA that simplifies obtaining and renewing trusted SSL/TLS certificates for free. You can find more information at `https://letsencrypt.org`.

Click on the link or button that provides additional information and choose to visit the website, ignoring warnings. The browser might ask you to add an exception for this certificate or verify that you trust it. If you are using Chrome, you might not see any option to proceed to the website. If this is the case, type `thisisunsafe` and press *Enter* directly in Chrome on the warning page. Chrome will then load the website. Note that you do this with your own issued certificate; don't trust any unknown certificate or bypass the browser SSL/TLS certificate checks for other domains.

When you access the site, the browser will display a lock icon next to the URL like *Figure 17.11*:

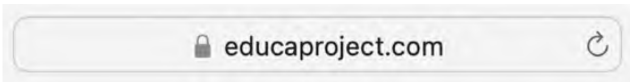


Figure 17.11: The browser address bar, including a secure connection padlock icon

Other browsers might display a warning indicating that the certificate is not trusted, like *Figure 17.12*:

Figure 17.12: The browser address bar, including a warning message

Your browser might mark the certificate as unsafe, but you are using it for testing purposes only. You are now serving your site securely over HTTPS.

Redirecting HTTP traffic over to HTTPS

You are redirecting HTTP requests to HTTPS with Django using the `SECURE_SSL_REDIRECT` setting. Any request using `http://` is redirected to the same URL using `https://`. However, this can be handled in a more efficient manner using NGINX.

Edit the `config/nginx/default.conf.template` file and add the following lines highlighted in bold:

```
# upstream for uWSGI
upstream uwsgi_app {
    server unix:/code/educa/uwsgi_app.sock;
}

server {
    listen       80;
    server_name www.educaproject.com educaproject.com;
```

```
    return 301 https://$host$request_uri;
}

server {
    listen               443 ssl;
    ssl_certificate      /code/educa/ssl/educa.crt;
    ssl_certificate_key  /code/educa/ssl/educa.key;
    server_name   www.educaproject.com educaproject.com;
    # ...
}
```

In this code, you remove the directive `listen 80;` from the original `server` block, so that the platform is only available over HTTPS (port `443`). On top of the original `server` block, you add an additional `server` block that only listens on port `80` and redirects all HTTP requests to HTTPS. To achieve this, you return an HTTP response code `301` (permanent redirect) that redirects to the `https://` version of the requested URL using the `$host` and `$request_uri` variables.

Open a shell in the parent directory, where the `docker-compose.yml` file is located, and run the following command to reload NGINX:

```
docker compose exec nginx nginx -s reload
```

This runs the `nginx -s reload` command in the `nginx` container. You are now redirecting all HTTP traffic to HTTPS using NGINX.

Your environment is now secured with TLS/SSL. To complete the production environment setup, the only remaining step is integrating Daphne to handle asynchronous requests, and get our course chat rooms running in production.

Configuring Daphne for Django Channels

In *Chapter 16*, *Building a Chat Server*, you used Django Channels to build a chat server using WebSockets and you used Daphne to serve asynchronous requests by replacing the standard Django `runserver` command. We will add Daphne to our production environment.

Let's create a new service in the Docker Compose file to run the Daphne web server.

Edit the `docker-compose.yml` file and add the following lines inside the `services` block:

```
daphne:
    build: .
    working_dir: /code/educa/
    command: ["../wait-for-it.sh", "db:5432", "--",
              "daphne", "-b", "0.0.0.0", "-p", "9001",
              "educa.asgi:application"]
    restart: always
    volumes:
```

```
      - .:/code
    environment:
      - DJANGO_SETTINGS_MODULE=educa.settings.prod
      - POSTGRES_DB=postgres
      - POSTGRES_USER=postgres
      - POSTGRES_PASSWORD=postgres
    depends_on:
      - db
      - cache
```

The daphne service definition is very similar to the web service. The image for the daphne service is also built with the Dockerfile you previously created for the web service. The main differences are as follows:

- working_dir changes the working directory of the image to /code/educa/.
- command runs the educa.asgi:application application defined in the educa/asgi.py file with daphne in the 0.0.0.0 hostname and port 9001. It also uses the wait-for-it bash script to wait for the PostgreSQL database to be ready before initializing the web server.

Since you are running Django on production, Django checks the ALLOWED_HOSTS when receiving HTTP requests. We will implement the same validation for WebSocket connections.

Edit the educa/asgi.py file of your project and add the following lines highlighted in bold:

```
import os
from django.core.asgi import get_asgi_application
from channels.routing import ProtocolTypeRouter, URLRouter
from channels.security.websocket import AllowedHostsOriginValidator
from channels.auth import AuthMiddlewareStack

os.environ.setdefault('DJANGO_SETTINGS_MODULE', 'educa.settings')

django_asgi_app = get_asgi_application()

from chat.routing import websocket_urlpatterns

application = ProtocolTypeRouter({
    'http': django_asgi_app,
    'websocket': AllowedHostsOriginValidator(
        AuthMiddlewareStack(
            URLRouter(websocket_urlpatterns)
        )
    ),
})
```

The Channels configuration is now ready for production.

Using secure connections for WebSockets

You have configured NGINX to use secure connections with SSL/TLS. You need to change `ws` (WebSocket) connections to use the `wss` (WebSocket Secure) protocol now, in the same way that HTTP connections are now being served over HTTPS.

Edit the `chat/room.html` template of the `chat` application and find the following line in the `domready` block:

```
const url = 'ws://' + window.location.host +
```

Replace that line with the following one:

```
const url = 'wss://' + window.location.host +
```

By using `wss://` instead of `ws://`, you are explicitly connecting to a secure WebSocket.

Including Daphne in the NGINX configuration

In your production setup, you will run Daphne on a UNIX socket and use NGINX in front of it. NGINX will pass requests to Daphne based on the requested path. You will expose Daphne to NGINX through a UNIX socket interface, just like the uWSGI setup.

Edit the `config/nginx/default.conf.template` file and make it look as follows:

```
# upstream for uWSGI
upstream uwsgi_app {
    server unix:/code/educa/uwsgi_app.sock;
}

# upstream for Daphne
upstream daphne {
    server daphne:9001;
}

server {
    listen       80;
    server_name www.educaproject.com educaproject.com;
    return 301 https://$host$request_uri;
}
```

```
server {
    listen                443 ssl;
    ssl_certificate       /code/educa/ssl/educa.crt;
    ssl_certificate_key   /code/educa/ssl/educa.key;
    server_name   www.educaproject.com educaproject.com;
    error_log     stderr warn;
    access_log    /dev/stdout main;

    location / {
        include       /etc/nginx/uwsgi_params;
        uwsgi_pass    uwsgi_app;
    }

    location /ws/ {
        proxy_pass            http://daphne;
        proxy_http_version    1.1;
        proxy_set_header      Upgrade $http_upgrade;
        proxy_set_header      Connection "upgrade";
        proxy_redirect        off;
    }

    location /static/ {
        alias /code/educa/static/;
    }

    location /media/ {
        alias /code/educa/media/;
    }
}
```

In this configuration, you set up a new upstream named `daphne`, which points to the `daphne` host and port `9001`. In the `server` block, you configure the `/ws/` location to forward requests to Daphne. You use the `proxy_pass` directive to pass requests to Daphne and you include some additional proxy directives.

With this configuration, NGINX will pass any URL request that starts with the `/ws/` prefix to Daphne and the rest to uWSGI, except for files under the `/static/` or `/media/` paths, which will be served directly by NGINX.

Figure 17.13 shows the final production setup, including the Daphne server:

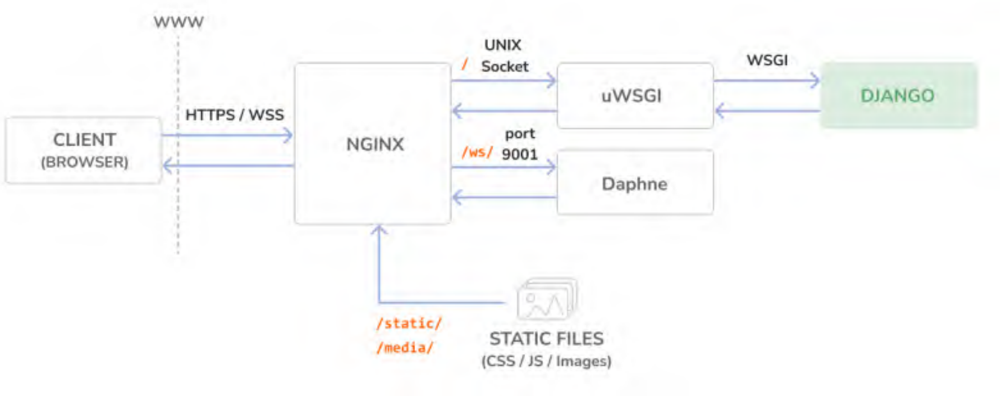


Figure 17.13: The production environment request/response cycle, including Daphne

NGINX runs in front of uWSGI and Daphne as a reverse proxy server. NGINX faces the web and passes requests to the application server (uWSGI or Daphne) based on their path prefix. Besides this, NGINX also serves static files and redirects non-secure requests to secure ones. This setup reduces downtime, consumes fewer server resources, and provides greater performance and security.

Stop the Docker application from the shell by pressing the *Ctrl* + *C* keys or using the stop button in the Docker Desktop app. Then, start Compose again with the following command:

```
docker compose up
```

Use your browser to create a sample course with an instructor user, log in with a user who is enrolled in the course, and open `https://educaproject.com/chat/room/1/` with your browser. You should be able to send and receive messages like the following example:

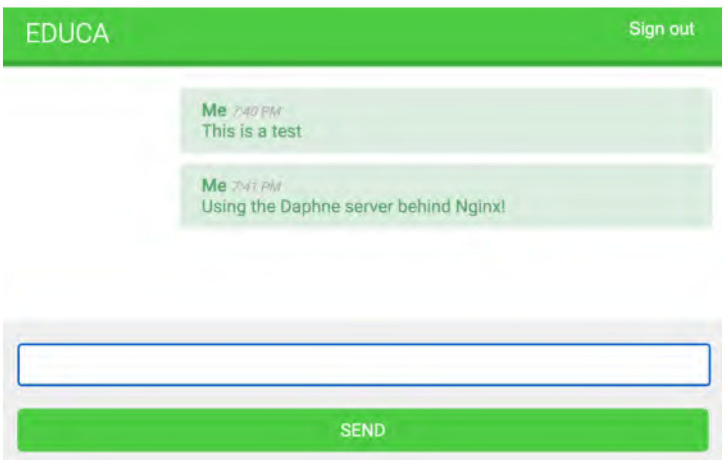


Figure 17.14: Course chat room messages served with NGINX and Daphne

Daphne is working correctly, and NGINX is passing WebSocket requests to it. All connections are secured with SSL/TLS.

Congratulations! You have built a custom production-ready stack using NGINX, uWSGI, and Daphne. You could do further optimization for additional performance and enhanced security through configuration settings in NGINX, uWSGI, and Daphne. However, this production setup is a great start!

You have used Docker Compose to define and run services in multiple containers. Note that you can use Docker Compose both for local development environments as well as production environments. You can find additional information on using Docker Compose in production at `https://docs.docker.com/compose/production/`.

For more advanced production environments, you will need to dynamically distribute containers across a varying number of machines. For that, instead of Docker Compose, you will need an orchestrator like Docker Swarm mode or Kubernetes. You can find information about the Docker Swarm mode at `https://docs.docker.com/engine/swarm/`, and about Kubernetes at `https://kubernetes.io/docs/home/`.

Note that managing systems and cloud infrastructure demands expertise in configuration, optimization, and security. To ensure a secure and efficient production environment, consider bringing a systems/DevOps expert on board or enhancing your own expertise in these areas.

Now that we have a complete environment that processes HTTP requests in a performant manner, it's a good time to dive into middleware for request/response processing across our application.

Creating a custom middleware

You already know the `MIDDLEWARE` setting, which contains the middleware for your project. You can think of it as a low-level plugin system, allowing you to implement hooks that get executed in the request/response process. Each middleware is responsible for some specific action that will be executed for all HTTP requests or responses.

> You should avoid adding expensive processing to middleware since they are executed in every single request.

Figure 17.15 shows the middleware execution in Django:

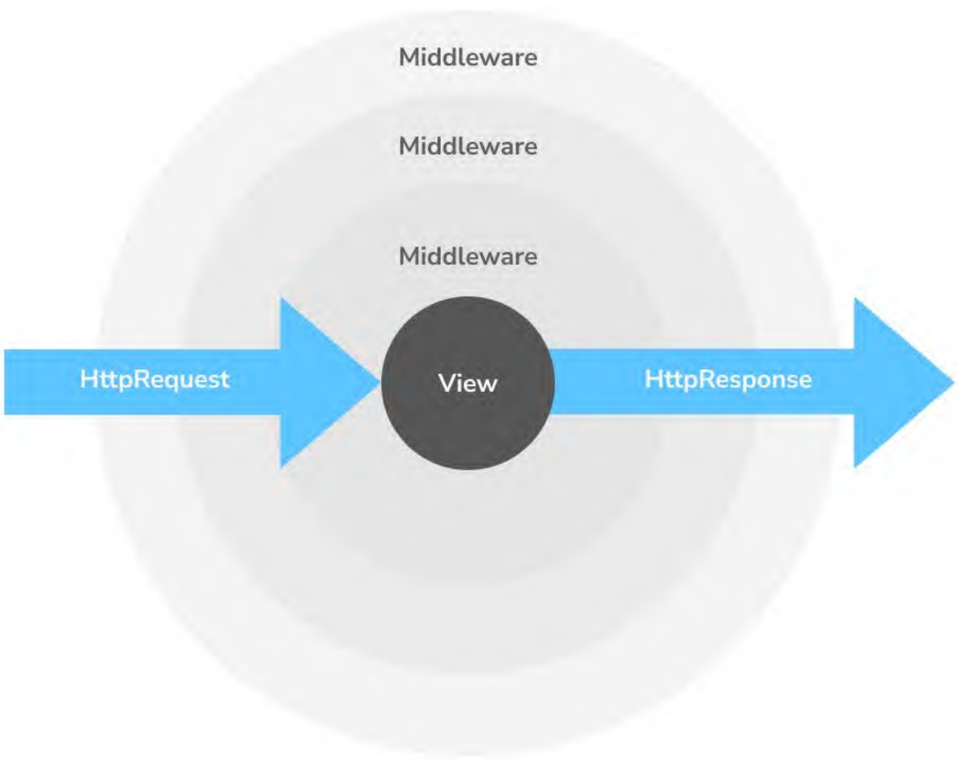


Figure 17.15: Middleware execution in Django

When an HTTP request is received, middleware is executed in order of appearance in the `MIDDLEWARE` setting. When an HTTP response has been generated by Django, the response passes through all middleware back in reverse order.

Figure 17.16 shows the execution order of the middleware components included in the `MIDDLEWARE` setting when creating a project with the `startproject` management command:

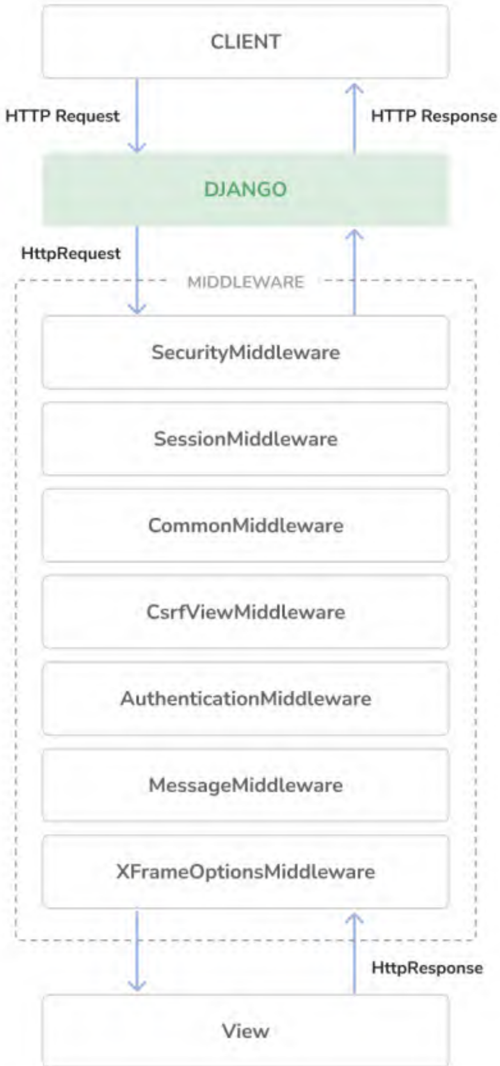


Figure 17.16: Execution order for default middleware components

Middleware can be written as a function, as follows:

```
def my_middleware(get_response):
    def middleware(request):
        # Code executed for each request before
        # the view (and later middleware) are called.
        response = get_response(request)
```

```
        # Code executed for each request/response after
        # the view is called.
        return response
    return middleware
```

A middleware factory is a callable that takes a `get_response` callable and returns middleware. The `middleware` callable takes a request and returns a response, just like a view. The `get_response` callable might be the next middleware in the chain or the actual view in the case of the last listed middleware.

If any middleware returns a response without calling its `get_response` callable, it short-circuits the process; no further middleware gets executed (nor does the view), and the response returns through the same layers that the request passed in through.

The order of middleware components in the `MIDDLEWARE` setting is very important because each component may depend on the data set in the request by other middleware components executed previously.

When adding a new middleware to the `MIDDLEWARE` setting, make sure to place it in the right position.

You can find more information about middleware at `https://docs.djangoproject.com/en/5.0/topics/http/middleware/`.

Creating subdomain middleware

You are going to create custom middleware to allow courses to be accessible through a custom subdomain. Each course detail URL, which looks like `https://educaproject.com/course/django/`, will also be accessible through the subdomain that makes use of the course slug, such as `https://django.educaproject.com/`. Users will be able to use the subdomain as a shortcut to access the course details. Any requests to subdomains will be redirected to each corresponding course detail URL.

Middleware can reside anywhere within your project. However, it's recommended that you create a `middleware.py` file in your application directory.

Create a new file inside the `courses` application directory and name it `middleware.py`. Add the following code to it:

```
from django.urls import reverse
from django.shortcuts import get_object_or_404, redirect
from .models import Course

def subdomain_course_middleware(get_response):
    """
    Subdomains for courses
    """
    def middleware(request):
        host_parts = request.get_host().split('.')
        if len(host_parts) > 2 and host_parts[0] != 'www':
```

```
                # get course for the given subdomain
                course = get_object_or_404(Course, slug=host_parts[0])
                course_url = reverse('course_detail', args=[course.slug])
                # redirect current request to the course_detail view
                url = '{}://{}{}'.format(
                    request.scheme, '.'.join(host_parts[1:]), course_url
                )
                return redirect(url)
            response = get_response(request)
            return response
        return middleware
```

When an HTTP request is received, you perform the following tasks:

1. You get the hostname that is being used in the request and divide it into parts. For example, if the user is accessing `mycourse.educaproject.com`, you generate the `['mycourse', 'educaproject', 'com']` list.
2. You check whether the hostname includes a subdomain by checking whether the split generated more than two elements. If the hostname includes a subdomain, and this is not `www`, you try to get the course with the slug provided in the subdomain.
3. If a course is not found, you raise an HTTP `404` exception. Otherwise, you redirect the browser to the course detail URL.

Edit the `settings/base.py` file of the project and add `'courses.middleware.subdomain_course_middleware'` at the bottom of the `MIDDLEWARE` list, as follows:

```
MIDDLEWARE = [
    # ...
    'courses.middleware.subdomain_course_middleware',
]
```

The middleware will now be executed in every request.

Remember that the hostnames allowed to serve your Django project are specified in the `ALLOWED_HOSTS` setting. Let's change this setting so that any possible subdomain of `educaproject.com` is allowed to serve your application.

Edit the `educa/settings/prod.py` file and modify the `ALLOWED_HOSTS` setting, as follows:

```
ALLOWED_HOSTS = ['.educaproject.com']
```

A value that begins with a period is used as a subdomain wildcard; `'.educaproject.com'` will match `educaproject.com` and any subdomain for this domain, for example, `course.educaproject.com` and `django.educaproject.com`.

Serving multiple subdomains with NGINX

You need NGINX to be able to serve your site with any possible subdomain. Edit the `config/nginx/default.conf.template` file at these two occurrences:

```
server_name  www.educaproject.com educaproject.com;
```

Replace the occurences of the preceding line with the following one:

```
server_name  *.educaproject.com educaproject.com;
```

By using the asterisk, this rule applies to all subdomains of `educaproject.com`. In order to test your middleware locally, you need to add any subdomains you want to test to `/etc/hosts`. For testing the middleware with a `Course` object with the slug `django`, add the following line to your `/etc/hosts` file:

```
127.0.0.1  django.educaproject.com
```

Stop the Docker application from the shell by pressing the *Ctrl* + *C* keys or using the stop button in the Docker Desktop app. Then, start Compose again with the following command:

```
docker compose up
```

Then, open `https://django.educaproject.com/` in your browser. The middleware will find the course by the subdomain and redirect your browser to `https://educaproject.com/course/django/`.

Your custom subdomain middleware is working!

Now, we will delve into a final topic that is extremely useful for projects: automating tasks and making them available as commands.

Implementing custom management commands

Django allows your applications to register custom management commands for the `manage.py` utility. For example, you used the `makemessages` and `compilemessages` management commands in *Chapter 11*, *Adding Internationalization to Your Shop*, to create and compile translation files.

A management command consists of a Python module containing a `Command` class that inherits from `django.core.management.base.BaseCommand` or one of its subclasses. You can create simple commands or make them take positional and optional arguments as input.

Django looks for management commands in the `management/commands/` directory for each active application in the `INSTALLED_APPS` setting. Each module found is registered as a management command named after it.

You can learn more about custom management commands at `https://docs.djangoproject.com/en/5.0/howto/custom-management-commands/`.

You are going to create a custom management command to remind students to enroll in at least one course. The command will send an email reminder to users who have been registered for longer than a specified period and who aren't enrolled in any course yet.

Create the following file structure inside the `students` application directory:

```
management/
    __init__.py
    commands/
        __init__.py
        enroll_reminder.py
```

Edit the `enroll_reminder.py` file and add the following code to it:

```
import datetime
from django.conf import settings
from django.contrib.auth.models import User
from django.core.mail import send_mass_mail
from django.core.management.base import BaseCommand
from django.db.models import Count
from django.utils import timezone


class Command(BaseCommand):
    help = 'Sends an e-mail reminder to users registered more' \
           'than N days that are not enrolled into any courses yet'

    def add_arguments(self, parser):
        parser.add_argument('--days', dest='days', type=int)

    def handle(self, *args, **options):
        emails = []
        subject = 'Enroll in a course'
        date_joined = timezone.now().today() - datetime.timedelta(
            days=options['days'] or 0
        )
        users = User.objects.annotate(
            course_count=Count('courses_joined')
        ).filter(course_count=0, date_joined__date__lte=date_joined)
        for user in users:
            message = f"""Dear {user.first_name},
            We noticed that you didn't enroll in any courses yet.
            What are you waiting for?"""
            emails.append(
                (
                    subject,
                    message,
```

```
                        settings.DEFAULT_FROM_EMAIL,
                        [user.email]
                    )
                )
            send_mass_mail(emails)
            self.stdout.write(f'Sent {len(emails)} reminders')
```

This is your `enroll_reminder` command. The preceding code is as follows:

- The `Command` class inherits from `BaseCommand`.
- You include a `help` attribute. This attribute provides a short description of the command that is printed if you run the `python manage.py help enroll_reminder` command.
- You use the `add_arguments()` method to add the `--days` named argument. This argument is used to specify the minimum number of days a user has to be registered, without having enrolled in any course, in order to receive the reminder.
- The `handle()` command contains the actual command. You get the `days` attribute parsed from the command line. If this is not set, you use `0`, so that a reminder is sent to all users that haven't enrolled on a course, regardless of when they registered. You use the `timezone` utility provided by Django to retrieve the current timezone-aware date with `timezone.now().date()`. (You can set the timezone for your project with the `TIME_ZONE` setting.) You retrieve the users who have been registered for more than the specified days and are not enrolled in any courses yet. You achieve this by annotating the QuerySet with the total number of courses each user is enrolled in. You generate the reminder email for each user and append it to the `emails` list. Finally, you send the emails using the `send_mass_mail()` function, which is optimized to open a single SMTP connection for sending all emails, instead of opening one connection per email sent.

You have created your first management command. Open the shell and run your command:

```
docker compose exec web python /code/educa/manage.py \
  enroll_reminder --days=20 --settings=educa.settings.prod
```

If you don't have a local SMTP server running, you can look at *Chapter 2, Enhancing Your Blog with Advanced Features*, where you configured the SMTP settings for your first Django project. Alternatively, you can add the following setting to the `base.py` file to make Django output emails to the standard output during development:

```
EMAIL_BACKEND = 'django.core.mail.backends.console.EmailBackend'
```

Django also includes a utility to call management commands using Python. You can run management commands from your code as follows:

```
from django.core import management
management.call_command('enroll_reminder', days=20)
```

Congratulations! You can now create custom management commands for your applications.

Django management commands can be scheduled to run automatically using tools like cron or Celery Beat. Cron is a time-based job scheduler in Unix-like operating systems that enables users to schedule scripts or commands to run at specified times and intervals. You can read more about cron at `https://en.wikipedia.org/wiki/Cron`. On the other hand, Celery Beat is a scheduler that works with Celery to run functions at designated intervals. You can learn more about Celery Beat at `https://docs.celeryq.dev/en/stable/userguide/periodic-tasks.html`. By using either cron or Celery Beat, you can ensure your tasks are executed regularly without manual intervention.

Summary

In this chapter, you created a production environment using Docker Compose. You configured NGINX, uWSGI, and Daphne to serve your application in production. You secured your environment using SSL/TLS. You also implemented custom middleware and you learned how to create custom management commands.

You have reached the end of this book. Congratulations! You have learned the skills required to build successful web applications with Django. This book has guided you through the process of developing real-life projects and integrating Django with other technologies. Now, you are ready to create your own Django project, whether it is a simple prototype or a large-scale web application.

Good luck with your next Django adventure!

Expanding your project using AI

In this section, you are presented with a task to extend your project, accompanied by a sample prompt for ChatGPT to assist you. To engage with ChatGPT, visit `https://chat.openai.com/`. If this is your first interaction with ChatGPT, you can revisit the *Expanding your project using AI* section in *Chapter 3, Extending Your Blog Application*.

We have developed a comprehensive e-learning platform. However, when students are enrolled in multiple courses, each containing several modules, it can be challenging for them to remember where they last left off. To address this, let's use ChatGPT in conjunction with Redis to store and retrieve each student's progress within a course. For guidance, refer to the prompt provided at `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter17/prompts/task.md`.

> When you're refining your Python code, ChatGPT can help you explore different refactoring strategies. Discuss your current approach, and ChatGPT can provide advice on making your code more Pythonic, utilizing principles like **don't repeat yourself** (**DRY**) and modular design for cleaner, more maintainable code.

Additional resources

The following resources provide additional information related to the topics covered in this chapter:

- Source code for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/tree/main/Chapter17`
- Docker Compose overview: `https://docs.docker.com/compose/`
- Installing Docker Compose: `https://docs.docker.com/compose/install/compose-desktop/`
- Official Python Docker image: `https://hub.docker.com/_/python`
- Dockerfile reference: `https://docs.docker.com/reference/dockerfile/`
- `requirements.txt` file for this chapter: `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter17/requirements.txt`
- YAML file example: `https://yaml.org/`
- `Dockerfile build` section: `https://docs.docker.com/compose/compose-file/build/`
- Docker restart policy: `https://docs.docker.com/config/containers/start-containers-automatically/`
- Docker volumes: `https://docs.docker.com/storage/volumes/`
- Docker Compose specification: `https://docs.docker.com/compose/compose-file/`
- Official PostgreSQL Docker image: `https://hub.docker.com/_/postgres`
- `wait-for-it.sh` bash script for Docker: `https://github.com/vishnubob/wait-for-it/blob/master/wait-for-it.sh`
- Service startup order in Compose: `https://docs.docker.com/compose/startup-order/`
- Official Redis Docker image: `https://hub.docker.com/_/redis`
- WSGI documentation: `https://wsgi.readthedocs.io/en/latest/`
- List of uWSGI options: `https://uwsgi-docs.readthedocs.io/en/latest/Options.html`
- Official NGINX Docker image: `https://hub.docker.com/_/nginx`
- NGINX documentation: `https://nginx.org/en/docs/`
- `ALLOWED_HOSTS` setting: `https://docs.djangoproject.com/en/5.0/ref/settings/#allowed-hosts`
- Django's system check framework: `https://docs.djangoproject.com/en/5.0/topics/checks/`
- HTTP Strict Transport Security policy with Django: `https://docs.djangoproject.com/en/5.0/ref/middleware/#http-strict-transport-security`
- Django deployment checklist: `https://docs.djangoproject.com/en/5.0/howto/deployment/checklist/`
- Self-generated SSL/TLS certificate directory: `https://github.com/PacktPublishing/Django-5-by-example/blob/main/Chapter17/educa/ssl/`
- Let's Encrypt Certificate Authority: `https://letsencrypt.org/`
- Using Docker Compose in production: `https://docs.docker.com/compose/production/`
- Docker Swarm mode: `https://docs.docker.com/engine/swarm/`

- Kubernetes: `https://kubernetes.io/docs/home/`
- Django middleware: `https://docs.djangoproject.com/en/5.0/topics/http/middleware/`
- Creating custom management commands: `https://docs.djangoproject.com/en/5.0/howto/custom-management-commands/`
- `cron`: `https://en.wikipedia.org/wiki/Cron`.
- `celery beat`: `https://docs.celeryq.dev/en/stable/userguide/periodic-tasks.html`

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`https://packt.link/Django5ByExample`

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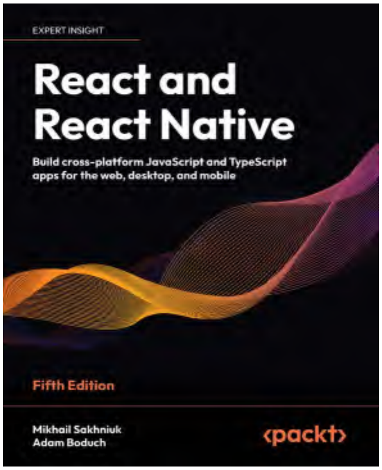

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