Introduction to API Development Using Python

Participant Guide

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COURSE CODE IN1803 / 4.29.2024

This course covers Introduction to API Development Using Python

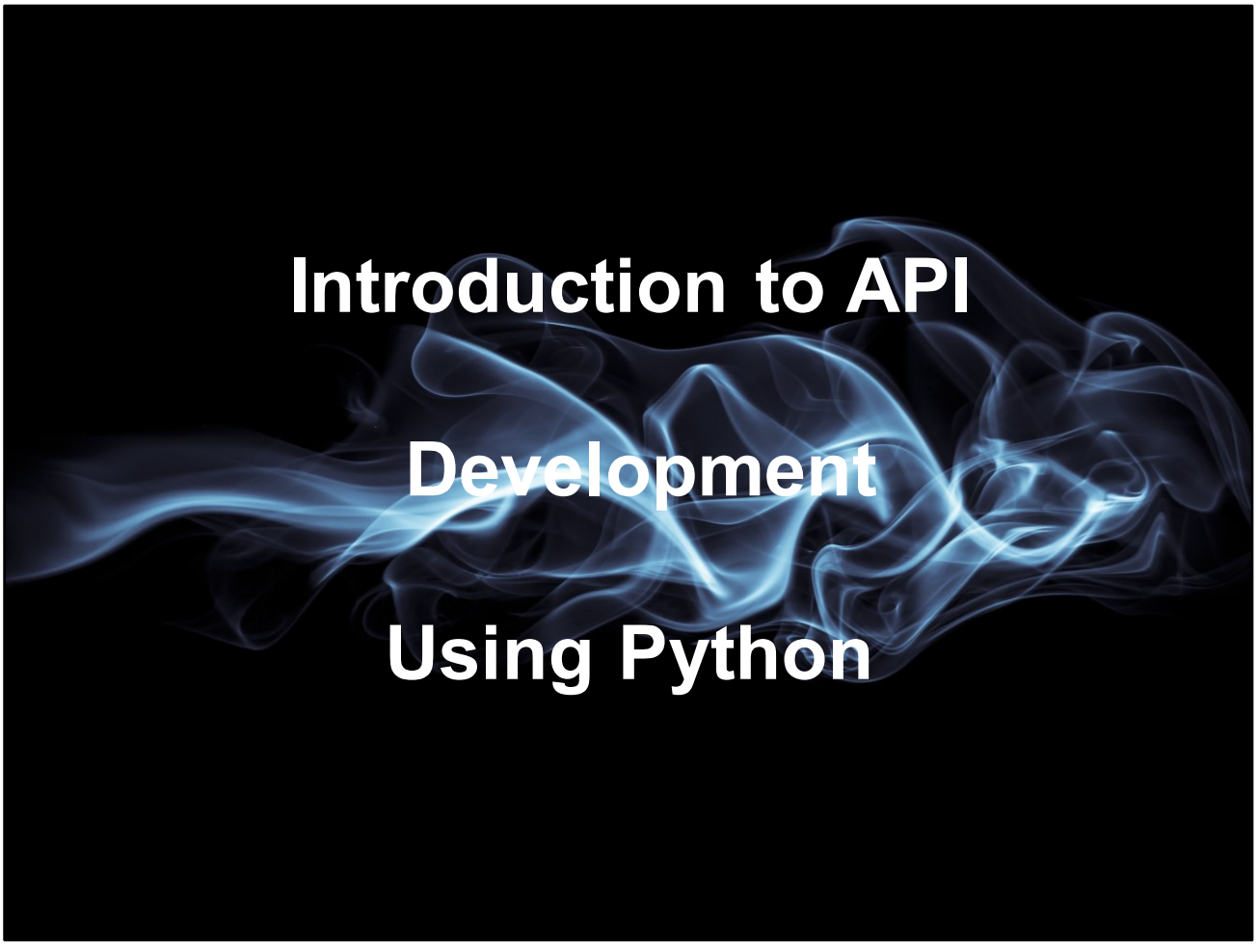
This course and all materials supplied to the student are designed to familiarize the student with the operation of the software programs.

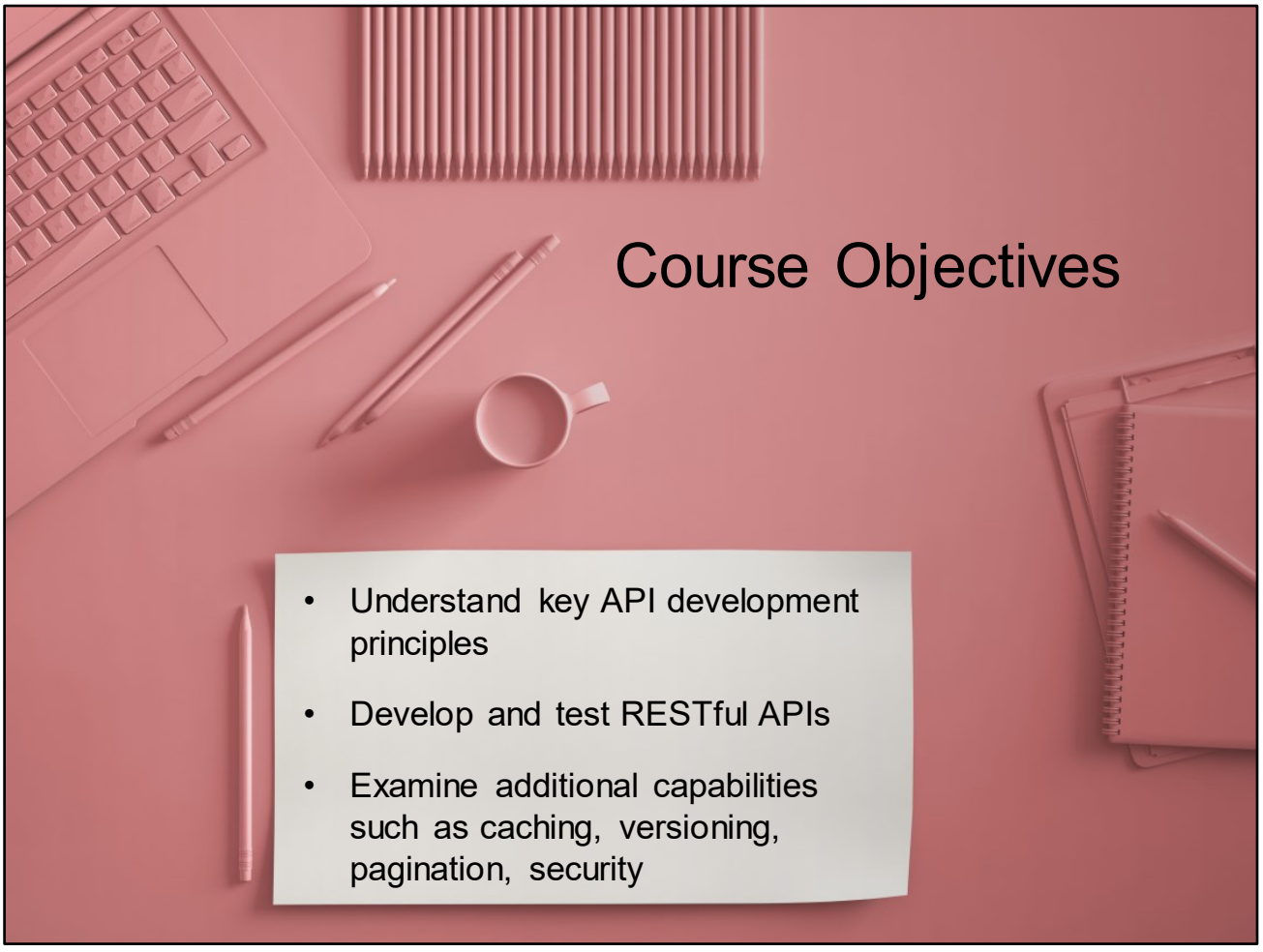
This version updated: 4/29/2024

Notes

Chapters at a Glance

Notes





Course Agenda

Day 1

Introduction

- Overview of API Concepts
- Python Tools and Environment Setup

Developing APIs

- Creating an API
- Creating a Python-Based Client
- Using Flask-RESTX

Course Agenda *(continued)*

Day 2

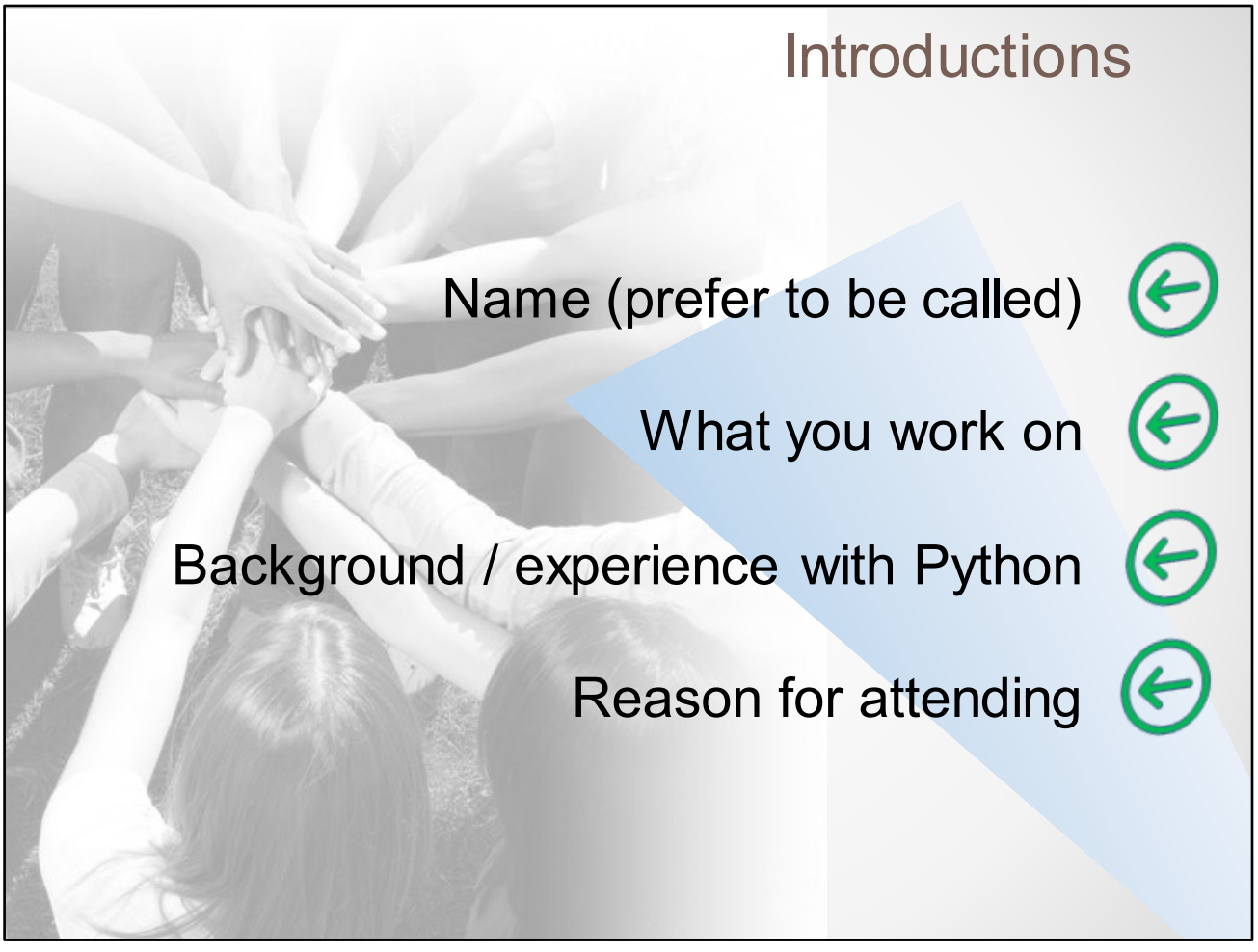
Developing APIs *(continued)*

- Incorporating a Database

Advanced Concepts

- Pagination
- Versioning
- Caching

Authorization and Authentication



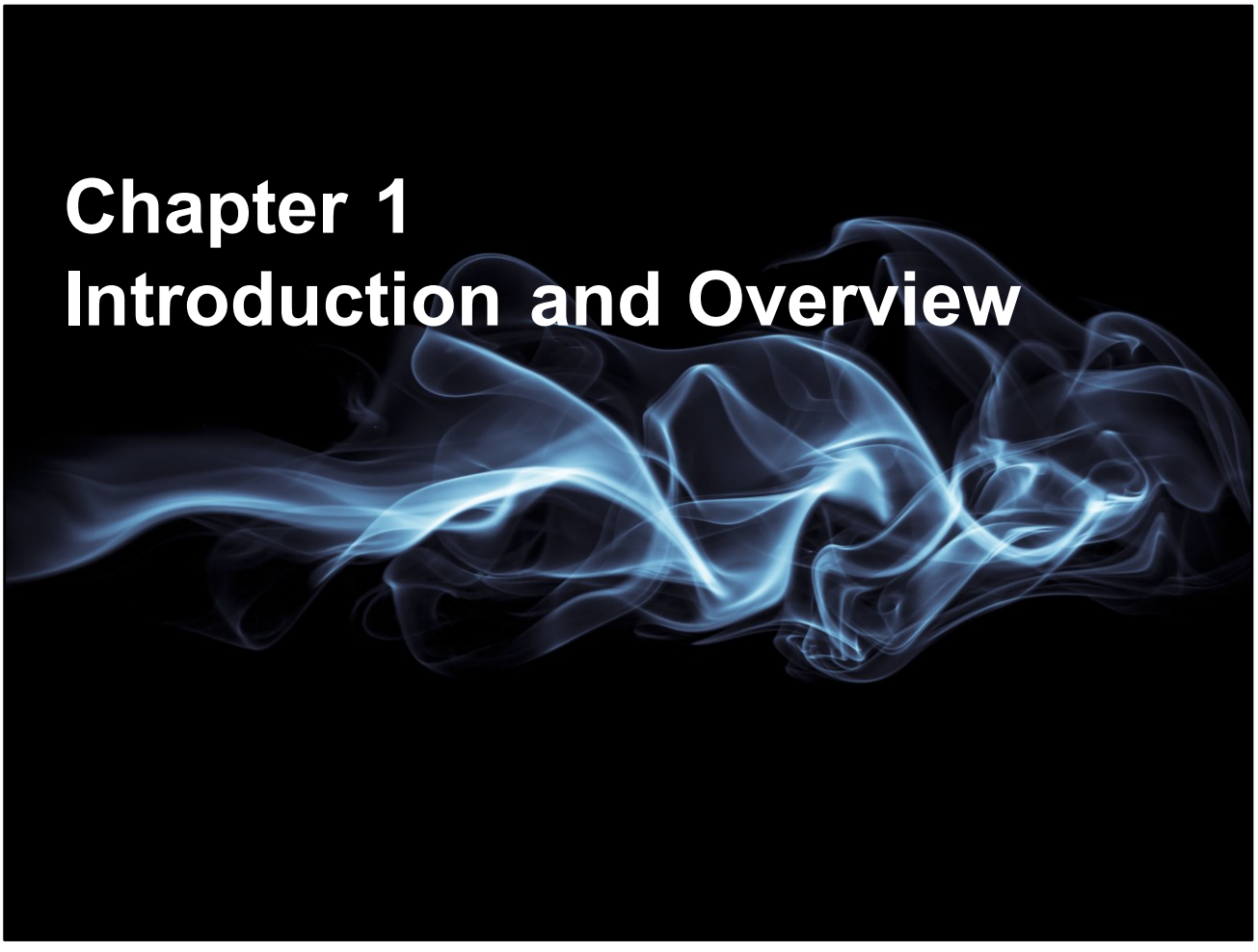
Typical Daily Schedule*

9:00	Start Day
10:10	Morning Break 1
11:20	Morning Break 2
12:30 – 1:30	Lunch
2:40	Afternoon Break 1
3:50	Afternoon Break 2
5:00	End of Day

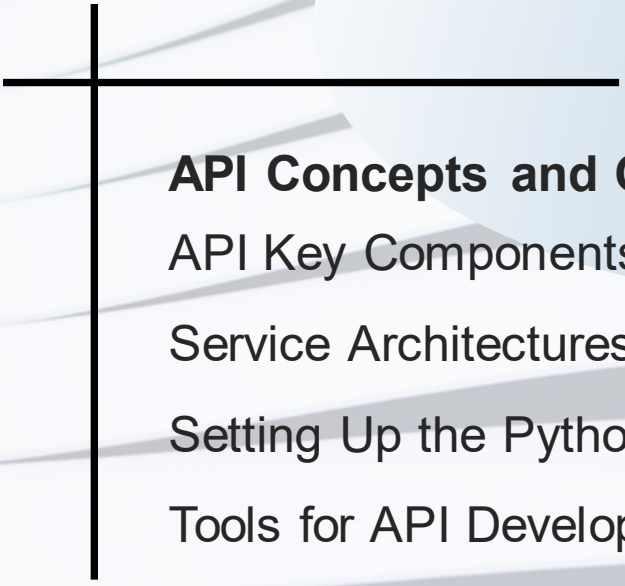
** Your schedule may vary, timing is approximate*

Get the Most From Your Experience

Ask Questions



Chapter 1 Overview



API Concepts and Overview

API Key Components and Life Cycle

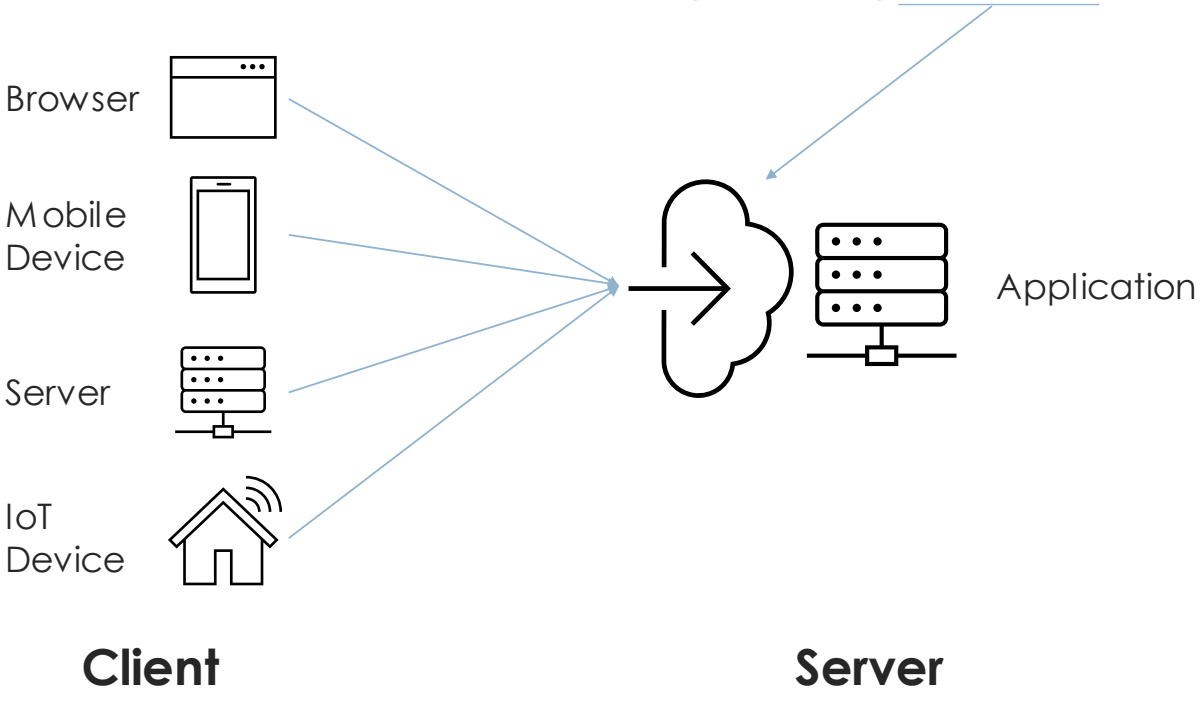
Service Architectures

Setting Up the Python Environment

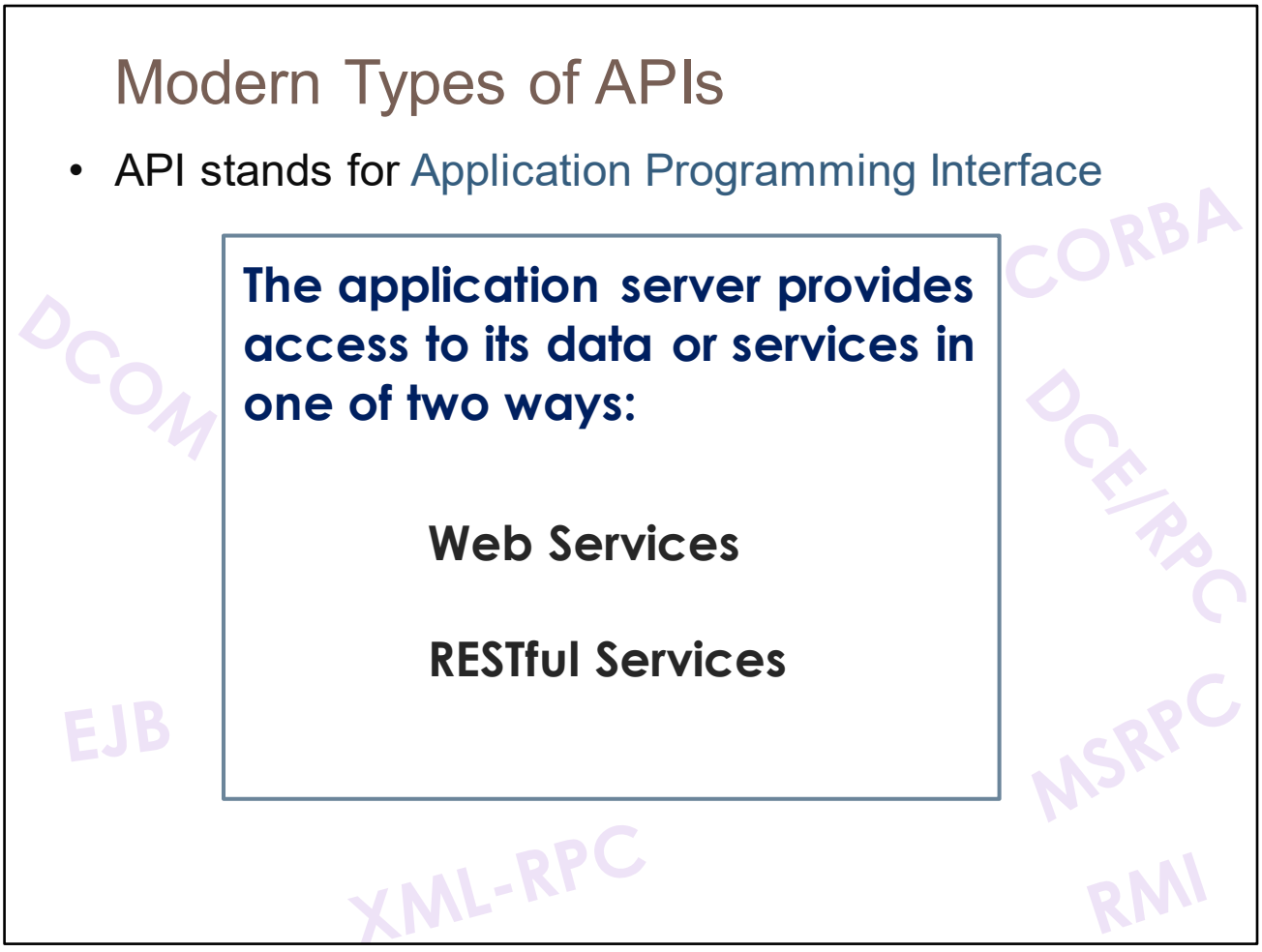
Tools for API Development

What Is an API?

- API stands for Application Programming Interface



API is an acronym that stands for Application Programming Interface. The acronym, usually used as a noun (e.g., "an API"), refers to the way in which one application communicates with another application. These applications are usually running on different machines.



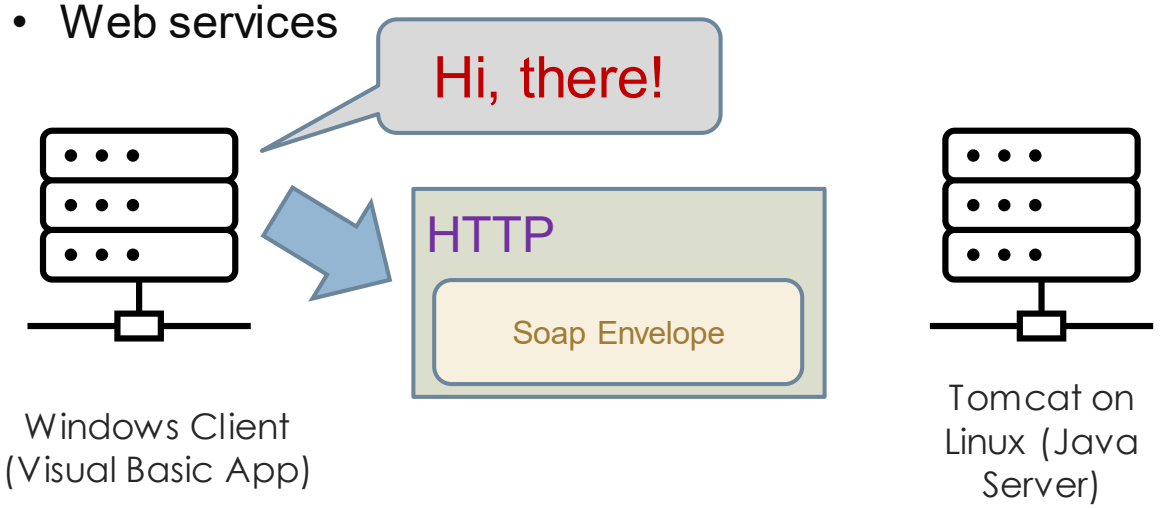
Over the years, different technologies for facilitating communication between two devices have come and gone (or largely been replaced). Many of these technologies focused on ways to transmit objects from one machine to another. They were often vendor-specific (focusing on the use of specific frameworks or tools) such as Microsoft DCOM or Java EJBs. Portability and interoperability were problems with these solutions. They were often complex and required creating special adapters called *stubs* and *skeletons* or required converting objects into other formats using serializers and deserializers. They were also very brittle requiring high maintenance.

As internet popularity grew in the 1990s, replacement technologies for distributed communications developed. Web services evolved due in part to the rise of XML at the time and the growing number of web-based servers that used the HTTP protocol.

Over time, web services would doom itself by becoming overly complicated (SOAP, WSDL, UDDI, WS-Security, WS-Reliability, etc.) and in response, the world shifted toward simpler technologies: JSON and REST.

Web Services

- Web services




```
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope/"
soap:encodingStyle="http://www.w3.org/2003/05/soap-encoding">
<soap:Header>...</soap:Header>
<soap:Body> ...
  <c:makeGreeting xmlns:c="http://domain.com/greetapp/">
    Hi, there!</c:makeGreeting>
</soap:Body>
</soap:Envelope>
```

Web services evolved in an effort to improve interoperability between different systems. It emphasized the HTTP protocol as the transport layer and embedded XML as the payload within an HTTP POST request (commonly). Information could now easily be exchanged between a Microsoft Visual Basic Application running on Windows and a Java application server running on Linux or Unix.

The Browser as a Client

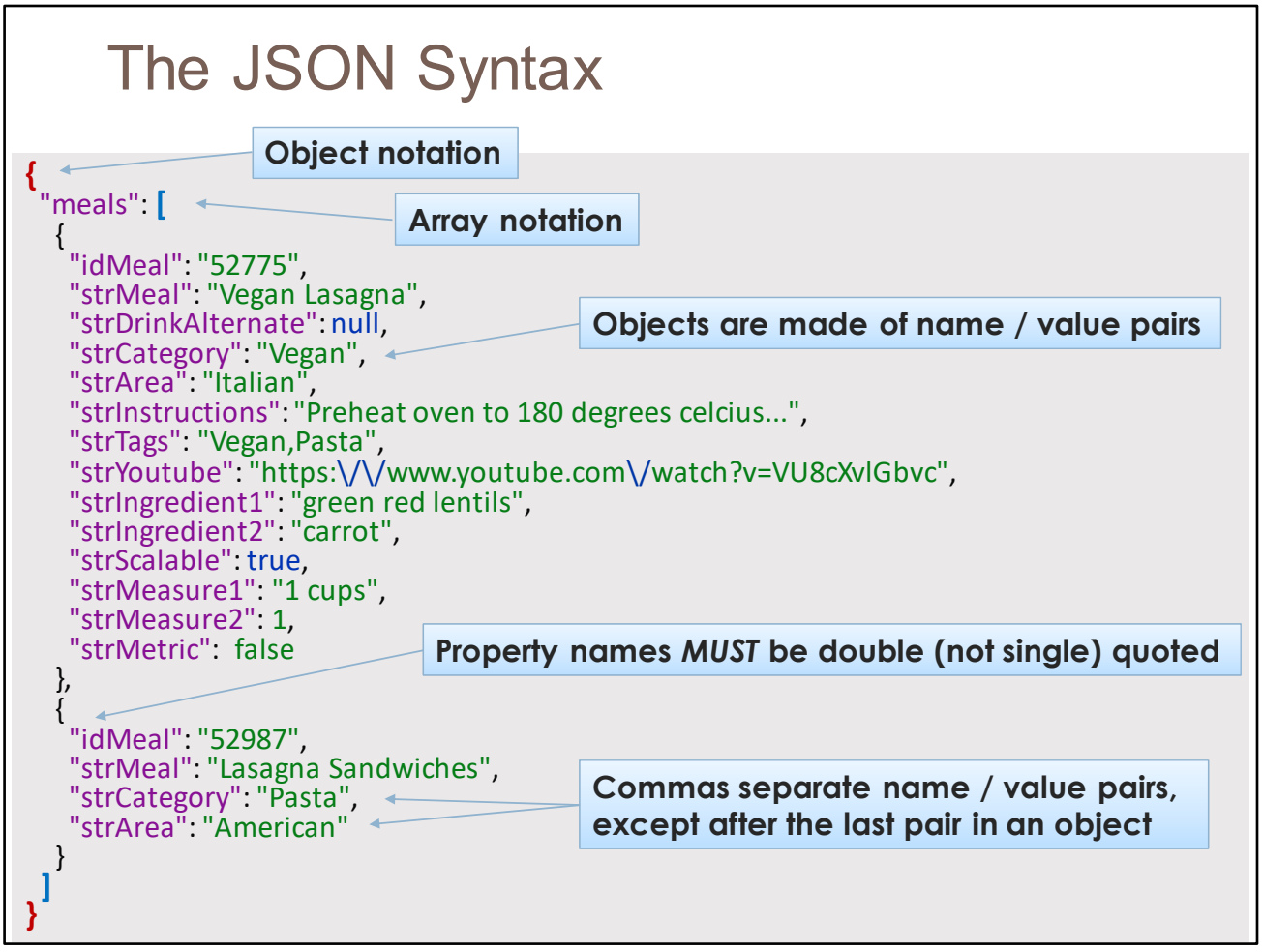
- Browsers are good at running an embedded programming language called *JavaScript*
- The combined power of HTML, CSS, and JavaScript allowed browsers to become *thinner* clients
  - Older alternatives were called "thick" clients due to the more complex code required to run them
- Browsers, however, aren't very good at manipulating XML
- The lack of good XML processing capabilities within browsers spelled trouble for web services

During the late 1990s and early 2000s, browsers evolved rapidly. JavaScript become a predominant development language and gave rise to more interactive web applications that could incorporate new techniques like Ajax. This facilitated communication between the browser and the server. The early 2000s was a transformative period where web applications became powerful clients. The growth of JavaScript also gave rise to a special data format called JSON (pronounced "Jay-son") which could easily be extracted and rendered into a web page.

JSON

- JavaScript Object Notation (JSON) naturally occurs within the JavaScript language
  - Browsers consume and create JSON data without any additional tools
- Due to the quick rise in popularity of JSON, other programming languages quickly added support for it
- Within a few years, the JSON data format became a preferred way of exchanging data

JSON wasn't actually invented, it was discovered. It already existed within the JavaScript language. Doug Crockford (writer of the book *JavaScript: the Good Parts*) readily admits that he identified JSON, he didn't create it.

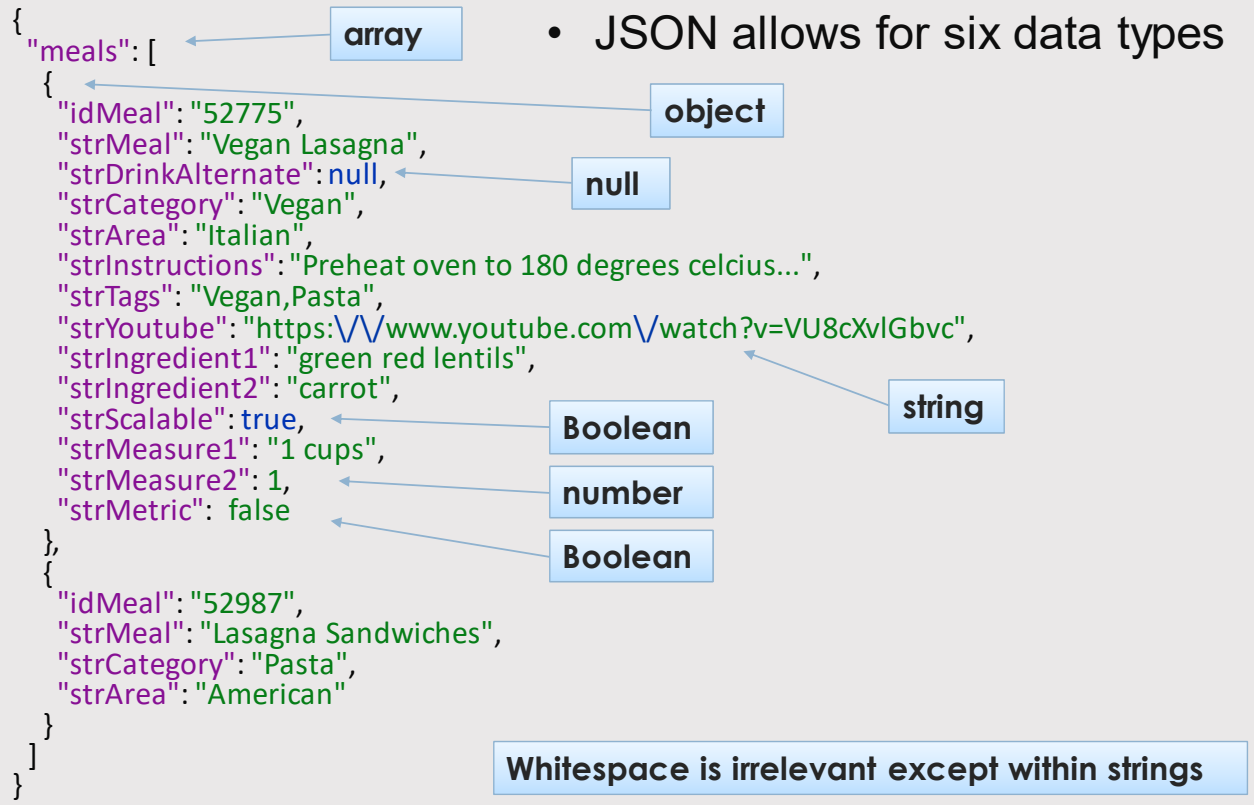


For many years, a standard for JSON did not exist. An RFC for JSON is managed by the IETF and can be found at: https://datatracker.ietf.org/doc/html/rfc8259.

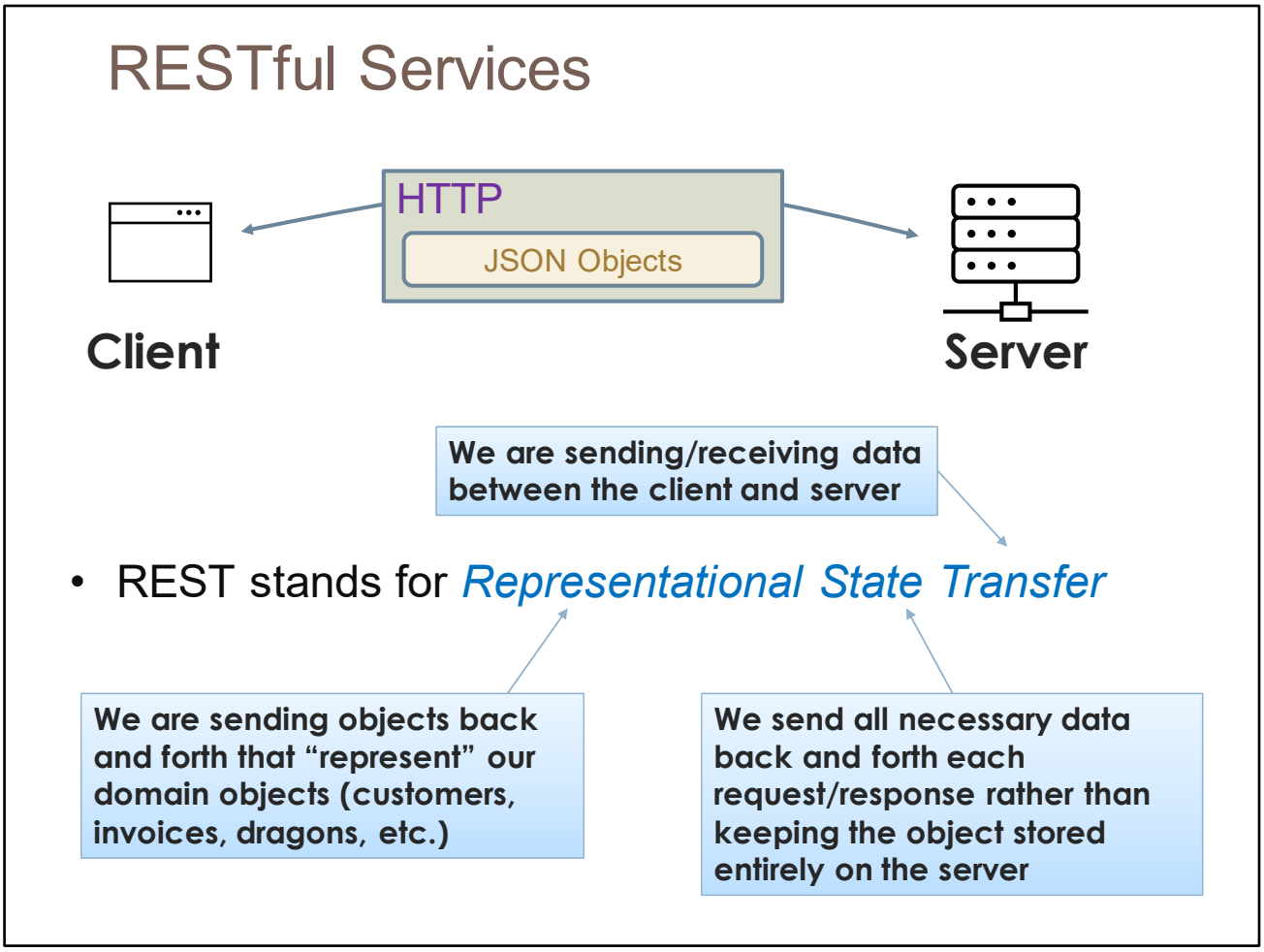
Does the top-level structure of a JSON message have to be an object or an array? While it almost always is, recently a simple string, number, Boolean, or null is now allowed also.

This API response can easily be obtained by typing **`https://www.themealdb.com/api/json/v1/1/search.php?s=lasagna`** into your browser.

Whitespace and JSON Data



Valid JSON data types include objects, arrays, strings, numbers, true, false, and null. While JSON data is used within JavaScript, they are not the same. For example, JSON does not define a function type, an undefined type, or other types, such as a date type. Only the six types mentioned above are explicitly defined within JSON.



REST is merely a style of communication between two devices.

At first, the REST acronym seems rather cryptic, but upon dissecting it, we see it identifies how this the style of communication. REST involves sending objects to and from the server (the "transfer" part of the acronym). It often uses JSON (though it is not required) as the data interchange format. JSON objects "represent" data maintained on the server. The objects are sent back and forth each time (the "state" part of the acronym) rather than using cookies, for example, to uniquely identify the user and then bring up the objects in a server session like a typical web-based application.

Classic Web Services vs RESTful APIs

Web Services	REST
XML for payload data	Can use plain-text, XML, JSON (commonly), etc.
Uses SOAP (Simple Object Access Protocol)	No specific protocol
Invokes methods remotely	Access data via URIs
Has formal standards: SOAP, WSDL, WS-Security, etc.	Solutions tend to be simpler to learn, build, and execute
XML is difficult to work with within browsers	JSON is easy to use within browsers
Has error handling capabilities built into SOAP	Errors are managed through HTTP status codes

There are several differences between classic (SOAP-based) web services and RESTful solutions. One of the primary differences is that RESTful solutions utilize the HTTP protocol to manipulate resources while web services usually make HTTP POST requests to invoke methods on the server side. We'll discuss more about REST's manipulation of URLs shortly.

RESTful Resources

- A *resource* is a core or fundamental component in a RESTful application
- A resource is an object being served (returned)
  - It usually derives from the business domain
  - Typically, operations will be performed on this entity
- Resource examples:
  - *Invoices*
  - *Patients*
  - *Customers*
  - *Documents*

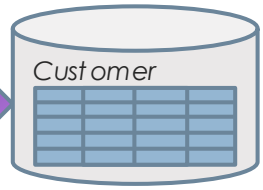
A resource can be a collection (like *accounts*) or singular (like *account*) and may contain sub-resources (like *address*)

Creating resources is a core task in designing RESTful solutions. Operations will be defined around these resources. Care must be taken on how large or small to make these resources. In other words, how coarse-grained vs. fine-grained the objects should be is a design decision that must be considered (more on resource modeling later). Larger resources will involve fewer requests made to the server but involve sending and receiving more data values.

Key Components of a RESTful Service

- URIs to map to resources

https://hostname.com/api/customers



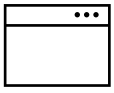
- Manipulation of resources via HTTP methods

GET
PUT
DELETE
POST

https://hostname.com/api/customers/121

https://hostname.com/api/customers

- Transfer of state (stateless)



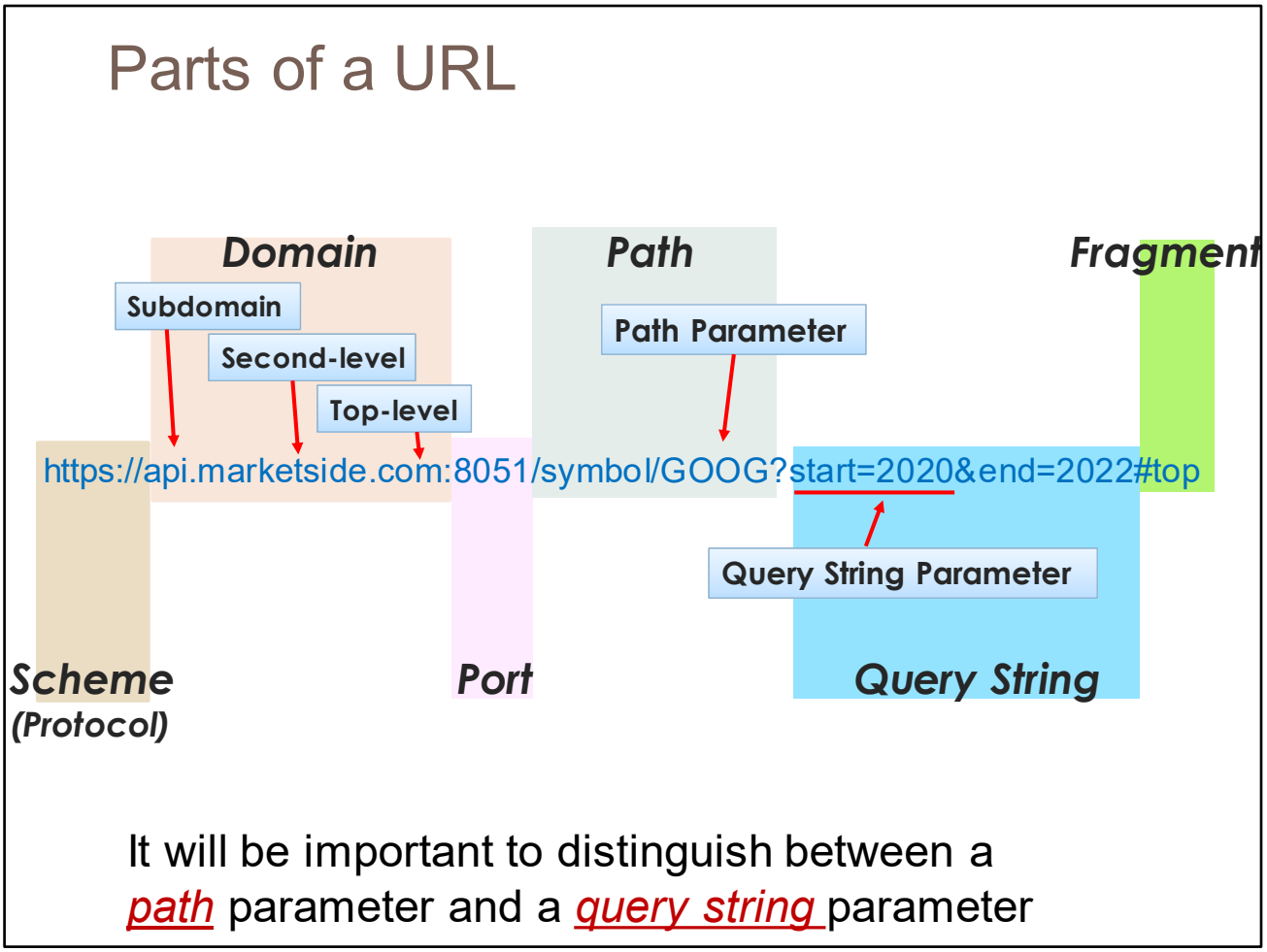
Client

```
{
  customer_id: 121,
  name: Blackburn Industries,
  …
}
```

- Cacheable

```
Expires: Fri, 20 May 2022 19:20:49 GMT
```

Several principles guide the development of RESTful solutions (each of these are discussed further later).

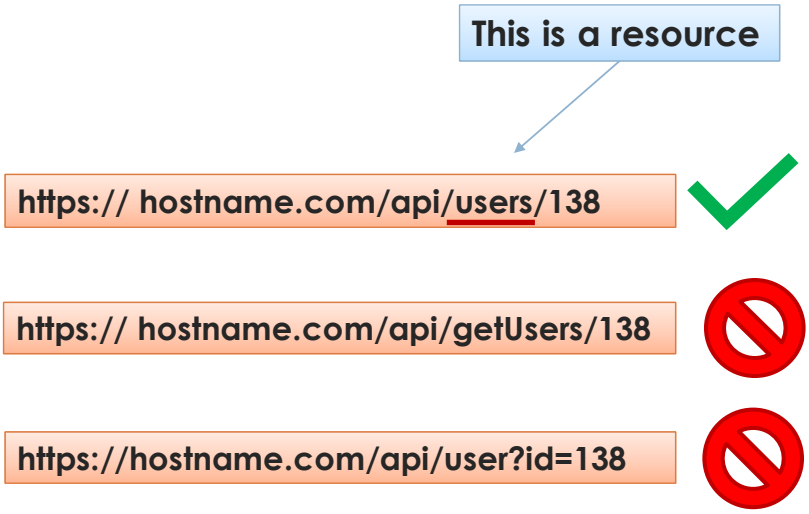


For ease of discussion throughout the course, the terms above will be used to refer to parts of a URL.

It's important to take note of the difference in placement of variables in a URL. This distinction is not only a part of the RESTful design solution but makes a difference programmatically when writing code to access these values. Take note of what is called the "path" versus the "query string."

RESTful Design Principles

- Design the API around resources (nouns)



Resources should map to a unique URI (like http://hostname.com/api/users). Resources are usually related to a domain or business objects from your application.

To make the API URL sound more consistent, generally prefer the use of plural nouns.

RESTful Design Principles *(continued)*

- Use HTTP methods to define operations

GET /api/invoices/2952	*Reads* a specific invoice
PUT /api/invoices/2952	*Updates* a specific invoice
PATCH /api/invoices/2952	*Partially Updates* a specific invoice
DELETE /api/invoices/2952	*Deletes* a specific invoice

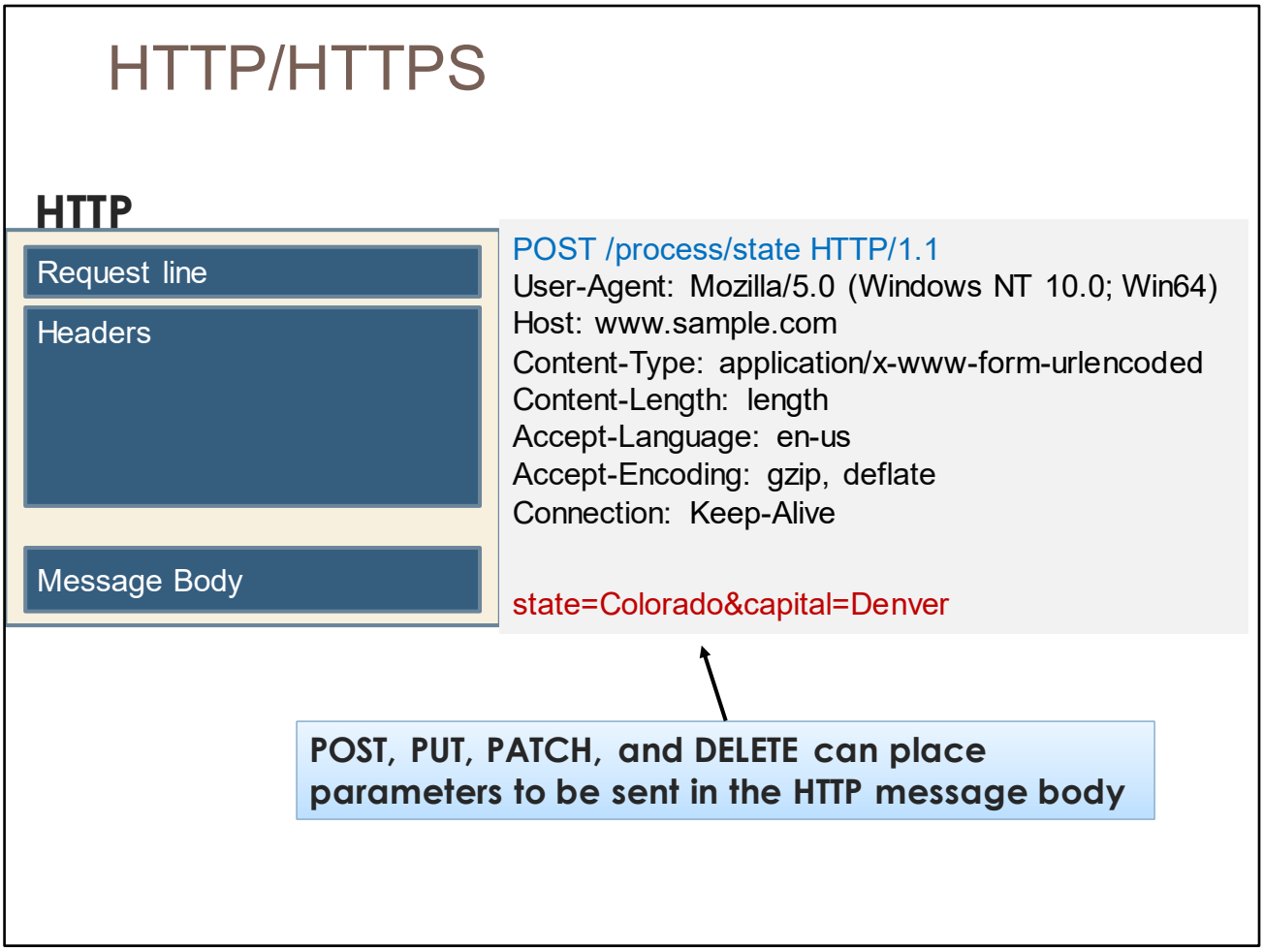
GET /api/invoices	Retrieves all invoices
POST /api/invoices	*Creates* a new invoice

Think of a RESTful request as being like a sentence. The HTTP method is the "verb" of the sentence while the resource is the noun.

(from above) "GET (verb, HTTP method) the invoice 2952 (noun, resource)."

As previously mentioned, we tend to utilize the plural form of our resource in the URL.

The PATCH method is used when you only wish to update one or two (or so) fields of an object. In doing so, you may PATCH by only sending the required fields that need updating. Generally, a PUT will "resend" the entire object, performing an overwrite of the entire object, which may overwrite fields you didn't intend to update (and may accidentally change values that you didn't intend to change). More is discussed with PATCH a little later.

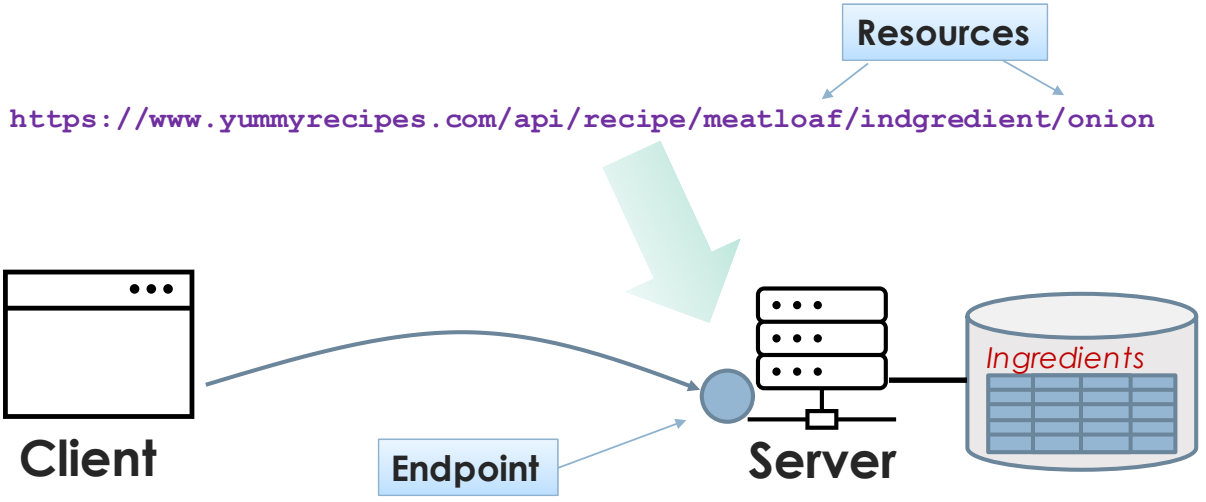


To better understand how to set up and design an API, we'll have to understand the technologies used. The HTTP protocol is a good place to begin.

Above is a dissection of a message sent using the HTTP protocol. The HTTP message defines a request line followed by zero or more headers followed by a blank line and then the message body. A GET request will not have a message body.

Endpoints vs Resources

- Endpoints are *locations* (addresses), often exposing services or resources
- Resources are objects that are returned from a URL



You may often hear the term endpoint. Endpoints are typically addresses that identify a service location (commonly described in web services, but RESTful resource URIs could also be endpoints). Different endpoints can return similar resources. In addition, a single endpoint could return different resources such as collections of objects or single objects.

Using Python for RESTful Development

- Python is a great language for developing APIs
  - One of the most popular languages to learn
  - Huge community support and tools to assist
  - Expressive language: easy to learn, easy to read
  - Works naturally with JSON data
    - Python dictionaries are very similar to the JSON format

Why Python for API development? We could specify a long list of why Python is so wonderful for RESTful development. But perhaps to help us get a better evaluation of whether Python would help, let's examine the question *why not Python?*
Here are a few disadvantages when considering Python for API development:

1. Performance. While Python can hold its own for most implementations, if high concurrency, high performance is a primary consideration, Python may not be the first choice.

2. Python on the client-side may be limited. Python isn't typically encountered frequently in mobile/handheld computing environments. However, as an option on the server-side it is a great choice.

3. Less developed database access layer. While wonderful tools do exist, like Django and SQLAlchemy, for interacting with the database, the layers sometimes feel less mature than in other languages such as Java and C# programming languages.

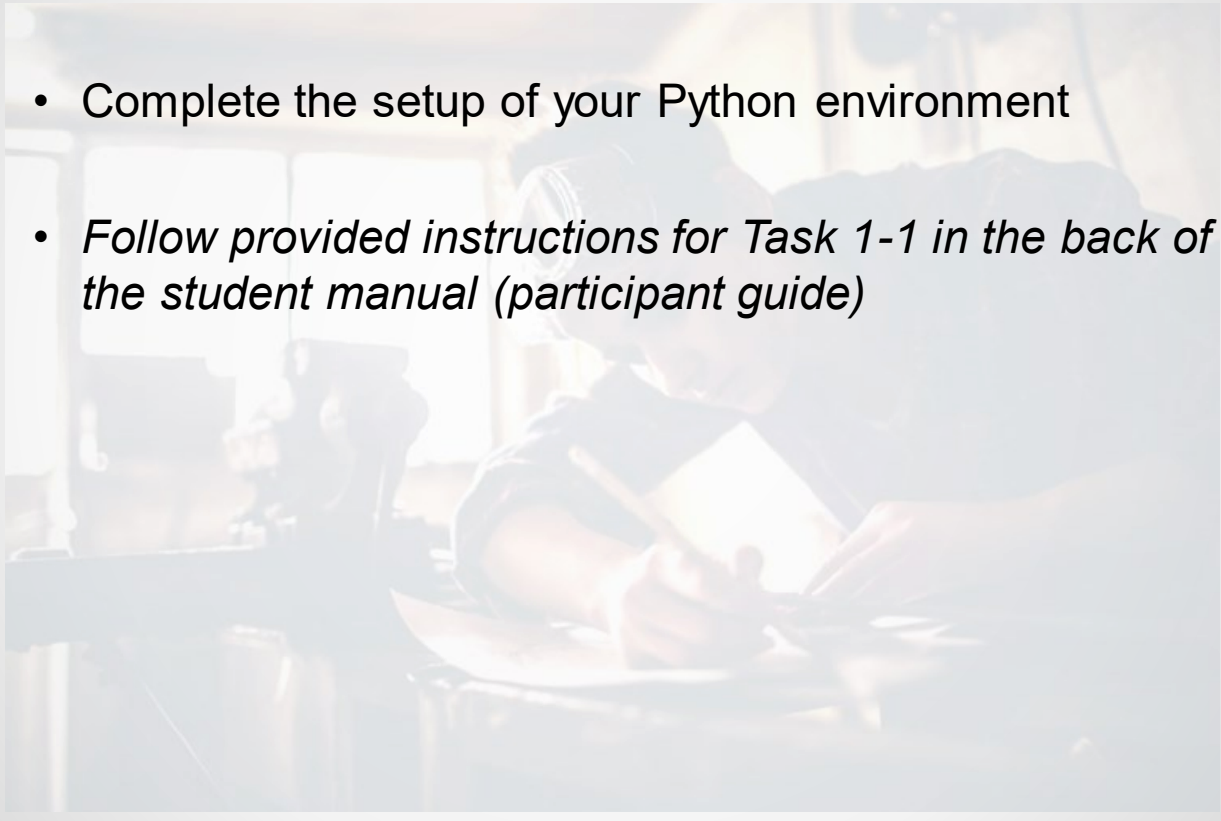
RESTful Python API Frameworks

- Numerous tools exist for developing RESTful applications

Server-side Tools	Client-side Tools
Flask	*Requests*
FastAPI	PycURL
Django / Django REST	Urllib (Standard library)
Falcon	
Bottle	

This list of tools is not exhaustive. It includes useful frameworks and libraries that can be used on both the server-side as well as client-side. Several of these tools are explored during this course. The scope of Django is too large for this course.

Your Turn! - Task 1-1



- Complete the setup of your Python environment
- *Follow provided instructions for Task 1-1 in the back of the student manual (participant guide)*

Your Turn! - Task 1-2

- Viewing APIs
- *Use your browser to view results from the URLs*
- These can be easily obtained from task1_2_starter.json

https://api.coinlore.net/api/tickers/?start=1&limit=5

Change these values, what happens?

https://apimeme.com/meme?top=some&bottom=text

Is this still an API? What does it return?

https://datausa.io/api/data?
drilldowns=State&measures=Population&year=latest

Have fun generating your own memes at https://apimeme.com/.

Dictionaries

- Dictionaries are collections of name/value pairs

```
capitals = {'Alabama': 'Montgomery', 'Alaska': 'Juneau',...,
            'Wyoming': 'Cheyenne'}

print(f'Keys: {capitals.keys()}')
```

To get just the keys

Keys: dict_keys(['Alabama', 'Alaska', … 'Wyoming'])

```
print(f'Values: {capitals.values()}')
```

To get just the values

Values: dict_values(['Montgomery', 'Juneau', …, 'Cheyenne'])

```
print(f'Keys and values: {capitals.items()}')
```

To get both at once

Keys and values: dict_items([('Alabama', 'Montgomery'), ('Alaska', 'Juneau'), …, ('Wyoming', 'Cheyenne')])

```
print(f'{capitals["Montana"]}, {capitals.get("Montana")},
        {capitals.get("Montana", "Not found.")}')
```

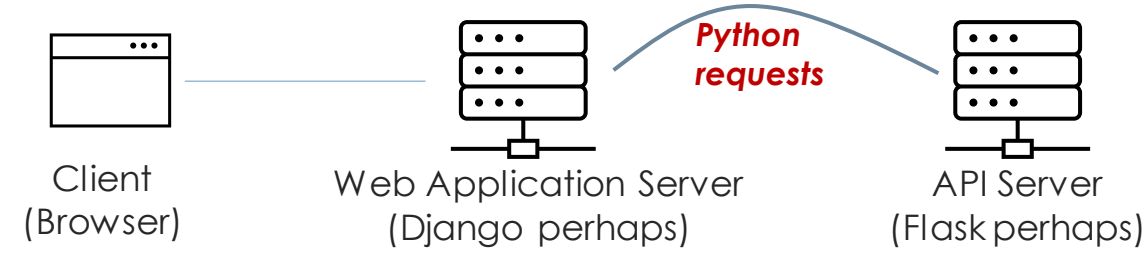
Helena, Helena, Helena

student_files/ch01_overview/01_dicts_and_json.py

Dictionaries are the default data structure encountered when going back and forth between JSON and Python. So, it is important to know to use them.

Introducing Python Requests

- While Python is not commonly used in mobile and handheld devices, it is heavily used on computing platforms (OS X, Windows, Linux)
- So, Python can also be used as a *RESTful client* in REST-based apps
- A great tool for building Python-based clients is called requests



Often, the client to an API server is another server. Quite frequently, we see a web-based server interacting with an API server.

In the Python world, this can be a Django frontend server interacting with a Flask API server (to be introduced shortly). The Django application would need to make requests to the remote API server. To do this, the requests module would need to be invoked from within the Django app.

Python *requests*

- *requests* allows for easily sending HTTP requests
- *requests* is third-party, which means it must be installed into the Python environment
  - *pip install* statements can vary:

    pip3 install requests

    python -m pip install requests

pip install requests

A basic *requests* module request

params get added into the query string

```
text_str = requests.get(url,
                        params = { param1: value1 },
                        headers = { name: value }).text
```

As with any tool used within this course, if it doesn't ship with Python originally, it is considered a third-party tool and must be installed. The utility in Python for installing third-party frameworks is called *pip* (Python Installation Package tool).

Different Python versions on different platforms installed differently will likely need to invoke the pip tool in a slightly different way. You will need to remember how it was invoked on your system. Shown above are some variations on how to invoke the pip tool. If needed, discover the approach that is appropriate on your machine.

The params parameter of the requests.get() call enables passing query string parameters.

Other *requests* Module APIs

```
python_dict = requests.get(url, params={param1: value1}).json()
```

Converts a JSON response to a Python dictionary

```
r = requests.post(url,
                  params = { param1: value1 },
                  data = { bodyParam1: bodyVal1 },
                  json = obj,
                  headers = { name: value })
```

Python dict that ends up in the HTTP body

Alternatively, a Python object that ends up in the HTTP body

```
r = requests.put()
r = requests.patch()
r = requests.delete()
```

These each take similar arguments as requests.post()

The requests module methods shown here will serve as useful tools for creating a Python client shortly.

The ***params*** argument is useful for encoding dictionary key-value pairs into the query string of a URL.

The ***data*** argument is useful for encoding dictionary key-value pairs into the body of the HTTP message.

The object returned from *requests.get(), post(), put()*, etc., is a response object (called r here).

Using the *requests* Module

```
import requests

r = requests.get('https://jsonplaceholder.typicode.com/posts/1', params={'age': 37})

print(r.url)
```

```
https://jsonplaceholder.typicode.com/posts/1?age=37
```

```
print(r.text)
```

Raw text

```
{
  "userId": 1,
  "id": 1,
  "title": "sunt aut facere ... reprehenderit",
  "body": "quia et suscipit ... architecto"
}
```

Dictionary

```
print(r.json())
```

```
{'userId': 1, 'id': 1, 'title': 'sunt aut ... reprehenderit', 'body': 'quia et suscipit ... architecto'}
```

```
print(r.headers)
```

```
{'Date': 'Thu, 13 Jan 2022 02:39:07 GMT',
 'Content-Type': 'application/json', ...
```

```
print(r.status_code)
```

```
200
```

student_files/ch01_overview/02_using_requests.py

The code above makes a request to an API using the Python requests module. Various attributes are then displayed (shown in the green boxes) after the request completes.

Your Turn! - Task 1-3

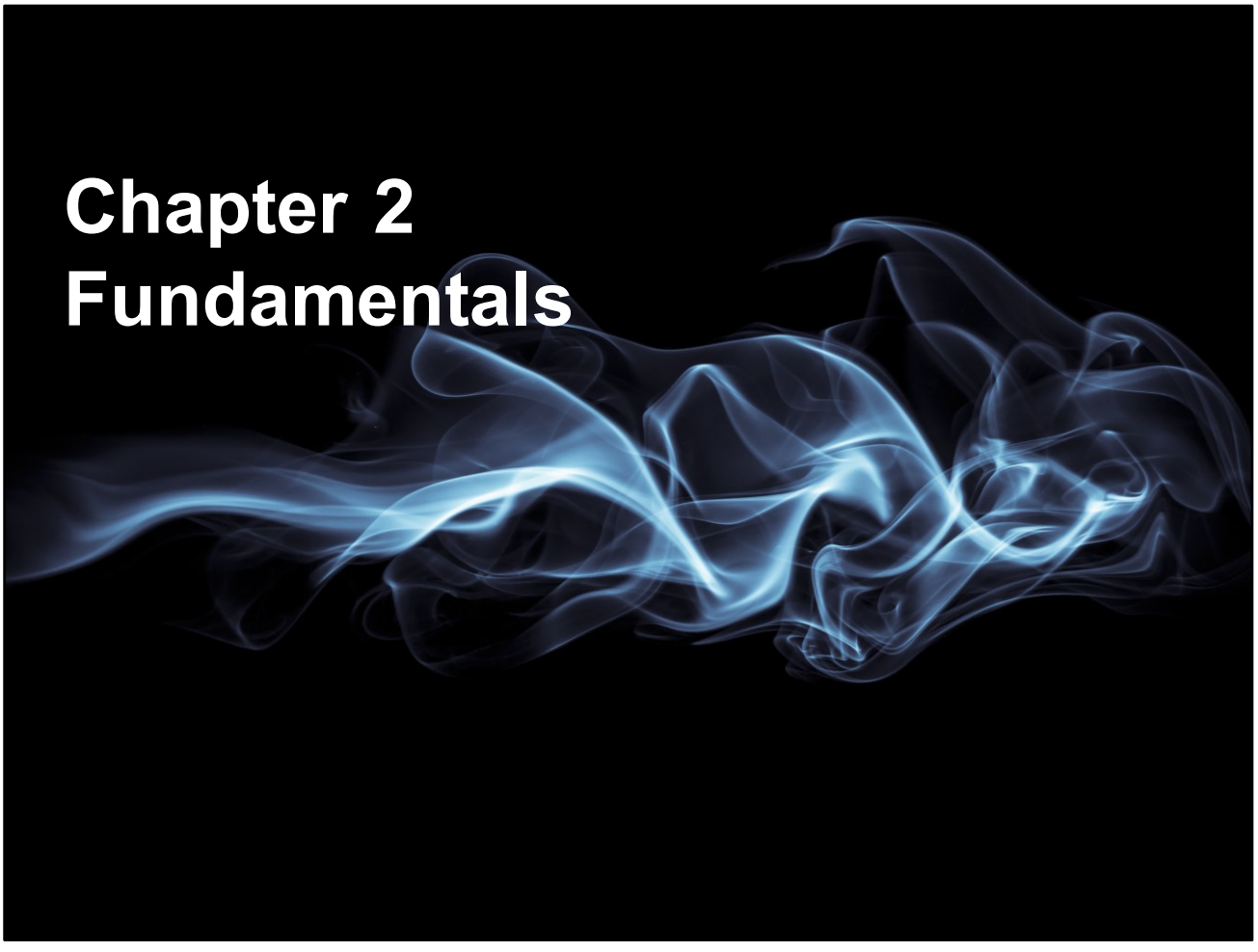
- Use the Python requests module to make a request and print the responses (either as raw text or as a dictionary) for the URLs used in Task 1-2
- *Work from the task1_3_starter.py file*

https://api.coinlore.net/api/tickers/?start=1&limit=5
https://apimeme.com/meme?top=Tell%20Me%20More&bottom=About%20Chocolate
https://datausa.io/api/data?drilldowns=State&measures=Population&year=latest

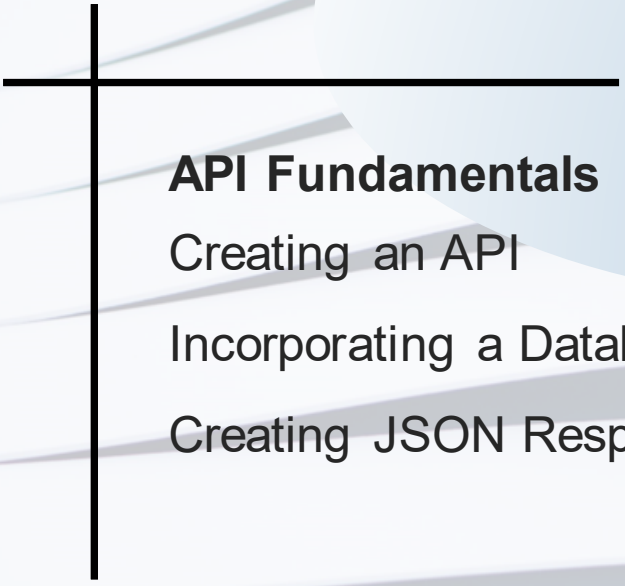
Chapter 1 Summary

- API commonly refers to RESTful services
- RESTful services expose resources on the server
  - They are accessed from a client using HTTP calls
  - Responses often return JSON data to a client
  - Various HTTP methods (GET, POST, PUT, PATCH, DELETE) are used to modify the server resource
- Python provides amazing tools to simplify RESTful application development
  - Those tools include Flask, Django, and FastAPI

Chapter 2
Fundamentals



Chapter 2 Overview



API Fundamentals

Creating an API

Incorporating a Database

Creating JSON Responses

Creating a First Simple API

- In our demonstration, we'll create a RESTful app that provides celebrity data

student_files/data/celebrity_100.csv

```
Name,Pay (USD millions),Year,Category
Oprah Winfrey,225.0,2005,Personalities
Tiger Woods,87.0,2005,Athletes
Mel Gibson,185.0,2005,Actors
George Lucas,290.0,2005,Directors/Producers
Shaquille O'Neal,33.4,2005,Athletes
Steven Spielberg,80.0,2005,Directors/Producers
Johnny Depp,37.0,2005,Actors
Madonna,50.0,2005,Musicians
Elton John,44.0,2005,Musicians
Tom Cruise,31.0,2005,Actors
Brad Pitt,25.0,2005,Actors
Dan Brown,76.5,2005,Authors
Will Smith,35.0,2005,Actors
David Letterman,40.0,2005,Personalities
```

The above output shows the contents of the celebrity_100.csv file. This file is found in the data directory within the student_files folder.

Introducing Flask

- Flask is a popular Python tool for building RESTful applications

- Since it is a third-party tool, it must be installed first

```
pip install Flask
```

https://flask.palletsprojects.com

For more on Flask, visit https://flask.palletsprojects.com/en/2.1.x/.

Flask will be our primary tool used. It is popular within Python. Top options for creating APIs in Python are Flask, Django, and FastAPI. The latter is a newer option that arrived in 2018 and uses modern approaches such as automatic type checking at runtime, parameter validation, object marshalling, and an asynchronous framework to tie it all together.

Defining Resources

- As part of our design process, we must decide on what our resources will be
- Given the data on the prior slide, we'll use a *celebrity* object, and similarly a plural noun for our URI
- So, a likely URL will look like the following:

http://localhost:8051/api/celebrities/tom%20cruise

Our initial example design will be centered around our data file (celebrity_100.csv), therefore our initial resource will be a celebrity object.

First Flask Code, Starting the Server

- Our first version instantiates the Flask server and starts it

```
from flask import Flask

app = Flask(__name__)

app.run(host='localhost', port=8051)
```

Defines the main Flask application object

Starts the server

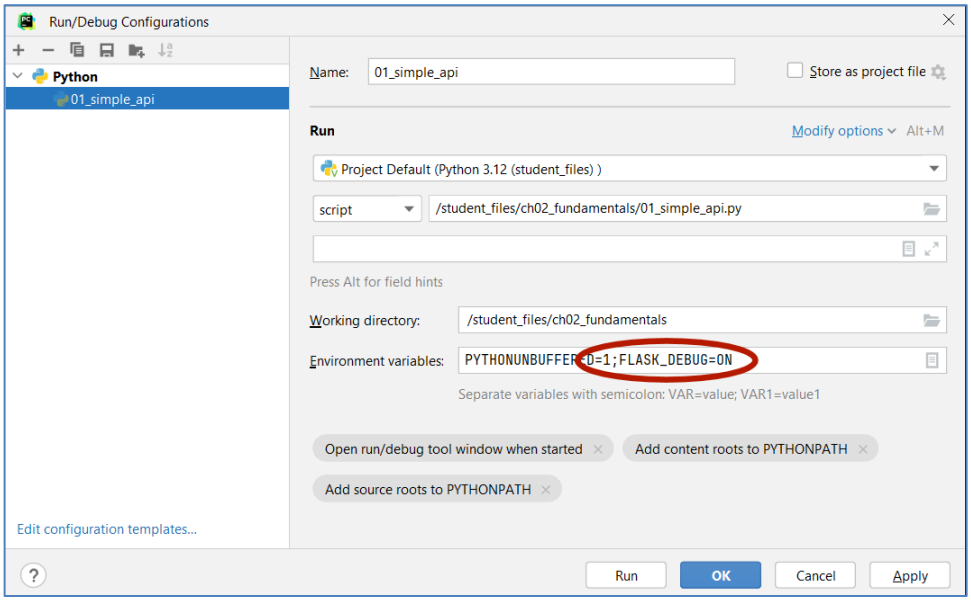
Example startup within PyCharm:

```
01_simple_api
C:\student_files\venv\Scripts\python.exe
 C:\student_files\ch02_fundamentals\01_simple_api.py
 * Serving Flask app '01_simple_api'
 * Debug mode: off
WARNING: This is a development server. Do not use it in a produc
 * Running on http://localhost:8051
Press CTRL+C to quit
```

To turn debug mode on:
export FLASK_DEBUG=ON *(Unix, Linux)*
set FLASK_DEBUG=ON *(Windows)*

student_files/ch02_fundamentals/01_simple_api.py

There's not much to test out yet. When the server is started within PyCharm, the output above will be shown. To start the server in a debug mode, create environment variables as shown above. In PyCharm, select **Run > Edit Configurations...** and add the following as shown:



Loading Some Data to Work With

- The app acquires data from a file at startup

```
from flask import Flask
from pathlib import Path


app = Flask(__name__)

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open()][1:]


app.run(host='localhost', port=8051)
```

```
[
  ['Oprah Winfrey', '225.0', '2005', 'Personalities'],
  ['Tiger Woods', '87.0', '2005', 'Athletes'],
  ['Mel Gibson', '185.0', '2005', 'Actors'],
  ['George Lucas', '290.0', '2005', 'Directors/Producers'], …
]
```

student_files/ch02_fundamentals/02_acquiring_data.py

In this updated version of our app, no new Flask code was added. Instead, we acquire the celebrity data from the specified file (found in the data directory of your student files). The new line of code is called a list comprehension, and it builds a list containing nested lists (as shown in green at the bottom of the slide).

Defining a Mapping

- A critical piece for working with Flask is to define which function should be called when a URI request arrives

@app.route('path', methods=[])

```
from flask import Flask
from pathlib import Path


app = Flask(__name__)

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open()][1:]


@app.route('/api/celebrities/<name>', methods=['GET'])
def do_stuff(name):
    return f'Hi there {name}!'


app.run(host='localhost', port=8051)
```

Encountering this URL (as a GET request only) will cause the do_stuff() function to be called

student_files/ch02_fundamentals/03_creating_a_mapping.py

The app.route() decorator establishes how a function is bound to a URL. It can also specify which HTTP methods are valid in order for the function to be called.

Defining a Mapping *(continued)*

- The app.route() decorator gives Flask control over your functions

```
from flask import Flask
from pathlib import Path

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open()][1:]


@app.route('/api/celebrities/<name>', methods=['GET'])
def do_stuff(name):
    return f'Hi there {name}!'


app.run(host='localhost', port=8051)
```

@app.route() is a special syntax in Python called a decorator

But what is this <name> item?

student_files/ch02_fundamentals/03_creating_a_mapping.py

The full topic of decorators is beyond the scope of our course and perhaps not necessary. All that is needed to understand about decorators is that they replace the stated function with a different function. So, in this case, Flask is replacing our do_stuff() function with another function of their own.

Flask Routing Styles

- Flask supports several mapping styles

```
@app.route('/api/state/<st_name>/capital/<cap_name>')

def do_stuff(st_name, cap_name):
    ...
```

```
@app.route('/api/email/<int:id>')
def do_stuff(id):
    ...
```

This type casts the value after /email/ encountered in the URL to an int type

The angle brackets, < >, allow variables to be provided in the path of the URL. Note: this is different from query string parameters which appear after the ? In the URL.

In addition to an int typecast, float may also be used.

Testing It Out

- To test out our partial implementation, first run the Python script
  - If using PyCharm, right-click anywhere in the source file and select

    Run 03_create_a_mapping.py

- Next, in a browser navigate to

  http://localhost:8051/api/celebrities/tom%20cruise

- You should get a response

  Hi there tom cruise!

Creating a JSON Response

```
from flask import Flask, jsonify
from pathlib import Path

app = Flask(__name__)

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open()][1:]
print('Celebrity data read.')


@app.route('/api/celebrities/<name>', methods=['GET'])
def do_stuff(name):
    results = ['value1', 'value2', 'value3']
    return jsonify(results=results, name=name, sample='message')


app.run(host='localhost', port=8051)
```

- *jsonify()* creates a JSON-based response

```
{
    "name": "tom cruise",
    "results": ["value1","value2","value3"],
    "sample": "message"
}
```

student_files/ch02_fundamentals/04_working_with_json.py

To examine how to return JSON data, we provided some sample response data. Anything passed into the Flask jsonify() method will be converted into the JSON response. Values provided within jsonify() should be keyword arguments (e.g., key=value format).

GET Single Celebrity

```
from flask import Flask, jsonify, Response
from pathlib import Path

app = Flask(__name__)

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open()][1:]

@app.route('/api/celebrities/<name>', methods=['GET'])
def get_one_celebrity(name):
    try:
        results = [row for row in data if name.casefold() in row[0].casefold()]
    except Exception as err:
        results = err.args

    return jsonify(results=results, name=name)


app.run(host='localhost', port=8051)
```

Our final version adds logic to check celebrity name matches to the submitted value

student_files/ch02_fundamentals/05_get_single_celebrity.py

In our function, we wrote a little Python logic to iterate through our data and match the name from the URL to the name column in our data structure. We save any name matches and return those.

For those unfamiliar, the Python casefold() method is similar to Python's lower() method but works for larger character sets (containing characters from other languages).

We also renamed do_stuff() to get_one_celebrity() now.

Flask's Request Object

- Flask provides a request object that will be available within your methods

Note: don't confuse the client-side *requests* module with Flask's *request* parameter

  - request will be pre-populated with useful request data
    - remote_addr - (string) addr of client
    - path - url part after the port but before the query string
    - form - (dict) submitted form (body) params
    - args - (dict) submitted query string params
    - headers - (dict) client's request headers

These are only a few. There are numerous request object parameters. See the docs for more: https://flask.palletsprojects.com/en/2.0.x/api/#incoming-request-data.

Flask's Request Object *(1 of 2)*

A client to test the Flask request object

```
from datetime import date
import requests
birthdate = date.today().strftime('%Y-%m-%d')
payload = {'first': 'Fred', 'middle': 'Aaron', 'pay': 3.0}
url = f'http://localhost:8051/celebrity/Savage?category=Actors&birthdate={birthdate}'
print(f'Results: {requests.post(url, data=payload).json()}')
```

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

app = Flask(__name__)

@app.route('/celebrity/<last_name>', methods=['POST'])
def do_stuff(last_name):

    print(f'remote_addr: {request.remote_addr}')

    print(f'path: {request.path}')

    print(f'path param: {last_name}')

    ...(continued next slide)...
```

remote_addr: 127.0.0.1

path: /celebrity/Savage

path param: Savage

student_files/ch02_fundamentals/05b_flask_request_obj.py and 05c_testing_flask_request_obj.py

The client is shown in the top box above while our API is shown in the lower box. Our client code uses requests to make a request to the server. It is purposely adding additional parameters (both in the query string part of the URL and the body of the HTTP request) so that they can be extracted on the server side using Flask's request object.

The *requests* module (discussed earlier) is for the client-side while Flask's request object is used on the server side to extract out client request details.

Flask's Request Object *(2 of 2)*

```
... (from previous slide) ...

print(f'form: {request.form}, sample: {request.form.get("first")}')
```

```
{'first': 'Fred', 'middle': 'Aaron', 'pay': '3.0'}, sample: Fred
```

```
print(f'args: {request.args}, sample: {request.args.get("category")}')
```

```
args: {'category': 'Actors', 'birthdate': '2022-01-19'}, sample: Actors
```

```
print(f'headers: {request.headers}, sample: {request.headers.get("User-Agent")}')
```

```
headers: Host: localhost:8051
User-Agent: python-requests/2.27.1
Accept-Encoding: gzip, deflate
Content-Length: 31
sample: python-requests/2.27.1
```

```
return Response(
        jsonify({'message': 'Completed.'}).data,
        status=200, mimetype='application/json')

app.run(host='localhost', port=8051)
```

student_files/ch02_fundamentals/05b_flask_request_obj.py and 05c_testing_flask_request_obj.py

This is a continuation of the code presented on the previous slide.

Your Turn! - Task 2-1

- Create a RESTful app to retrieve invoice data given an invoice order number
  - Valid invoice order numbers are: *536365 - 581587*
  - *Implement only the HTTP GET method*
- Use the Flask starter code provided in *ch02_fundamentals/task2_1_starter.py*

```
InvoiceNo,StockCode,Description,Quantity,InvoiceDate,UnitPrice,CustomerID,Country
536365,85123A,WHITE HANGING HEART T-LIGHT HOLDER,6,12/1/2010 8:26,2.55,17850,United Kingdom
536365,71053,WHITE METAL LANTERN,6,12/1/2010 8:26,3.39,17850,United Kingdom
536365,84406B,CREAM CUPID HEARTS COAT HANGER,8,12/1/2010 8:26,2.75,17850,United Kingdom
536365,84029G,KNITTED UNION FLAG HOT WATER BOTTLE,6,12/1/2010 8:26,3.39,17850,United Kingdom
536365,84029E,RED WOOLLY HOTTIE WHITE HEART.,6,12/1/2010 8:26,3.39,17850,United Kingdom
536365,22752,SET 7 BABUSHKA NESTING BOXES,2,12/1/2010 8:26,7.65,17850,United Kingdom
536365,21730,GLASS STAR FROSTED T-LIGHT HOLDER,6
536366,22633,HAND WARMER UNION JACK,6,12/1/2010
536366,22632,HAND WARMER RED POLKA DOT,6,12/1/20
536367,84879,ASSORTED COLOUR BIRD ORNAMENT,32,12,
```

For now, test it out in a browser using invoice 536365.
Also, test it out using invoice 1.

Consuming APIs

- The Python requests module could be used to consume API data

```
import json
import requests

base_url = 'http://localhost:8051'
path = '/api/celebrities/'
default = 'Kevin'

celeb_name = input('Enter celebrity to find info about (def. Kevin): ')
if not celeb_name:
   celeb_name = default

results = requests.get(f'{base_url}{path}{celeb_name}').json()

print(json.dumps(results, indent=4))
```

http://localhost:8051/api/celebrities/Kevin

student_files/ch02_fundamentals/06_consuming_apis.py

The variable 'results' will be a Python dictionary. It would look (in part) like this:

```
{
   "name": "Kevin",
   "results": [
      [
         "Kevin Garnett",
         "29.0",
         "2008",
         "Athletes"
      ],
      [
         "Kevin Spacey",
         "16.0",
         "2014",
         "Television actors"
      ],
      [
         "Kevin Hart",
         "87.5",
         "2016",
         "Comedians"
      ],
      [
         "Kevin Hart",
         "39.0",
         "2020",
         "Comedians"
      ]
   ]
}
```

Using *requests* to Check HTTP Status

```
import requests

r = requests.get('http://httpbin.org/status/200')

if r.ok:
    print('Request was successful.')

if r.status_code == 200:
    print('Request was successful.')

if r:
    print('Requests returned a non-400 or 500 error code.')

r = requests.get('http://httpbin.org/status/400')
try:
    r.raise_for_status()
except requests.exceptions.HTTPError as err:
    print(err)
```

student_files/ch02_fundamentals/07_checking_status.py

The third conditional above will return true for any non-400 or 500 error status codes. The bottom example shows how the request could be checked for any kind of errors returned in the response and then raise an exception because of it.

Your Turn! - Task 2-2

- Create a *Python client* to access the invoicing API created in task 2-1

`http://localhost:8051/api/invoices/536365`

- Work from the provided task2_2_starter.py file
- Ensure your Flask server from task 2-1 is running before testing your answer
  - Access invoice 536365 and display its results

Python Classes

- Classes allow for the grouping of attributes and methods

```
from pathlib import Path

class Celebrity:
    def __init__(self, name, pay, year, category):
        self.name = name
        self.pay = pay
        self.year = year
        self.category = category

    def __str__(self):
        return f'{self.year:<6}{self.name} ({self.category}) ${self.pay:>} million'

f = Path('../data/celebrity_100.csv').open(encoding='utf-8')
f.readline()  # reads the header
data = f.readline().strip().split(',')

celeb = Celebrity(*data)
print(celeb)
```

data (below) is passed into the __init__

['Oprah Winfrey', '225.0', '2005', 'Personalities']

2005 Oprah Winfrey (Personalities) $225.0 million

student_files/ch02_fundamentals/08_classes.py

Classes are commonly used within Python. The self parameter is required for all class methods (with a couple of exceptions not important here). The __init__() method will be called when an object instance is created of our class. Within the __init__() we attached the values passed in to our new object instance (a celebrity object called celeb).

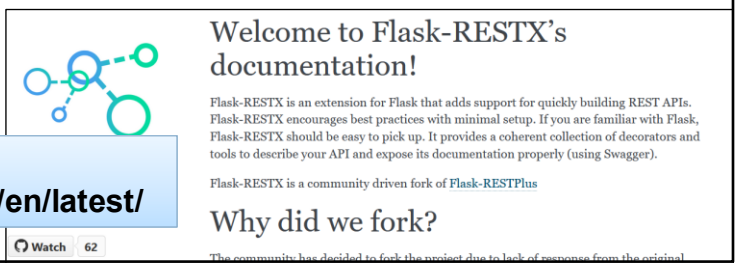
Introducing Flask-RESTX

- Flask-RESTX is an addon to Flask to enable easier class-based creation of Resources
  - As it is a third-party tool, it must be installed
    - Be sure to use the proper variation on your pip utility for your environment

```
pip install flask-restx
```

- Flask-RESTX is a compatible fork of Flask-RESTplus
  - Easy to use
  - Works in Python 3.4+

Flask-RESTX Documentation
https://flask-restx.readthedocs.io/en/latest/



Flask-RESTX is backward compatible with Flask-Restful and Flask-RestPlus but provides several additional features. Since it is the most currently maintained, this is the plugin we will use.

Using Flask-RESTX

```
from flask import Flask
from flask_restx import Resource, Api

app = Flask(__name__)
api = Api(app)

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open(encoding='utf-8')][1:]

@api.route('/api/celebrities/<name>')
class Celebrity(Resource):

    def get(self, name):
        try:
            results = [row for row in data if name.casefold() in row[0].casefold()]
        except Exception as err:
            results = err.args

        return {'results': results, 'name': name}

app.run(host='localhost', port=8051)
```

Most Flask plugins are implemented by passing the *app* object into the plugin's main object. Flask-RESTX's main object is called Api().

Extend a class from Resource

student_files/ch02_fundamentals/09_flask_restx.py

You can either try http://localhost:8051/api/celebrities/Kevin in your browser directly or you can run the example client code discussed earlier (06_consuming_apis.py).

This example now uses flask-RESTX which makes it easy to build classes that can contain the required methods to build a Resource. Classes should inherit from *Resource*.

Adding Other RESTful Operations

A second class is added for the plural URL conditions (GET all, POST)

Our class now supports the other RESTful (singular) methods

/api/celebrities

```
from flask import Flask
from flask_restx import Resource, Api

app = Flask(__name__)
api = Api(app, prefix='/api')

class Celebrities(Resource):
    def get(self):
        return {'celebrities': data}

    def post(self):
        print('post', api.payload)
        return {'action': 'post'}
```

/api/celebrities/Kevin

```
class Celebrity(Resource):
    def get(self, name):
        # unchanged from previous

    def delete(self, name):
        return {'action': 'delete'}

    def put(self, name):
        return {'action': 'put'}

api.add_resource(Celebrity, '/celebrities/<name>')
api.add_resource(Celebrities, '/celebrities/')

app.run(host='localhost', port=8051)
```

How we'll define our mappings now

student_files/ch02_fundamentals/10_adding_other_operations.py

This is a nice simplified version of our API represented across two classes. Each class is used for a different endpoint URI.

We defined our URL mappings now without the use of a decorator. This can be an easier alternative to placing decorators above the class names.

A Test Client

```
base_url = 'http://localhost:8051'
path = ' /api/celebrities/'
celeb_name = 'Kevin'

results = requests.get(f'{base_url}{path}{celeb_name}')
print(results.text)

r = requests.post(f'{base_url}{path}',
            data={'name': celeb_name, 'category': 'Actors',
                  'pay': 3.0, 'year': 2022})
print(results.text)

results = requests.put(f'{base_url}{path}{celeb_name}')
print(results.text)

print('deleting:')
results = requests.delete(f'{base_url}{path}{celeb_name}')
print(results.text)

print('get all:')
results = requests.get(f'{base_url}{path}')
print(results.text)
```

This test client uses Python's requests framework to make requests to our REST API server

```
{"results": [["Kevin Garnett", "29.0", ...
```

```
{"action": "post"}
```

```
{"action": "put"}
```

```
{"action": "delete"}
```

```
(displays all records)
```

student_files/ch02_fundamentals/11_testing_other_operations.py

The client here can make requests to our previously shown Flask server containing the Celebrity and Celebrities classes.

Your Turn! - Task 2-3

- Incorporate Flask-RESTX into our previous invoice application (Task 2-1)
  - Keep the URIs the same as Task 2-1
- Create two classes: *Invoice* and *Invoices*
- Add a *get()* and *post()* method to Invoices and a *get()*, *delete()*, and *put()* method to Invoice
- Place temporary return values in each of the methods
- Use the provided test client to test your solution (*task2_3_client.py*)

Work from your finished task2_1_starter.py file or the provided task2_3_starter.py file

Postman and Testing APIs

- Postman is a popular client for creating and testing APIs
  - Runs on Windows, Mac, Linux
  - Postman has several tiers for usage including a Free plan for small teams

Homepage: https://www.postman.com/

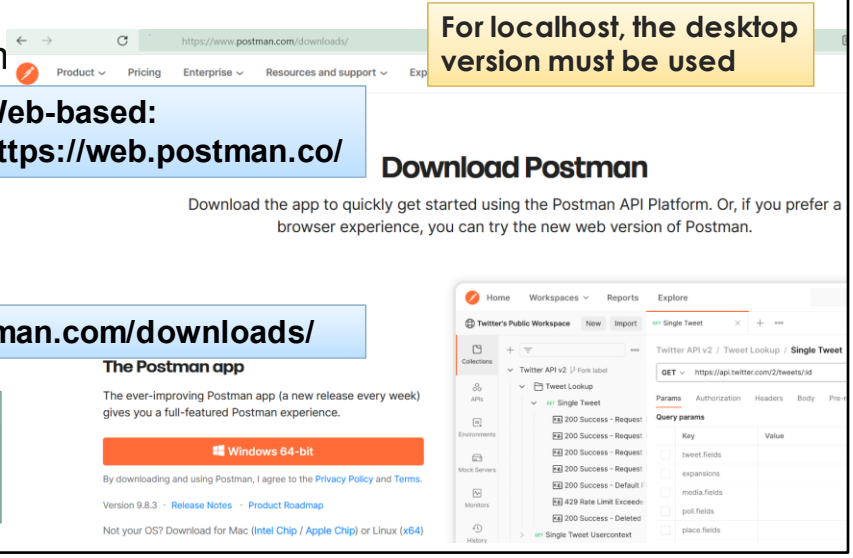
  - Can be used from a web-based interface, or

Web-based: https://web.postman.co/

  - As a desktop app installed from

https://www.postman.com/downloads/

For localhost, the desktop version must be used

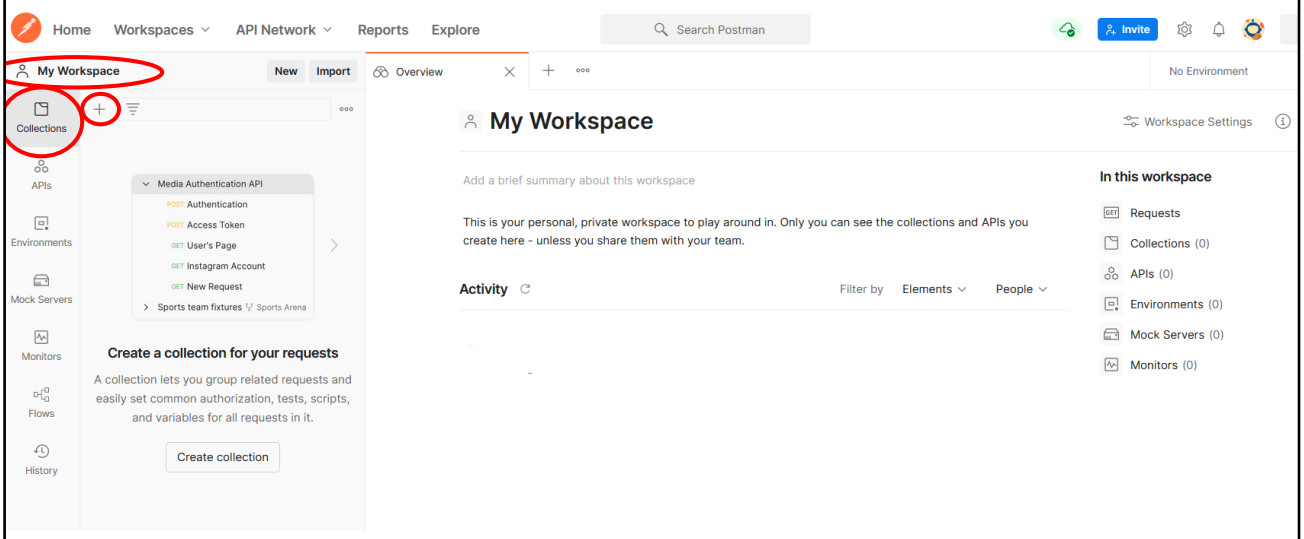


Either the web or desktop versions require creating an account (free)

Postman is widely used and is offered at several levels depending on needs and team size. For many, the free plan will suffice, but for large-scale collaborative needs, higher-level plans may be necessary.

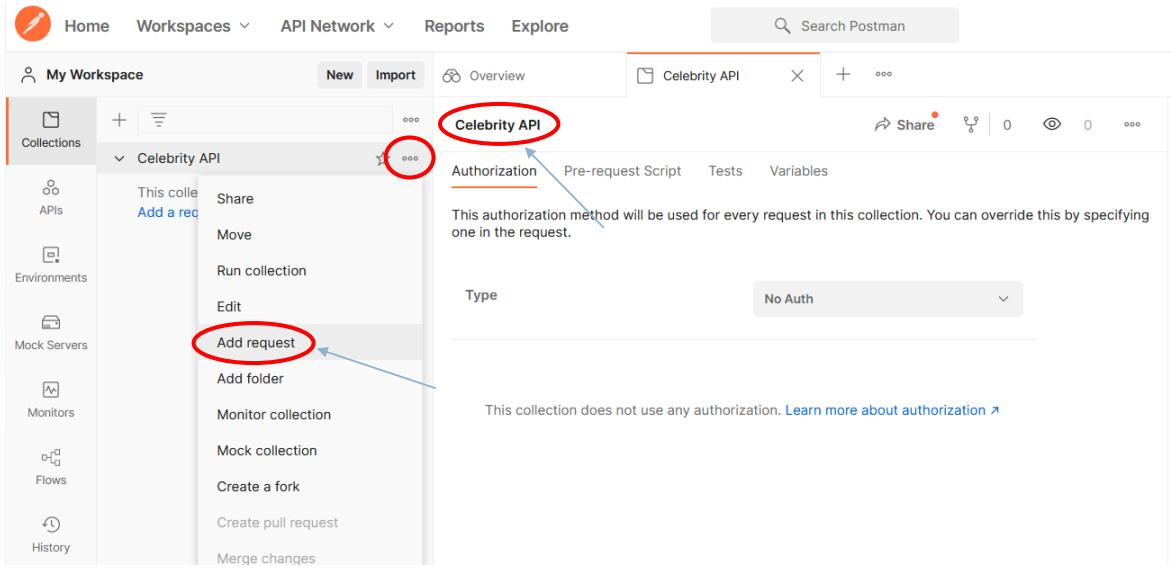
To test using localhost as the domain of the URL, the desktop app version must be used.

Using Postman: Creating Collections



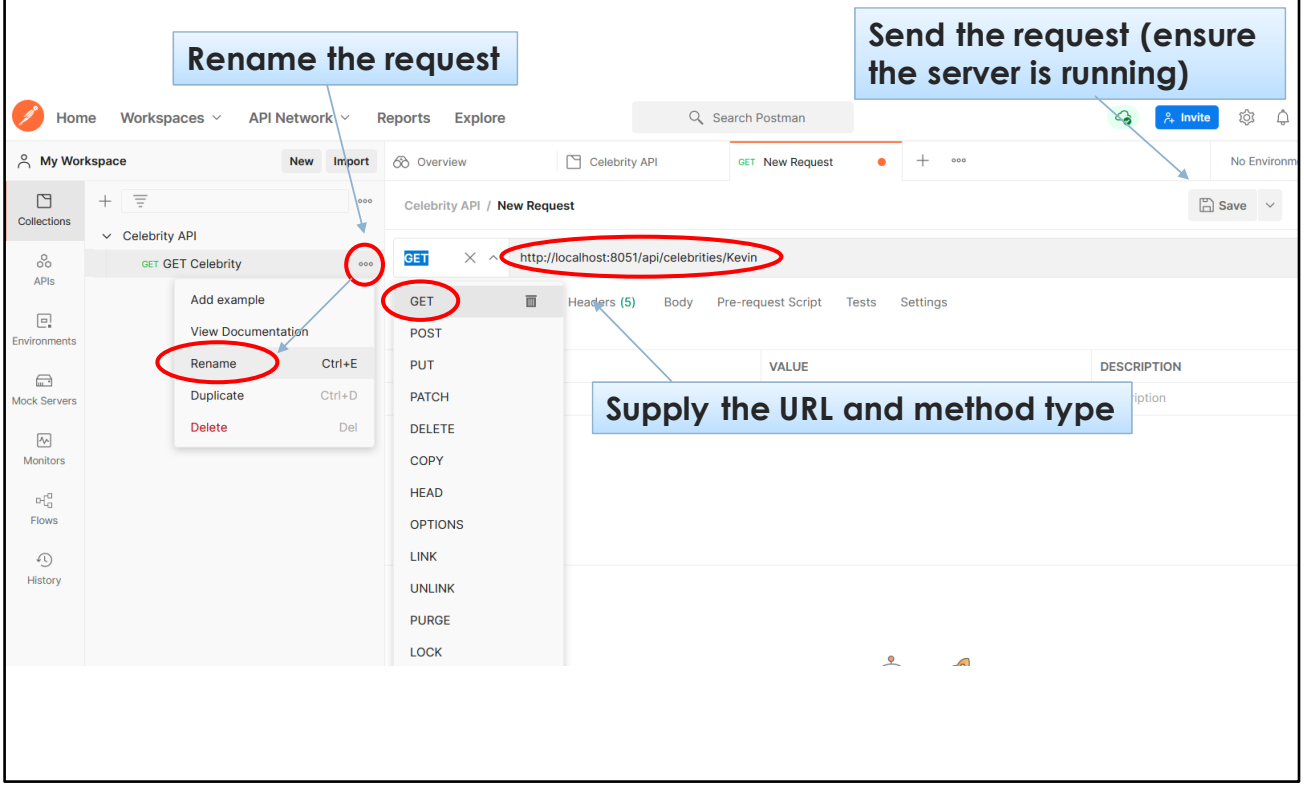
On the screen shown above, the browser-based version loaded the **web.postman.co** url and signed in. Next, a collection was created. Collections are groupings of URLs (typically related to an API set).

Using Postman: Adding Requests



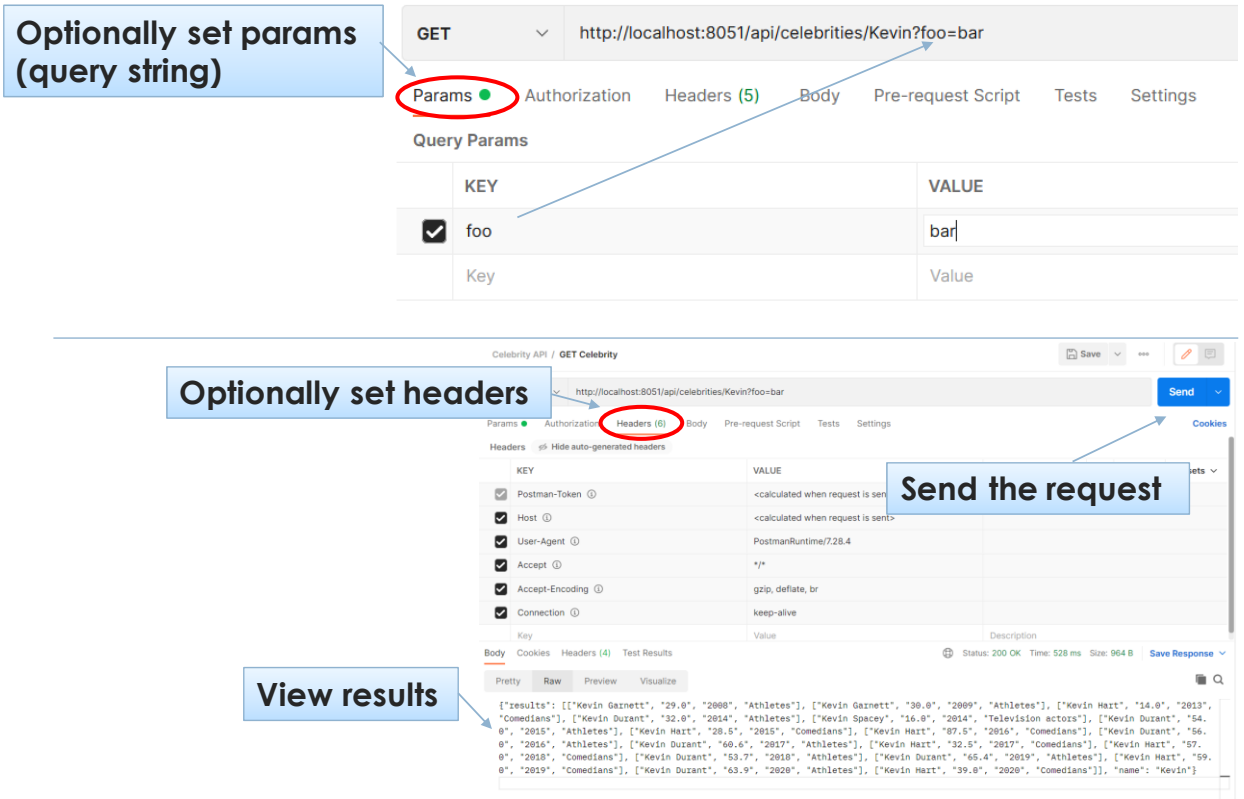
Once a collection is created, you can give the overall API a name and define API requests.

Using Postman: Sending Requests



By supplying the URL and method type for the request, it can easily be sent or re-sent anytime.

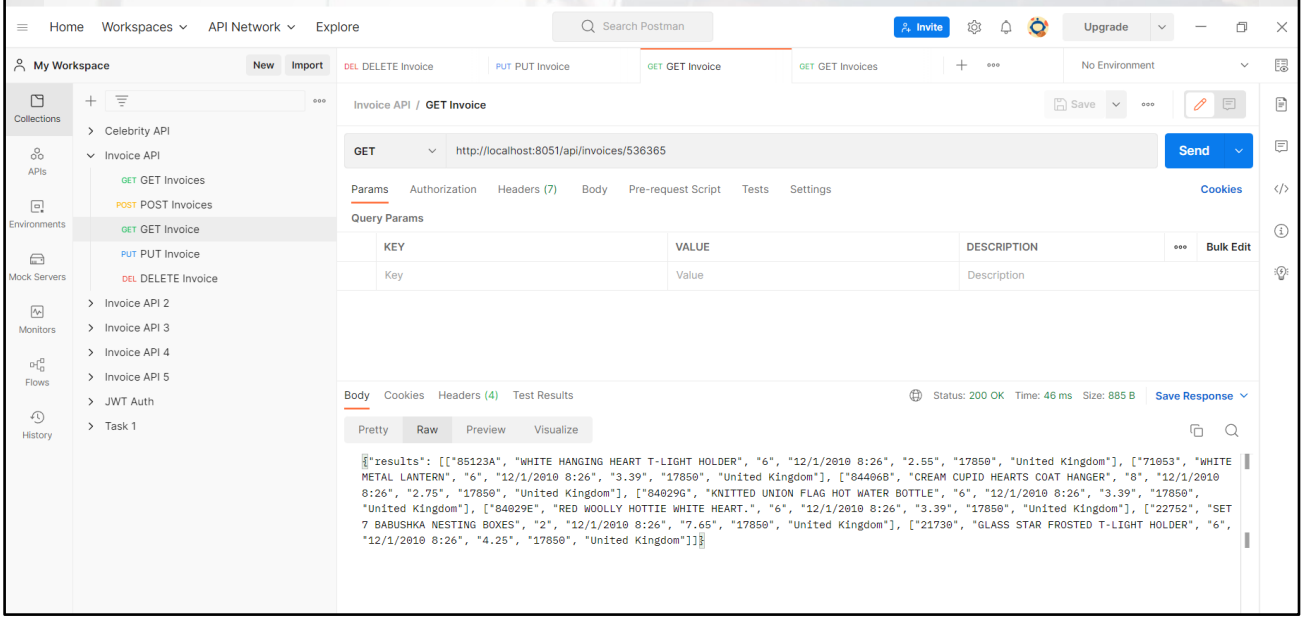
Using Postman: Setting Params, Etc.



Postman provides a nice degree of customization of requests including the ability to set query string params, headers, and body parameters.

Your Turn! - Task 2-4 (optional)

- Use Postman to verify our Invoice application
- Test each of the endpoints and methods created in the previous exercise



Bringing In the Database

- A commonly used Python tool for interacting with a database is called *SQLAlchemy*

  https://flask-sqlalchemy.palletsprojects.com/en/2.x/

- SQLAlchemy performs *automatic Python object-to-relational database mapping* (ORM)

- SQLAlchemy is a third-party tool and must be installed

  pip install sqlalchemy

- Flask-SQLAlchemy is a plugin that integrates the two frameworks

  pip install flask-sqlalchemy

  - Flask plugins must be installed normally
  - *Our setup already includes both of these*

SQLAlchemy provides a means to integrate the Python world with the database. It not only converts relations to objects (and vice-versa), but it takes care of the database SQL statements as well.

Flask supports a plugin called Flask-SQLAlchemy that can integrate the two frameworks, Flask and SQLAlchemy, making integration with most relational databases an easy task.

Configuring SQLAlchemy with Flask

- Three steps to get SQLAlchemy up and running
  1. Configure the Flask-SQLAlchemy plugin (shown below)
  2. Define models to interact with the database
  3. Invoke model methods to perform database operations

- Step 1. Configure the plugin by defining how to connect to the database

```
from flask import Flask, request
from flask_restx import Resource, Api
from flask_sqlalchemy import SQLAlchemy

student_files_dir = Path(__file__).parents[1]
db_file = student_files_dir / 'data/course_data.db'

app = Flask(__name__)
api = Api(app, prefix='/api')

app.config['SQLALCHEMY_DATABASE_URI'] =
                                    'sqlite:///' + str(db_file)

db = SQLAlchemy(app)
```

This is the location of our database

student_files/ch02_fundamentals/12_flask_sqlalchemy_post.py

To configure the Flask-SQLAlchemy plugin, add a parameter called SQLALCHEMY_DATABASE_URI to the Flask app config object. When the Flask-SQLAlchemy plugin starts up, it will look within the Flask app's config object for this value. For other databases, other properties may be required, such as properties for a username and password to authenticate with the database.

The *app* object is passed into the SQLAlchemy() object instance.

Not shown: set `app.config['SQLALCHEMY_ECHO'] = True` to display the generated SQL statements to the console.

Defining and Using a Model

- Step 2. Create a model class to map to the database

```
app = Flask(__name__)
api = Api(app, prefix='/api')

app.config['SQLALCHEMY_DATABASE_URI'] = 'sqlite:///' + str(db_file)
db = SQLAlchemy(app)

class CelebrityModel(db.Model):
    __tablename__ = 'celebrity'
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(100))
    pay = db.Column(db.Float)
    year = db.Column(db.String(15))
    category = db.Column(db.String(50))

    def __init__(self, name, pay, year, category):
        self.name = name
        self.pay = pay
        self.year = year
        self.category = category

    def __str__(self):
        return f'{self.year} {self.name} {self.pay} {self.category}'
```

The model inherits from db.Model

Define the fields and types to map to the table

The __init__ and __str__ are optional but can be helpful

student_files/ch02_fundamentals/12_flask_sqlalchemy_post.py

A model class should inherit from db.Model (db was created from the Flask-SQLAlchemy plugin object). Then (at the class level!) add field definitions to the class that correspond to the fields that will map to the database. Optional __init__() and __str__() methods are provided for convenience for instantiation and debugging or logging purposes.

API POST with Flask-SQLAlchemy

- Step 3. We'll modify our Flask-RESTX class to interact with a database

```
class Celebrities(Resource):
    def get(self):
        return {'celebrities': ''}

    def post(self):
        name = request.form.get('name')
        year = request.form.get('year')
        category = request.form.get('category')
        pay = float(request.form.get('pay'))

        new_celeb = CelebrityModel(name, pay, year, category)
        db.session.add(new_celeb)
        db.session.commit()

        return {'id': new_celeb.id, 'name': name, 'year': year,
                'pay': pay, 'category': category}
```

The POST method extracts the new parameters from the HTTP request body

Instantiate a model, perform an INSERT

Commonly, the inserted object is returned

Test the POST operation either using Postman or by running 13_testing_flask_sqlalchemy_post.py

student_files/ch02_fundamentals/12_flask_sqlalchemy_post.py

Our POST method of the Celebrities class has been modified. It now extracts the HTTP request (body) parameters using Flask's provided (injected) request object. There are other ways to obtain the HTTP request data as well. This data is provided to the model class and then it is inserted into the database (via an SQL INSERT operation) using the db object session's add() method. We commonly return to the client a JSON-based form of the object that was inserted. Here, we returned that object by manually creating it.

Shortly, we'll use a handy tool, Flask-Marshmallow, to serialize the object to JSON for us.

About the Database

- The database used in the course is a SQLITE database file found in the *data* directory (called course_data.db)

- Since the DB tables will now have an id (primary key) column, we'll modify our solution slightly to work with the id column for GET, PUT, and DELETE

Note: When interacting with the database, it can be reset anytime by simply running the restore_db.py file in the student_files/data directory.

This resets the tables back to their original datasets.

Our New Celebrity Resource

```python
class Celebrities(Resource):
    def get(self):
        return {'celebrities': []}

    def post(self):
        name = request.form.get('name')
        year = request.form.get('year')
        category = request.form.get('category')
        pay = float(request.form.get('pay'))

        new_celeb =
                CelebrityModel(name, pay, year, category)
        db.session.add(new_celeb)
        db.session.commit()

        return {'id': new_celeb.id, 'name': name,
                'year': year, 'pay': pay, 'category': category}


api.add_resource(Celebrities, '/celebrities/')
```

```python
class Celebrity(Resource):
    def get(self, id):
        return {'action': 'get'}

    def delete(self, id):
        return {'action': 'delete'}

    def put(self, id):
        return {'action': 'put'}


api.add_resource(Celebrity,
                 '/celebrities/<id>')
```

The other 4 methods will be implemented shortly

student_files/ch02_fundamentals/12_flask_sqlalchemy_post.py

Shown are our two Resource classes. Four of the methods are not implemented yet. The get(), put(), and delete() methods have been adjusted slightly since we are now using a database. The database table has a primary key that can now be used as a path parameter when making requests.

Your Turn! - Task 2-5

- Add Flask-SQLAlchemy to the current Invoice application
- Complete the API's POST method found in the Invoices class
- Either work from your completed Task 2-3 or from the provided task2_5_starter.py file
- Test it by running the provided task2_5_client.py file or by running it within Postman

Flask-Marshmallow

- What is Flask-marshmallow?
  - Flask-marshmallow is a helpful tool for converting objects from Python to JSON or JSON to Python
  - Ideal for returning a Flask database object as JSON from an API

Marshmallow homepage: https://marshmallow.readthedocs.io/en/stable/
Flask-Marshmallow (plugin) home: https://flask-marshmallow.readthedocs.io/en/latest/

- To use Marshmallow:
  1. Configure the plugin within Flask
  2. Define and instantiate a "schema" (the fields to be serialized)
  3. Use the schema to return from API methods (as needed)

Marshmallow is a standalone tool within Python. Marshmallow by itself is useful in converting Python objects to dictionaries. While numerous tools can do this, some of them have problems if the objects do not have underlying dictionaries. In other cases, the utilities for doing this are framework-specific (like Flask's jsonify()).

Flask-Marshmallow simply takes the easy-to-use marshmallow framework and brings it into Flask (as has been done with other plugins like SQLAlchemy and RESTX).

Here, we make use of it to automatically convert the database SQLAlchemy objects into JSON directly.

Installing Flask-Marshmallow

- Flask-marshmallow is third-party module and must be installed using the appropriate statement

```
pip install flask-marshmallow
```

- When using SQLAlchemy objects with Marshmallow, another plugin, Marshmallow-SQLAlchemy, should also be installed

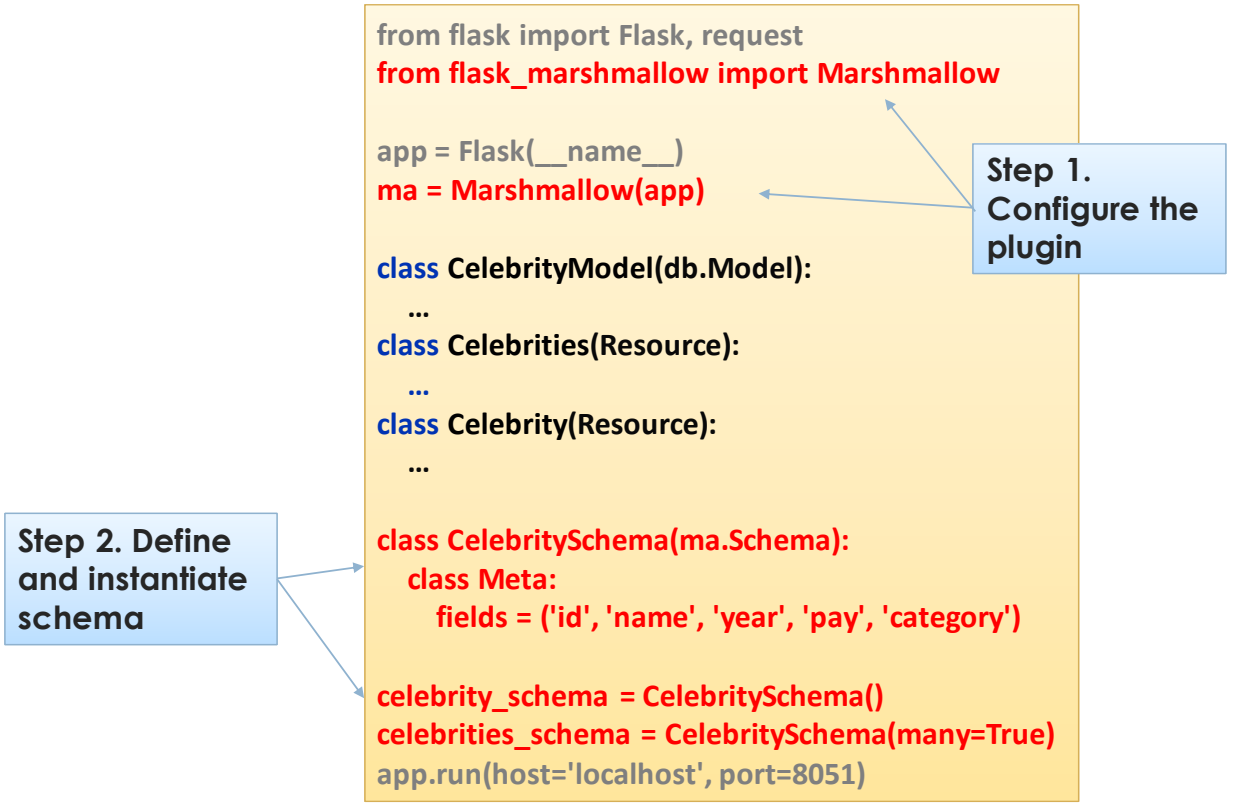
```
pip install marshmallow-sqlalchemy
```

- *Neither of these need to be installed for our environment*

When using both SQLAlchemy and Marshmallow (specifically for converting SQLAlchemy objects) it is best to install two items: flask-marshmallow *and* marshmallow-sqlalchemy.

Don't be confused with these tools. All they do is provide an automatic conversion of Python objects to JSON format.

Integrating Flask-Marshmallow Is Easy



student_files/ch02_fundamentals/14_flask_sqlalchemy_marshmallow.py

Configuring Flask-Marshmallow is only two lines: an import and passing the Flask app object into the Marshmallow main object. Next, define a class that identifies which fields will be exposed (serialized). Instantiate these so that the instances can be used in your API methods (next slide).

POST Again with Flask-Marshmallow

```
class Celebrities(Resource):
    def get(self):
        return {'celebrities': ''}

    def post(self):
        name = request.form.get('name')
        year = request.form.get('year')
        category = request.form.get('category')
        pay = float(request.form.get('pay'))

        new_celeb = CelebrityModel(name, pay, year, category)
        db.session.add(new_celeb)
        db.session.commit()


        return celebrity_schema.jsonify(new_celeb)
```

celebrity_schema.jsonify(obj) - returns JSON

celebrity_schema.jsonify(obj) - returns a dict

Step 3. The Marshmallow schema definition will now convert your (SQLAlchemy) objects to JSON

Test the POST operation again (this time with Marshmallow included) either using Postman or by running *15_testing_flask_sqlalchemy_marshmallow.py*

student_files/ch02_fundamentals/14_flask_sqlalchemy_marshmallow.py

Hey, couldn't Flask's jsonify() do that? Well, Flask's jsonify() can't easily convert Python objects to JSON.

Can't the Python json module help? Sure, but there's a bit of manual work involved with using it and a bunch of work if the object is not serializable.

Marshmallow tries to provide a convenient way to handle object-to-dict or object-to-json conversions.

GET and GET-all with Flask-SQLAlchemy

```
class Celebrities(Resource):
    def get(self):
        all_celebs = CelebrityModel.query.all()
        return {'results': celebrities_schema.dump(all_celebs)}

    def post(self):
        (unchanged from previous)

class Celebrity(Resource):
    def get(self, name):
        try:
            result = db.session.execute(db.select(CelebrityModel).filter_by(id=id)).scalar_one()
            return celebrity_schema.jsonify(result)
        except Exception as err:
            abort(404, f'Object does not exist ({err.args[0]}).')

    def delete(self, id):
        return {'action': 'delete'}

    def put(self, id):
        return {'action': 'put'}
```

Performs equivalent to a SELECT * FROM celebrity

Query the database and find the record that matches the specified id primary key

Test the two GET operations either using Postman or by running *17_testing_flask_sqlalchemy_get.py*

student_files/ch02_fundamentals/16_flask_sqlalchemy_get.py

Now that the pieces are in place, the remaining methods should come along easily. The two get() methods are shown above. The first is an API GET handler that returns matches to a celebrity name. The second returns all celebrity names.

schema.dump() - converts the object to a native Python type. Appropriate if you are wrapping additional code around the object (as we do in the case of the Celebrities get() above).

schema.jsonify() - simply turns the specified object into a JSON response. Useful when you are returning the object only (as we did in the case of the post() method on the previous slide) or the Celebrity get() method on this slide.

API PUT / DELETE with Flask-SQLAlchemy

```
class Celebrity(Resource):
    def get(self, id):
        (as shown previously)

    def delete(self, id):
        celeb = db.session.execute(db.select(CelebrityModel).filter_by(id=id)).scalar_one()
        db.session.delete(celeb)
        db.session.commit()
        return celebrity_schema.jsonify(celeb)

    def put(self, id):
        year = request.form.get('year')
        category = request.form.get('category')
        pay = float(request.form.get('pay'))

        celeb = db.session.execute(db.select(CelebrityModel).filter_by(id=id)).scalar_one()
        celeb.year = year
        celeb.category = category
        celeb.pay = pay

        db.session.commit()
        return celebrity_schema.jsonify(celeb)
```

Using the object id, lookup the object in the database, then use the object to perform a delete

Get the submitted data, instantiate a model, make any changes (e.g., celeb.year = year)

Test the two GET operations either using Postman or by running *19_testing_flask_sqlalchemy_put.py*

student_files/ch02_fundamentals/18_flask_sqlalchemy_put.py

The final methods are implemented here. put() and delete() are easily implemented now. For brevity, the exception handling statements are not shown here. Refer to the source file for these statements.

Implementing PATCH

- The PUT operation often performs a full object update
- If only a *partial* update is desired (such as the category and not the pay or year attributes) use PATCH

```
def patch(self, id):
try:
   celeb = db.session.execute(db.select(CelebrityModel).filter_by(id=id)).scalar_one()

   if 'year' in request.form:
      celeb.year = request.form.get('year')
   if 'category' in request.form:
      celeb.category = request.form.get('category')
   if 'pay' in request.form:
      celeb.pay = float(request.form.get('pay'))

   db.session.commit()
   return celebrity_schema.jsonify(celeb)

except Exception as err:
   abort(404, f'Unable to modify: ({err.args[0]}).')
```

student_files/ch02_fundamentals/20_flask_sqlalchemy_patch.py

The PATCH method is best suited for situations where only a part of an object will be updated. The PUT method can also still be implemented but is best when a full object update will occur.

Your Turn! - Task 2-6

- Add Flask-Marshmallow to the current Invoice application
- Complete the remaining API methods: get() found in the Invoices class, and get(), put(), and delete() found in the Invoice class
- Either work from your completed Task 2-5 file or work from the provided task2_6_starter.py file
- Test it by running the provided task2_6_client.py file or by running it within Postman

Error Handling and Common HTTP Statuses

- Best practices dictate that any error encountered on the server should return an appropriate 400 (usually) or 500 HTTP status code

Status Code	Description
400	Bad Request (Usually no URL mapping)
401	Unauthorized (Usually when client is not authenticated)
403	Forbidden (Usually when client is not authorized but is authenticated)
404	Not found (Good when resource id isn't found)
405	Method not allowed (e.g., A POST occurred on a GET only method)
429	Too many requests (User sent too many requests in a given period of time)
500	Internal Server Error (Usually a code execution error occurred on the server)

There are many more HTTP status codes.
A good reference is: *https://restfulapi.net/http-status-codes/*.

APIs should return an appropriate status code based on the condition of the error. Don't return 200 when the application has a logic error (even if the request was processed properly). Send back an appropriate 4xx code.

Non-Error Status Values

- There are other return status values that can be used to indicate non-error conditions

Status Code	Description
200	Ok (The majority of response status codes are 200)
201	Created (The server created a new resource)
204	No Content (The request processed successfully, but the server didn't have anything to respond with)
300	Multiple Choices (The request has multiple possible responses)
304	Not modified (Server code is not changed, client's cached version is okay to use)

Even though most successful responses will return 200 status, sometimes other values might make sense. For example, a 204 status code could be sent back in situations where a request was processed successfully but the server didn't have any message to return.

Handling Errors with Flask-RESTX

- The Flask-RESTX plugin provides an abort() method that will send back an HTTPException

```
def handle_no_celebrity_exists_error(message: str = f'Celebrity does not exist.',
                                     error_code: int = 404):
    abort(error_code, message)

class Celebrity(Resource):
def get(self, id):
    try:
        result = db.session.execute(db.select(CelebrityModel).filter_by(id=id)).scalar_one()
        return celebrity_schema.jsonify(result)
    except Exception:
        handle_no_celebrity_exists_error()
```

The custom method internally calls Flask-RESTX's abort() method

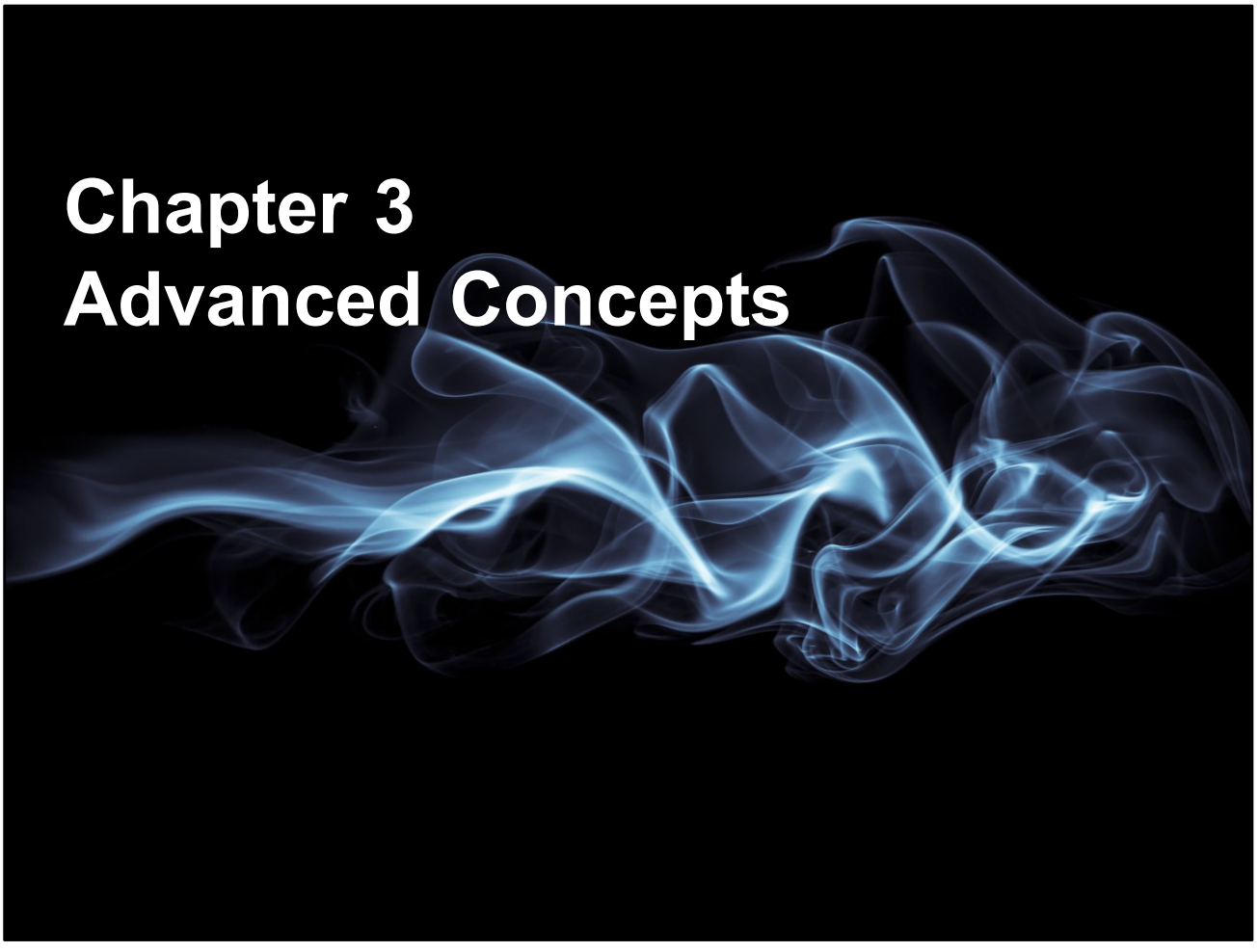
student_files/ch02_fundamentals/22_flask_sqlalchemy_errors.py

Here, a custom method was created that will invoke the Flask-RESTX abort() method for us. Now this method can be applied to get(), put(), patch(), and delete() methods and a custom JSON message is then sent back to the client.

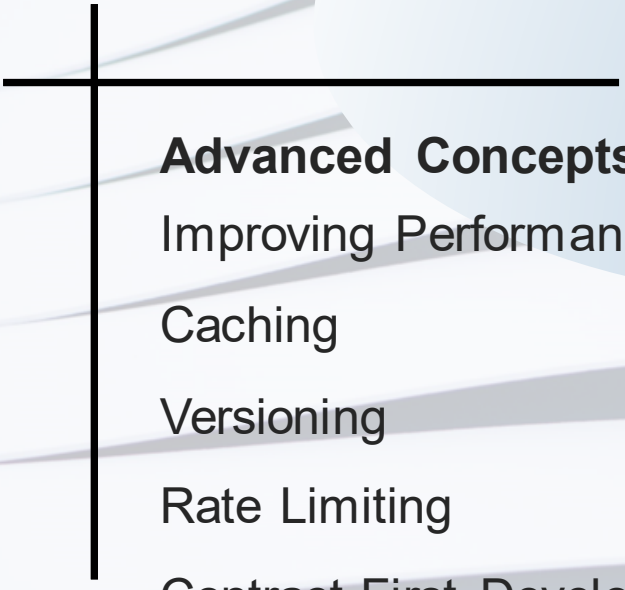
Notice we don't send back a 200 when an application error (like no celebrity found) occurs.

Chapter 2 Summary

- Python provides tools to facilitate building all aspects of APIs
- Flask is only one of many options for serving content
- The Flask environment provides numerous options for improving solutions via plugins, including:
  - Flask-RESTX (and earlier variations -ful/-plus) simplify the amount of coding required
  - Flask-SQLAlchemy provides database integration and ORM
  - Flask-Marshmallow provides easy object return state



Chapter 3 Overview



Advanced Concepts

Improving Performance

Caching

Versioning

Rate Limiting

Contract-First Development

HATEOAS

Improving Performance

- There are several ways in which application performance can be improved
  - Pagination - Limits the amount of data returned for large responses
  - Caching - Lets the client re-use data saved from previous responses
  - Rate Limits - Limit a client's number of requests over time
  - Versioning - Less for performance than to ensure continuity for clients

Let's explore these techniques over the remainder of this chapter…

Pagination

```
class Celebrities(Resource):
    page_size = 10

    def get(self):
        page = request.args.get('page') or '1'
        query = db.select(CelebrityModel).order_by(CelebrityModel.pay.desc())
        paged_celebs = db.paginate(query, page=int(page),
                                   per_page=self.page_size, error_out=False).items
        return {'results': celebrities_schema.dump(paged_celebs.items)}
```

Pages are 10 records

A page query parameter (e.g., page=2) or def. 1

Flask SQLAlchemy provides a paginate() method that takes a page number and page size. It returns a Paginate object that has an items attribute

```
import requests

base_url = 'http://localhost:8051'
path = '/api/celebrities/'

for n in range(1, 4):
    print(f'\ngetting page ({n}):')
    results = requests.get(f'{base_url}{path}', params={'page': n})
    print(f'Status: {results.status_code}')
    print(results.text)
```

Our test client retrieves 3 pages of 10 records per page

student_files/ch03_adv_concepts/01_pagination.py

In the code shown above, we see our Celebrities resource. We've defined our own page_size variable. This defines how many records will be returned. It is arbitrarily defined but can be easily changed now.

Also, the page_size variable could be made into something the client could manipulate and send to our server if we desired.

We used the Flask *request* object to obtain the submitted page parameter from the URL query string.

Caching

- Caching improves API performance by minimizing the amount of client requests made to the server
  - Caching only applies to GET requests
  - Caching can be implemented by setting just a couple of HTTP response headers
  - Use the Cache-Control header to define if and for how long response data can be saved

    Cache-Control: max-age=600 *(use browser cache if request is within 10 minutes of original)*

    Cache-Control: no-cache *(don't cache the response)*

    - With this header, browser-based clients will look toward their own cache implementation before making a request

Caching within browsers is automatic, however, non-browser clients may require logic to process the header. Caching only works in one direction. In other words, if the request indicates it is not to be cached with a Cache-Control header, it will only be obeyed in one direction (client to server). The response would have to indicate with its own header whether to cache the response info.

It's worth noting that leaving off the Cache-Control header doesn't necessarily disable caching. Browsers can attempt to employ caching on their own for certain types of content. The no-cache value will force the browser (client) to make a new request each time.

Rules for Caching

- If content is mutable (as most business entities), use Control-Cache: no-cache

- If content is deemed immutable set a reasonable max-age with
  Control-Cache: max-age= 31536000

Your Turn! - Task 3-1

- Currently, the invoice API returns too many records when retrieving all records (within Task 2-6)
  - Implement pagination on the Invoice application
  - Return 50 records at a time for the GET all method
  - Retrieve a page argument from the client
  - Use Flask's SQLAlchemy Pagination object
- Work from the provided task3_1_starter.py

Rate Limits

Homepage: https://flask-limiter.readthedocs.io/en/stable/

- Clients can make too many API requests overwhelming the server

pip install flask-limiter

  - Applying rate limits can reduce CPU workload and network bandwidth
  - Flask provides a 3rd party tool (that must be installed), called Flask-Limiter

```
from flask_limiter import Limiter
from flask_limiter.util import get_remote_address
from pathlib import Path

app = Flask(__name__)
limiter = Limiter(get_remote_address, app=app)

@app.route('/api/celebrities/<name>', methods=['GET'])
@limiter.limit('3/minute')
def get_one_celebrity(name):

  ...
```

student_files/ch03_adv_concepts/05_rate_limiting.py

For more on the Flask rate limiter, visit: https://flask-limiter.readthedocs.io/en/stable/.

Different rate limit values can be specified (they are parsed by the framework). Here are a few examples:

- 100 per hour
- 75/hour
- 50 per 2 hours
- 500/day;1000 per 7 days

API Versioning

- Versioning is needed when an API interface changes
  - Versioning refers to the client's perspective of the API
- Versioning *is required* when
  - The API sends back a new data format or values
  - APIs are removed
- Versioning *is not required* when a server *implementation* changes
  - For example, if you change your database implementation from MySQL to MS SQL Server
- Versioning *is also not required* when
  - New endpoints are added
  - New parameters are added to the response (generally)

Clients may spend considerable effort developing their apps to work with your API.

If you change your API, the client will need to update their apps as well. This can take time. To ensure the smoothest transition from the old API version to the new one, for a time, you will need to have both versions available simultaneously.

But how to do this? The answer is versioning. How do we version our API? Several strategies exist and are easy for the client to implement (mentioned momentarily).

Versioning Approaches

- Versioning can be implemented several ways
  - Via the domain name: **http://apiv1.sample.com/api/celebrities**
  - Via the path: **http://localhost:8051/api/v1/celebrities**
  - Via query string: **http://localhost:8051/api/celebrities?version=1**
  - Via custom HTTP headers:

```
POST /celebrities  HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64)
Host: www.sample.com
Content-Type: application/x-www-form-urlencoded
…
Accept-version: v1

name=Fred%20Savage&pay=3.0&category=Actors
```

The path approach is one of the most common techniques used, particularly for some of the large domain public APIs.

Defining the Contract and OAS

- RESTful services can be written as contract-first or contract-last
  - Contract-first - define and design the service, then code it
  - Contract-last - code up the API, then document it
- One way to create a contract-first solution is by using an Open-API Specification (OAS)
  - OAS uses either YAML or JSON for its format
    - Classic Swagger solutions favor YAML, while OAS proposed a JSON-based format

For more on OAS version 3.x, visit https://spec.openapis.org/oas/v3.1.0 and https://swagger.io/specification/.

Defining the API with OAS

```
{
  "openapi": "3.1.0",
  "info": {
    "title": "Celebrity App",
    "summary": "A celebrity info retrieval system.",
    "description": "This is a partial listing for our celebrity api.",
    "version": "1.0.0"
  },
  "paths": {
    "/api/celebrities": {
      "get": {
        "description": "Returns all celebrities.",
        "responses": {
          "200": {
            "description": "A list of celebrities.",
            "content": {
              "application/json": {
                "schema": {
                  "type": "array"
                }
              }
            }
          }
        }
      }
    },
    "/api/v2/celebrities": { ...
```

student_files/ch03_adv_concepts/openapi.json

This shows only a partial listing of what an OAS document structure looks like. It can be somewhat lengthy identifying numerous other items, such as servers involved, all of the operations and various paths, security information, and much more. It can also maintain multiple API versions (partially shown here).

Auto Generating an API

- Tools (for many languages) exist to generate code from an OAS document for both the API server and client

https://openapi-generator.tech/ *Select "Generators"*

- Swagger Codegen provides the ability to create an API based on an OpenAPI document

- Connexion, is a framework that generates an API server that maps your functions to your endpoints from a JSON or YAML-defined document (see next example)

For more on OAS version 3.x, visit https://spec.openapis.org/oas/v3.1.0 and https://swagger.io/specification/.

Generating a Solution with Connexion *(1 of 3)*

- The following runs Connexion to create our auto-generated API interface

To run this:
1) Go to ch03_adv_concepts/connexion_example
2) Run connexion_sample.py
3) Navigate to: http://localhost:8051/ui/

api.py

```
def get_celebrity(name):
    return f'You selected: {name}', 200
```

connexion_sample.py

```
import connexion

from connexion.resolver import RestyResolver

app = connexion.App(__name__)
app.add_api('swagger.yaml', resolver=RestyResolver('api'))


app.run(host='localhost', port=8051)
```

api.py

ch03_adv_concepts/connexion_example

To run this, you must have run the Task 1-1 setup at the start of our course. This will install necessary tools such as Flask and Connexion[swagger-ui].

Generating a Solution with Connexion *(2 of 3)*

swagger.yaml

```
swagger: "2.0"
info:
  title: Generated Flask Server

paths:
  '/celebrity/{name}':
    get:
      operationId: api.get_celebrity
      parameters:
        - name: name
          description: Celebrity name
          in: path
          type: string
          required: true
      responses:
        200:
          description: Response to a celebrity query
          schema:
            type: object
            properties:
              message:
                type: string
              status:
                type: integer
```

Our URL mapping: http://localhost:8051/celebrity/Kevin

get_celebrity() function within api.py

get_celebrity(name) takes a name parameter

It will be defined in the path

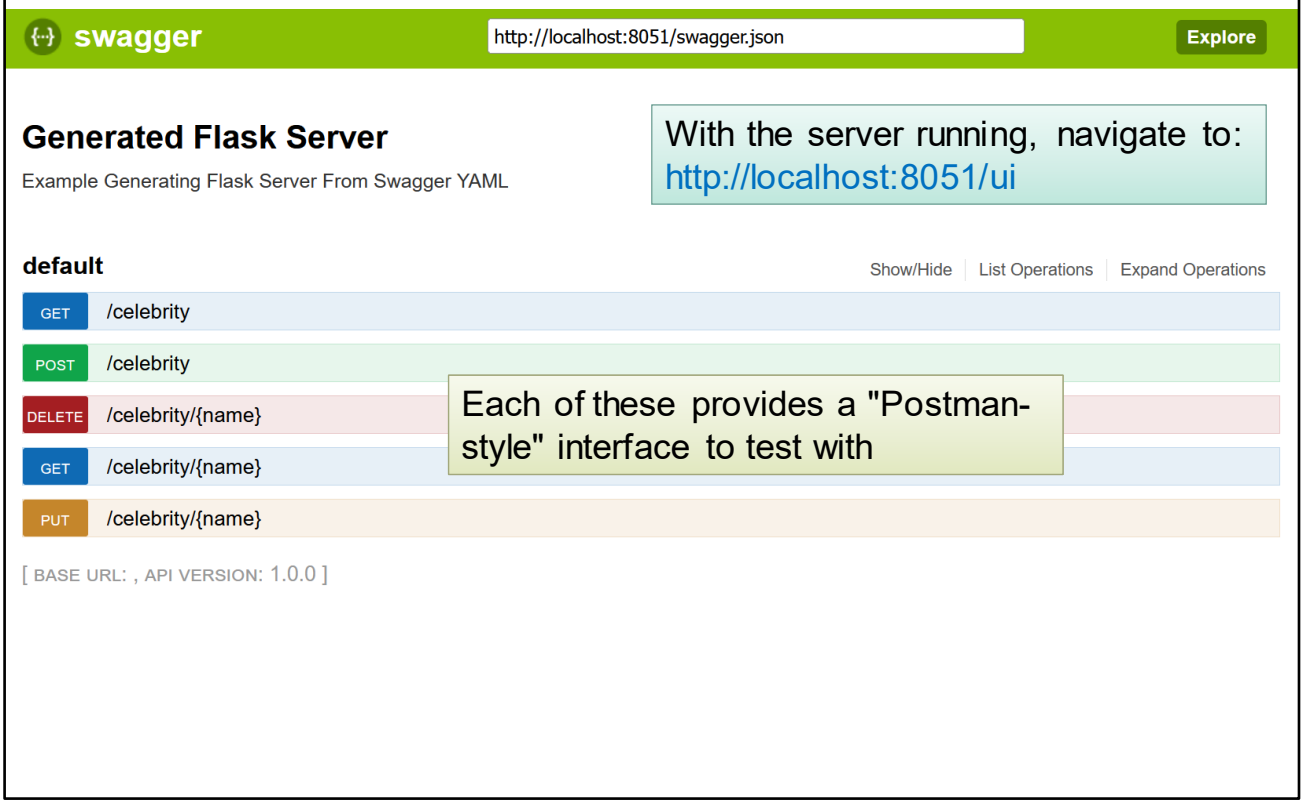
It returns an object with *message* & *status* props

See source file for more

ch03_adv_concepts/connexion_example

The first line of the document defines the format of the content. If it is swagger: "2.0" it will have one structure otherwise it could be openapi: "3.0.0" which will define a slightly different schema.

Generating a Solution with Connexion *(3 of 3)*



ch03_adv_concepts/connexion_example

Shown here is the autogenerated client for the Connexion example.

HATEOAS

- One problem with REST (or any service architecture) is that documentation is critical
- Every client must ask, "What are the valid URLs for this RESTful service?"
- To *promote looser coupling* between client and server and to provide a means for clients to *automatically discover* these services (resources), HATEOAS comes in
  - Stands for: Hypermedia As The Engine of Application State

To help promote loose coupling between the client and server (i.e., so that the client doesn't have to hard-code or have knowledge of various resource links), related resources can be embedded into GET requests. This can be done in a "links" property of the GET JSON response. The HATEOAS format is up to you; it doesn't have to be structured exactly like the example.

For more on this topic, check out: https://restcookbook.com/Basics/hateoas/

Sample HATEOAS Response

Server's GET Response

```
{
 "InvoiceNo": "536365",
 "StockCode": "85123A",
 "Quantity": 6,
 "Description": "LIGHT-HOLDER",
 "UnitPrice":2.55,
 "CustomerID": "17850",
 "Country": "United Kingdom",
 "links":[
   {
    "rel":"customer",
    "href":"https://hostname.com/customers/17850",
    "action":"GET",
    "types":["text/xml","application/json"]
   },
   {
    "rel":"customer",
    "href":"https://hostname.com/customers/17850",
    "action":"PUT",
    "types":["application/x-www-form-urlencoded"]
   },
   ...(see example in student files for more)...
  ]
}
```

A client must know the first request to make, but subsequent requests can be "discovered" in the "links"(or equivalent) section of the server's response

student_files/ch03_adv_concepts/hateoas.json

There are different formats for performing discovery. HATEOAS is only one.

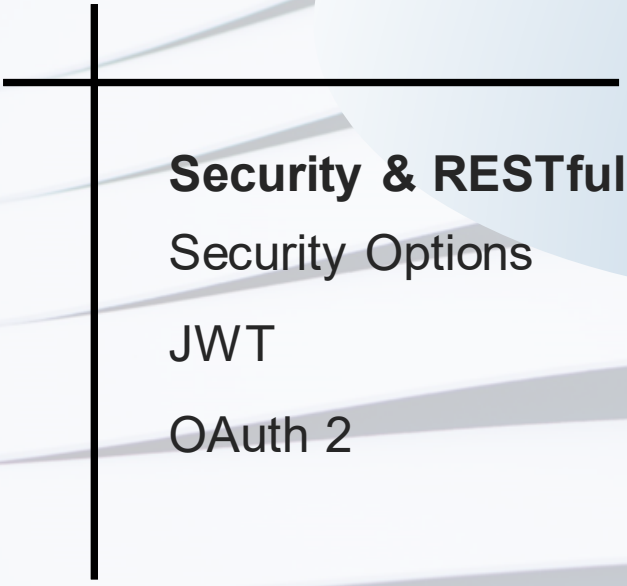
Also, in the works, is a way to define better support with JSON for linked actions. HAL and JSON-LD are two specifications that are evolving for this purpose.

Chapter 3 Summary

- Flexible APIs can provide filtering, sorting, and pagination features
  - These are commonly implemented using query string parameters
  - While a database might prefer limit and offset, the client doesn't need these
    - Simply provide a page attribute to allow pagination
- Caching can reduce the workload for both the API server and client
  - Client caching is easily controlled through Cache-Control
  - Other headers exist but often aren't necessary for APIs

Chapter 4
Authorization and Authentication

Chapter 4 Overview



Security & RESTful APIs

Security Options

JWT

OAuth 2

Securing RESTful APIs

- Most APIs require a level of security before resources can be accessed
- Several actively used authentication techniques exist
  - Basic Authentication
  - OAuth 1.0 (Digest Authentication)
  - Token (Bearer) Authentication (e.g., JSON Web Tokens, JWT)
  - API Keys
  - OAuth 2.0

There are several approaches that can be used when securing APIs. We'll discuss these in this chapter.

Basic Auth

- Basic authentication can be used as a challenge against unwanted visitors
  - It requires the use of a secure channel as credentials must be submitted in the HTTP request
  - Credentials are only encoded not encrypted so it should only be used with HTTPS

```
import requests
from requests.auth import HTTPBasicAuth
from bs4 import BeautifulSoup


page = 'https://jigsaw.w3.org/HTTP/Basic/'
auth = HTTPBasicAuth('guest', 'guest')
page_text = requests.get(page, auth=auth).text
soup = BeautifulSoup(page_text, 'html.parser')
print(soup.select('p')[2].text)
```

Python requests can handle basic auth queries

student_files/ch04_auth/01_basic_auth.py

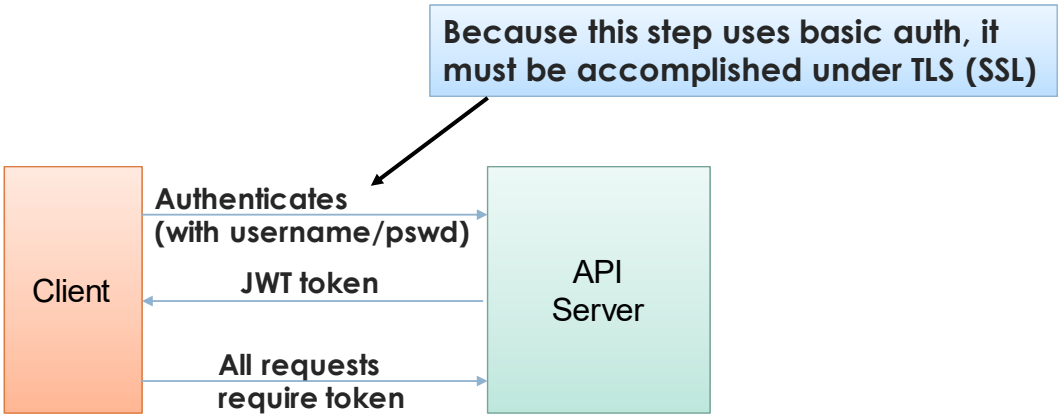
Basic authentication is secure only if you always make sure to use TLS (SSL).

In addition, basic auth always requires username and password to be sent and therefore raises the value of that request. In other words, if we are using OAuth 2, we are only sending a token each time. Compromise of that token while problematic, only gives the attacker access to that session, not the user's credentials or account info.

Compromise of a request that uses basic authentication exposes the user's username and password and potentially invalidates that user's account, possibly more. So careful consideration should be given to using basic auth in applications. Consideration as to how credentials are initially provided (like a web-based form, for example) or the cost to the user if the requests are compromised will need to be examined.

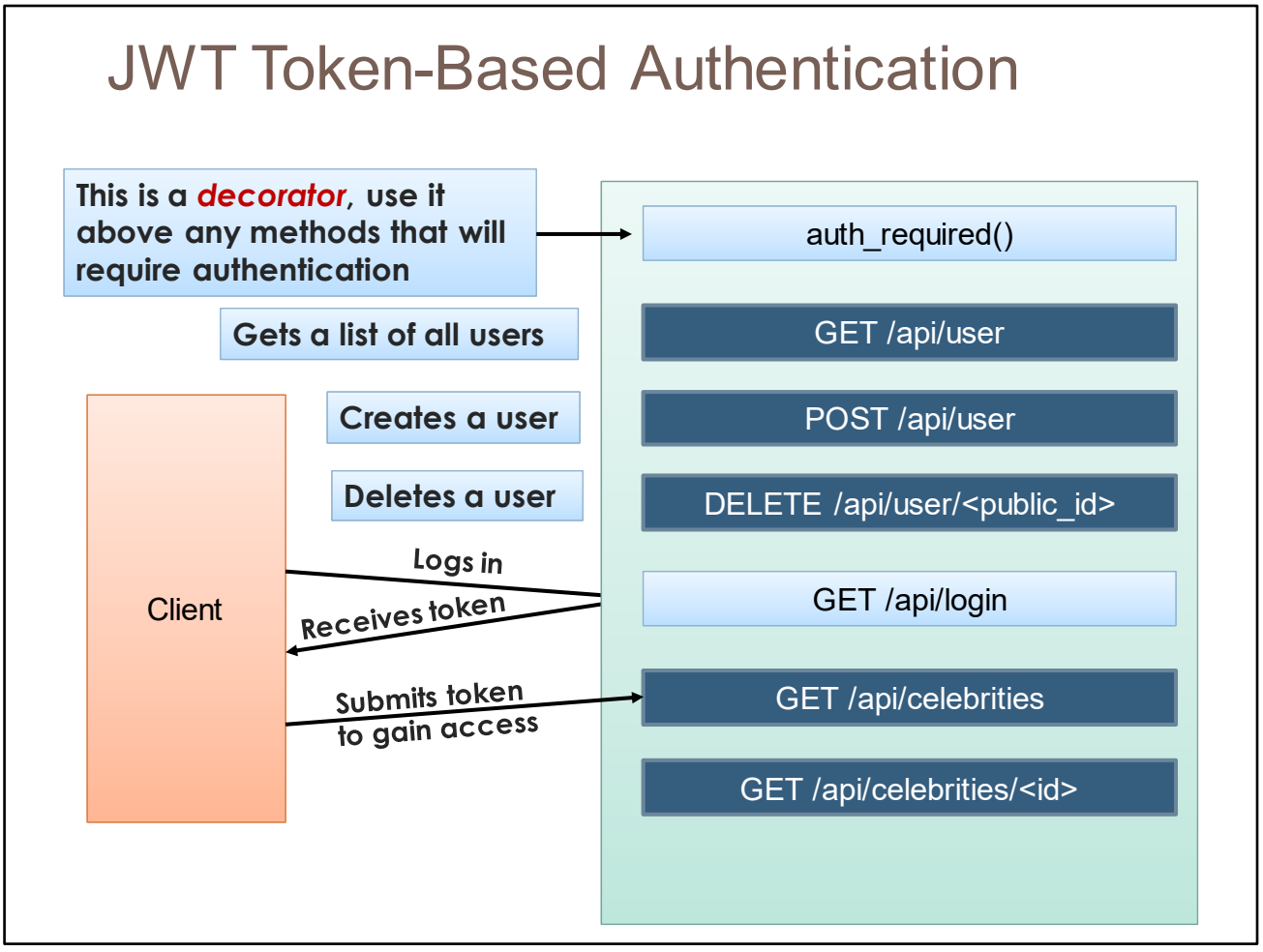
JSON Web Token-Based Authentication

- JSON Web Tokens (JWTs) can be a useful means for securing APIs



- JWTs only require authentication once, after that a token is used for authentication and authorization

JSON web tokens provide a means for identifying a user by examining a provided token. Because tokens are signed, they can't be tampered with by intercepting them. Because of the way the tokens are created, they can't be invalided. They can only be allowed to expire.



student_files/ch04_auth/02_celeb_auth.py

Our example exists in two files. The server is 02_celeb_auth.py while the client is 03_test_celeb_auth.py.

Our API has two sets of interfaces. One interface manages users while the other allows access to celebrity info.

The *auth_required* Decorator

```
def auth_required(orig_func):

    def wrapper(*args, **kwargs):
        token = None
        if 'x-access-token' in request.headers:
            token = request.headers['x-access-token']

        if not token:
            return jsonify({'message': 'Token is missing!'}), 401

        try:
            data = jwt.decode(jwt=token,
                              key=app.config['SECRET_KEY'],
                              algorithms=['HS256'])

            current_user = User.query.filter_by(public_id=data.get('public_id')).first()
        except Exception as err:
            print('Token is invalid--> ', err)
            return jsonify({'message': 'Token is invalid!'}), 401

        return orig_func(current_user, *args, **kwargs)
    return wrapper
```

The decorator is placed above any functions requiring authentication

Failure to authenticate will result in messages regarding the token

If the token is present, it is decoded using the jwt.decode() method

The decoded token should contain a public id of the user, which is used to query the database to obtain the user (if they exist)

student_files/ch04_auth/02_celeb_auth.py (server)

A little background on decorators can be found in the appendix.

This decorator should be placed above any function that will require authentication. It will look for the presence of the token under the key of "x-access-token" header. If it is not found or incorrect, a message will be returned. Otherwise, if it is present, it will be decoded using the jwt module's decode() method. The decoded token will result in a dictionary containing the user's public_id. This can be queried in the database to obtain the user object. With the user object, the originally desired function will be called and the current_user object will be injected into it. So, all functions that are decorated by this decorator must provide *current_user* as the first argument.

Testing JWT API Authentication

```
login_response = requests.get(f'{base_url}{path}/login', auth=credentials).json()
token = login_response.get('token')
```

The client logs in with credentials and gets a token in return

The token is added into the headers on each subsequent request

```
r = requests.get(f'{base_url}{path}/celebrities', headers={'x-access-token': token}).json())
```

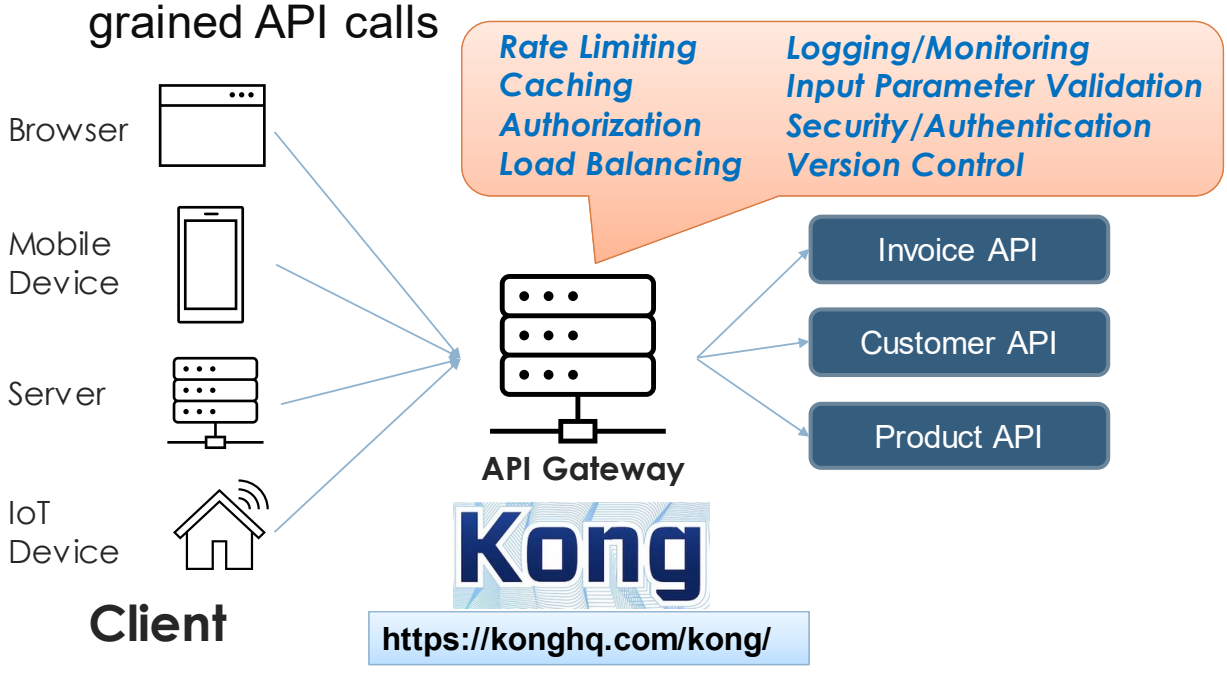
The test client (not shown) performs the following steps:

- Access celebrities without a token
- Access celebrities with an invalid token
- Authenticate (/api/login) as an admin
- Receives a token
- Access celebrites (with token) successfully
- Creates a new user (Sally) (not an admin)
- Logs in with the new user
- Retrieves a single celebrity successfully
- Attempts to delete a user (fails)
- Log in as admin user
- Deletes Sally

student_files/ch04_auth/03_test_celeb_auth.py (client)

API Gateway

- An API Gateway serves as a single point of entry when a client may need to interact with numerous fine-grained API calls

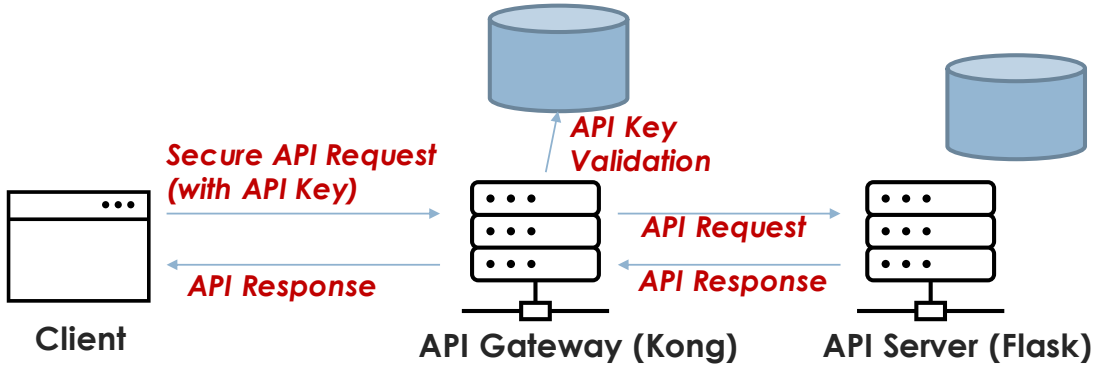


API gateways assist with providing a single interface in front of a microservices architecture thus simplifying client knowledge of the API network.

There are numerous options now for open-source API gateways. While KONG is the most popular and well-known, others such as Apache APISIX, Tyk (AWS), and Ocelot (for .NET) also exist.

API Keys

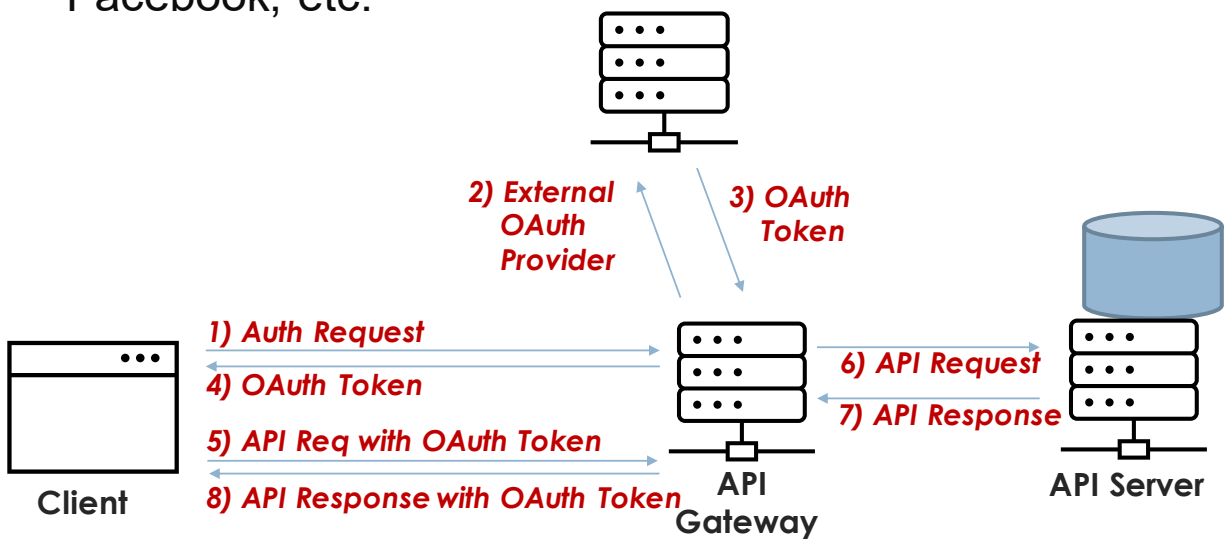
- API keys provide a means to link API access to a specific client
  - Usually, a client registers for an API key
  - The key is submitted for every GET request which identifies the client
  - Resource access and rate limits can then be applied
  - Common within public (non-private) APIs
  - API keys are not suitable for POST, PUT, PATCH, or DELETE



The use of an API key has become common particularly with publicly visible API services. Keys alone are typically not used to secure services. Instead, they are used as a tracking mechanism to control access and limit usage of the API.

OAuth 2

- OAuth provides token-based identity verification services from an external provider such as Google, Facebook, etc.



OAuth 2 is an authentication protocol that allows a client to communicate with a server once the client has been verified by a designated third-party provider. Once the provider verifies the client, it sends a token back to the client (via the API gateway or server) to be used for all subsequent requests made to the API host. OAuth 1 and OAuth 2 are completely different from each other.

Using an OAuth verifier provides easy access to services without the need to pass credentials. OAuth tokens must be provided in order to gain access to the API server. Tokens have an expiration (usually an hour).

Security Best Practices

- APIs should always send and receive over SSL (TLS)
- APIs that allow POST, PUT, PATCH and DELETE should use stronger forms of authentication, such as OAuth 2 or OpenID Connect
- Place API keys in the Authorization: header instead of the query string (as is too commonly done)

```
Authorization: Bearer zY%^33GhibW2%11Qy#1a8Z
```

Chapter 4 Summary

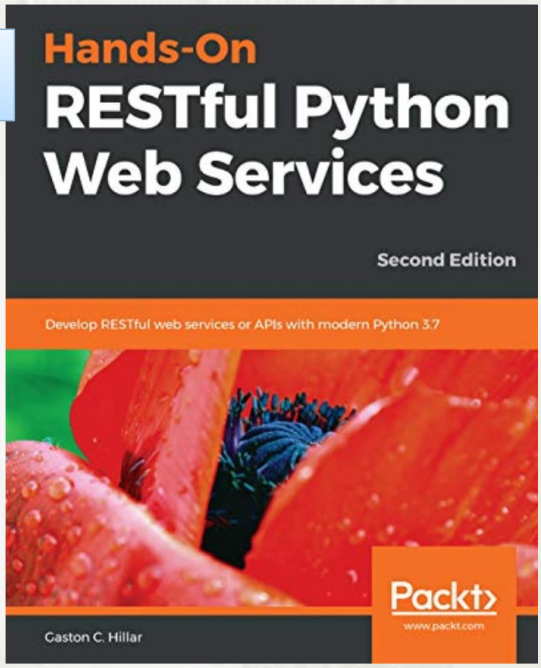
- As a minimum, all APIs should implement transport security using TLS (SSL)
- Use API keys for public APIs that primarily support GET operations to monitor client usage metrics
- Apply stronger forms of authentication for full-service APIs
  - Use OAuth 1 or 2 for most needs

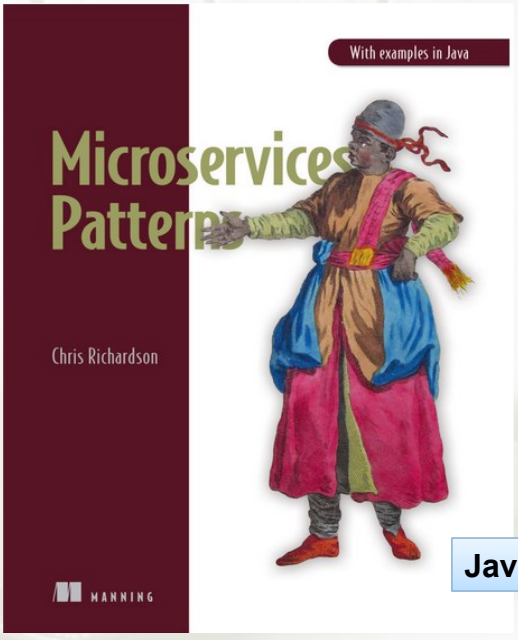
What Did We Learn?

- REST vs Web Services
- JSON Syntax
- Key REST Components
- Design Principles
- RESTful Methods
- Endpoints and Resources
- Python Requests
- Flask / Flask-RESTX
- Routes
- Postman
- Swagger
- Database Integration
- Flask-SQLAlchemy
- Object Serialization
- Flask-Marshmallow
- PUT vs PATCH
- Error Handling
- Pagination
- Caching
- Rate-Limits
- Versioning
- Data Compression
- HATEOAS
- Options for Securing Services
- OAuth
- API Keys
- Considerations for Security

Recommended Sources

Covers Flask, Django, SQLAlchemy, Other Python Tools, slightly dated (2018)





Java-based, but patterns are patterns (2018)

Other Resources

Well-known Flask Tutorial (2017)

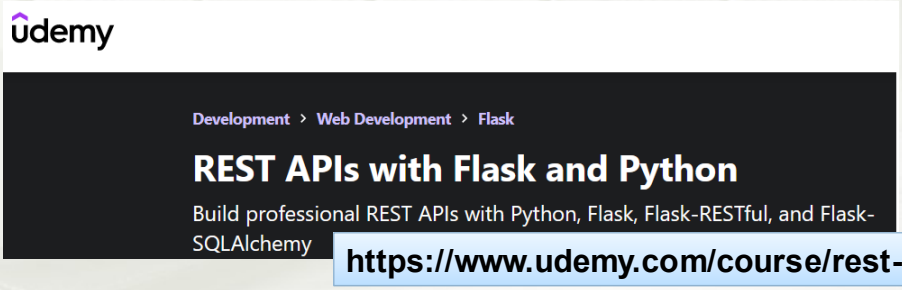
https://blog.miguelgrinberg.com/post/the-flask-mega-tutorial-part-i-hello-world

REST API with Flask & SQLAlchemy

https://www.youtube.com/watch?v=PTZiDnuC86g

Awesome API - Useful collection of resources

https://github.com/Kikobeats/awesome-api

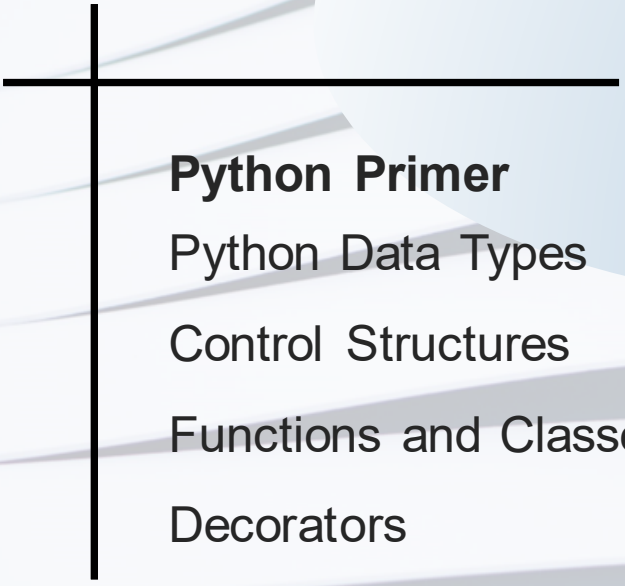


https://www.udemy.com/course/rest-api-flask-and-python/

Questions

Questions?

Appendix Overview



Python Primer

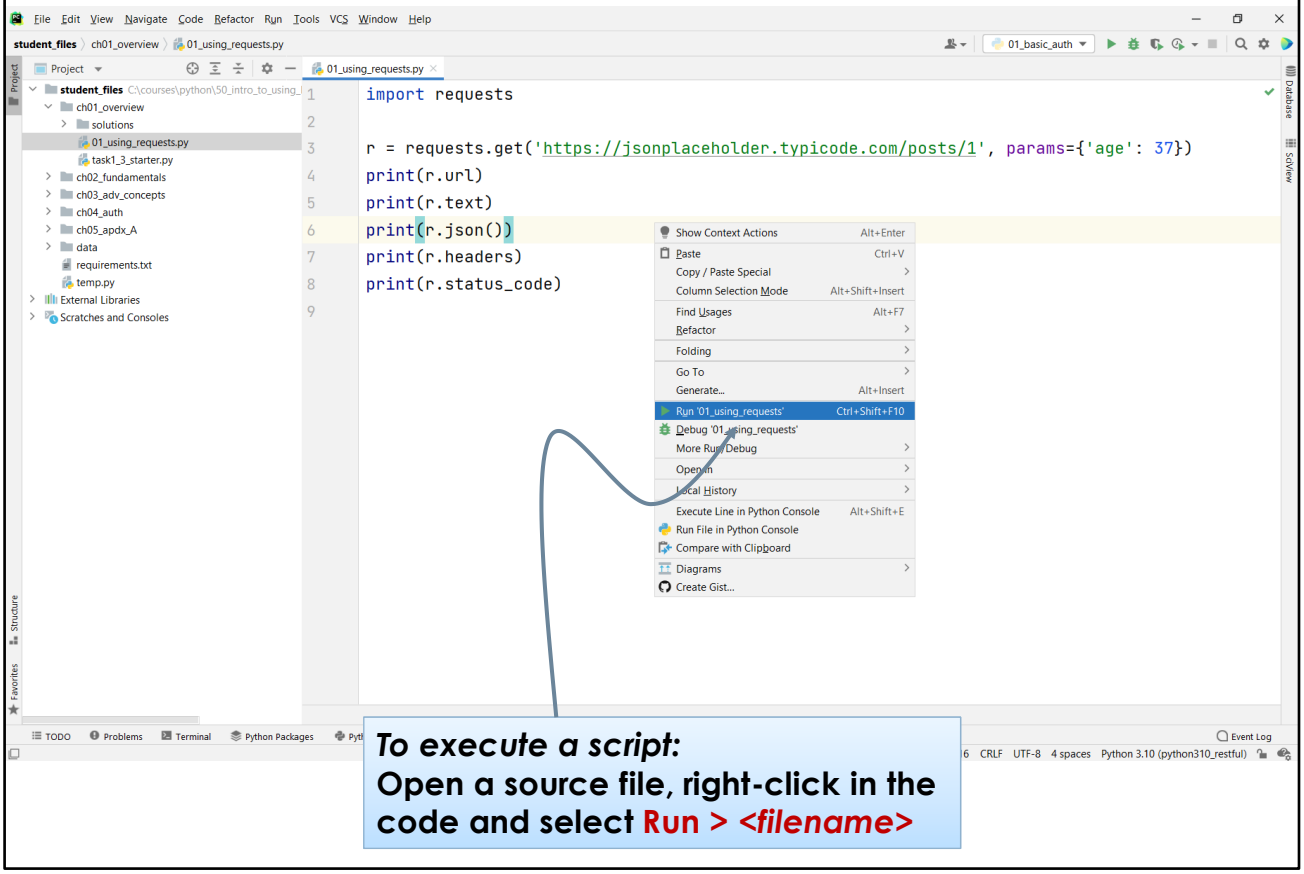
Python Data Types

Control Structures

Functions and Classes

Decorators

Running Scripts with PyCharm



To work with PyCharm, launch the program and select Open... from the options on the right and then locate the student_files directory.

Usually, a good first step is to verify the correct interpreter is selected for use. Do this by visiting File > Settings > Project: student_files > Project Interpreter and examining the interpreter option.

To execute a script, you will first need to wait until the IDE has "scanned" the environment. You may see a message "3 processes running" in the footer. Wait until this completes, then attempt to run the script.

Providing Command-Line Arguments

- When a script is run from a command-line, additional arguments can be retrieved
  - Import the sys module, use the argv list (array)

```
import sys

pet1, pet2 = 'dog', 'cat'

if len(sys.argv) >= 3:
    pet1 = sys.argv[1]
    pet2 = sys.argv[2]

print('My', pet1, 'chases my', pet2)
```

  - When running this script:

```
python  example01.py
python  example01.py  cat bird
```

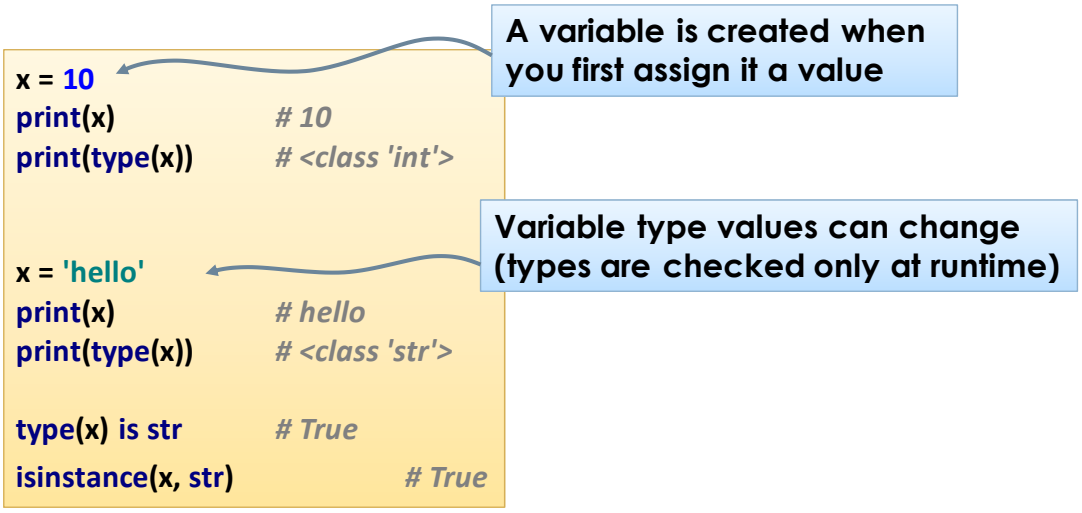
argv[0] argv[1] argv[2]

```
My dog chases my cat
My cat chases my bird
```

student_files/ch05_apdx_A/example01.py

Python Data Types

- Python has many built-in data types



- type() provides insight about what *kind* a variable is at runtime
  - Use isinstance() in practice to verify a variable's type

Converting Values

- Sometimes values need to be converted from one format to another
  - int or float *to String (str)*

```
s1 = str(55)          # '55'
s2 = str(3.14)        # '3.14'
```

  - String or float *to int*

```
i1 = int('37')        # 37
i2 = int(3.14)        # 3
```

  - int or String *to float*

```
f1 = float(55)        # 55.0
f2 = float('3.14')    # 3.14
```

Values that can't be converted will generate an exception called a *ValueError*

```
int('hello')
```

yields…

```
ValueError: invalid literal for int() with base 10: 'hello'
```

Exceptions such as ValueErrors can be properly dealt with using exception handling (not discussed in this primer).

Strings

- Strings are immutable sequences of Unicode characters
  - Type: str
  - Formal notation:

```
my_str = str('Python is great!')
my_str = 'Python is great!'
```

```
my_str = 'Python is fun'      my_str = 'Python is very fun'
```

Creates a new string object

  - Strings support both single and double quotes

PEP 8 does not have a preference

Triple quoted strings can span multiple lines. A common use for triple quoted strings is for documentation (called a docstring).

```
my_str = 'Python\'s great fun'
my_str = "Python is great fun"
my_str = """Python is so much fun"""
```

In Python 3, strings are Unicode characters. Some characters must be escaped to use them. Escape characters include:

\\	backslash
\'	single quote (as shown in the slide)
\"	double quote
\b	backspace character (ascii)
\n	linefeed
\r	carriage return
\t	tab

Conditional Control Structures

- Python has only one conditional control

There may be zero or more elif branches

The else is optional

```
if test:
    <one or more statements>
elif test2:
    <one or more statements>
else:
    <one or more statements>
```

Beginning and ending of blocks are determined by indentations (use 4 spaces)

```
if test:
    print('If test is true, this will execute')
    print('So will this!')
print('This will always execute!')
```

Sequences

- In Python, sequences (str, list, and tuple types) are ordered collections of objects

```
dirs = ['North', 'South', 'East', 'West']
```

- All sequences have some common features:
  - Random access and slicing

```
dirs[2]     # 'East'
dirs[-2:]   # ['East', 'West']
```

  - Concatenation (of the same type)

```
dirs + ['NW', 'NE', 'SW', 'SE']
```

  - Length (size)

```
len(dirs), len(dirs[0])
```

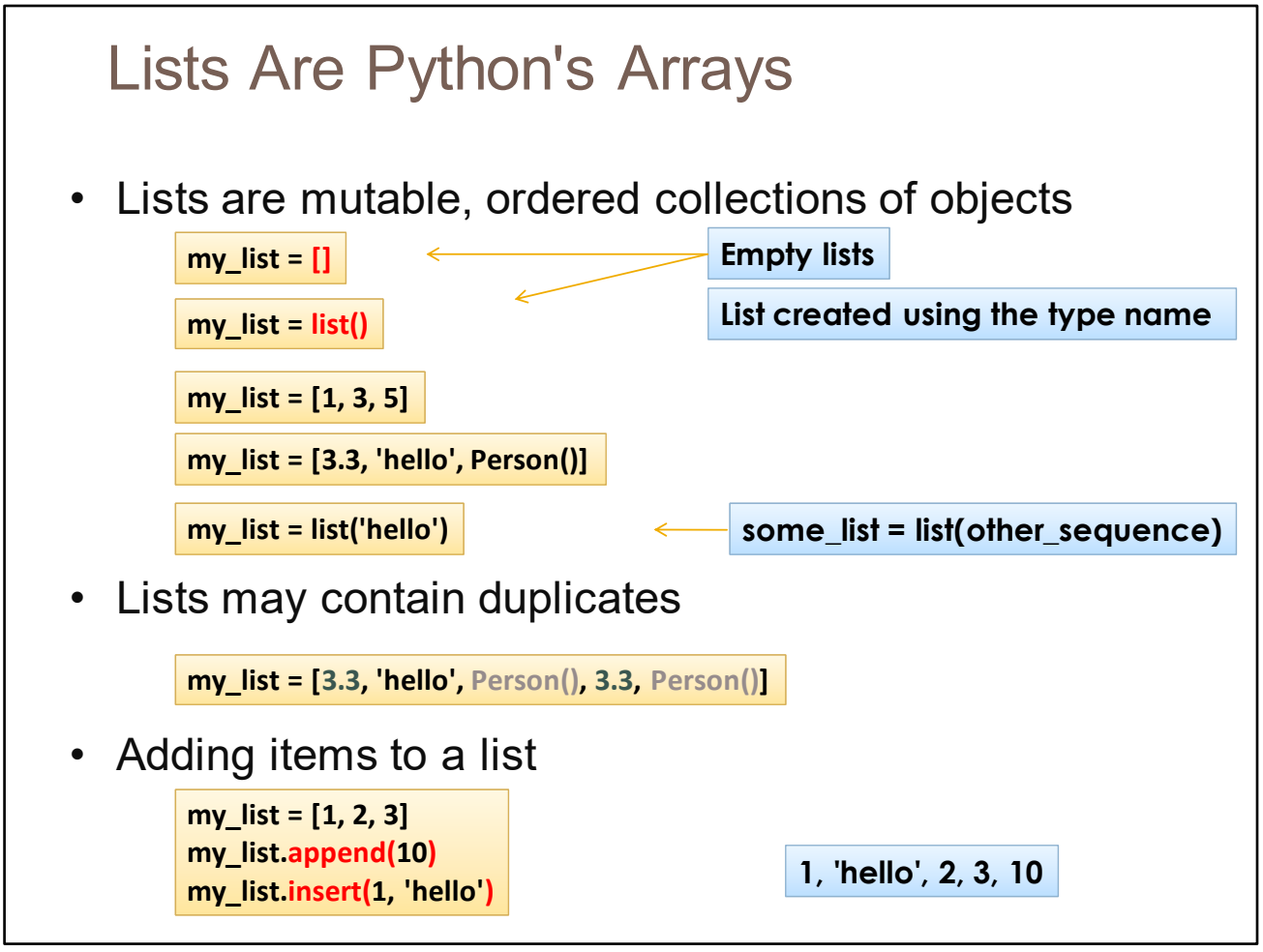
  - Membership

```
if 'East' in dirs:
    print(dirs.index('East'))
```

Sequences exhibit similar behaviors such as the ability to be randomly accessed, perform slicing, support membership checks, and have their size (length) returned through the len() function.

In addition, sequences also support a min() and max() function.
Examples of min() and max():

```
max([1973, 2001, 2015, 2013, 1994])
min([1973, 2001, 2015, 2013, 1994])
```



student_files/ch05_apdx_A/example02.py

Lists may be created using literal notation with square brackets [ ]. While literal notation is common, occasionally lists are created using the list() type name.

Use append() to add items onto the end of the list.

To add a value into the middle of a list, use insert(position, value), keeping in mind that sequences are zero-based in Python.

Tuples Are Python's Fixed Arrays

- Tuples are *immutable*, ordered collections of objects

```
my_tuple = ()
```
Empty tuple

```
my_tuple = tuple()
```
Tuple created using the type name

```
my_tuple = (1, 3, 5)
my_tuple = (3.3, 'hello', Person())
my_tuple = tuple('hello')
```
some_tuple = tuple(sequence)

```
my_tuple = (1,)
```
Tuple with one element

- Modifying a tuple causes an error, like this:

```
contact = ('John', 'Smith', ['123 Main St', 'Los Angeles', 'CA'])
contact[0] = 'Jonathan'
```

TypeError: 'tuple' object does not support item assignment

Tuples do not have append(), insert(), or other methods that attempt to modify the data as this would violate the concept of a tuple.

Iterative Control Structures

```
while test:
     <one or more statements>
```

This will execute the contents of the indented block as long as test is True

---

```
for one_item in iterable:
    <one or more statements>
```

This will take one item from the iterable at a time, process it within the indented block, and then get the next item.

- Performance note:
  - For larger iterations, the for-loop performs better than the while-loop and should usually be preferred
  - *for* executes at the C-level, *while* executes in the PVM

Note: Both the while and for loops have a second part, an else block. However, because this block is extremely rare to use, it has been left out of our discussion here.

Examples Using the *for* Loop

```
seasons = ['Spring', 'Summer', 'Fall', 'Winter']

for season in seasons:
    if season.lower().startswith('s'):
        print(f'{season} has {len(season)} characters.')
```

```
Spring has 6 characters.
Summer has 6 characters.
```

```
records = [
    ('John',  'Smith',   43, 'jsbrony@yahoo.com'),
    ('Ellen', 'James',   32, 'jamestel@google.com'),
    ('Sally', 'Edwards', 36, 'steclone@yahoo.com'),
    ('Keith', 'Cramer',  29, 'kcramer@sintech.com')
]

for record in records:
    print(f'{record[0]} {record[1]}, {record[2]} {record[3]}')
```

```
John Smith, 43 jsbrony@yahoo.com
Ellen James, 32 jamestel@google.com
Sally Edwards, 36 steclone@yahoo.com
Keith Cramer, 29 kcramer@sintech.com
```

student_files/ch05_apdx_A/example02.py

Python's for and while loops are the only iterative control structures. There is not a classic 3 part for( ) loop as in C++, Java, and other languages. Both while and for support the break and continue statements.

Iterating *(continued)*

- All of these can iterate the *records* data structure

```
for record in records:
    print('{0} {1}, {2} {3}'.format(*record))


for (first, last, age, email) in records:
    print(f'{first} {last}, {age} {email}')


for first, last, age, email in records:
    print('{first} {last}, {age} {email}'.format(first=first,
                                                 last=last,
                                                 age=age,
                                                 email=email))
```

student_files/ch05_apdx_A/example02.py

Each of these produces the same output as the one on the previous slide. The last, while a bit cumbersome, can be useful when the string is a variable that's already defined elsewhere and can't be changed.

Primer on Dictionaries

- Dictionaries are collections of name/value pairs
  - They are unordered, mutable, iterable
  - Support len() function and in operator
  - Keys are hashable (immutable), values can be any type

```
d = { key1: value1, key2: value2, ... }
```

```
my_dict = {}
my_dict = dict()
my_dict = { 'pet1': 'dog', 'pet2': 'fish' }
my_dict = dict(pet1='dog', pet2='fish')

my_dict['pet3'] = 'cat'
print(my_dict['pet2'])
```

empty dicts

No quotes on keys here

adding / changing values

accessing values

Dictionaries are useful data structures as they provide a means to store any kind of data yet access that data via a key. Because dictionary keys must be unique, attempting to add an entry to a dictionary that has the same key in existence will replace the value with the new value.

Dictionaries became ordered in Python 3.6.

Accessing Dictionaries

```
d1 = {'Smith': 43, 'James': 32, 'Edwards': 36, 'Cramer': 29}
```

- Direct access can generate a KeyError

```
d1['Smith']          # returns 43
d1['Green']          # generates a KeyError
```

- Use exception handling to deal with a KeyError

```
try:
    value = d1['Green']     # generates a KeyError
except KeyError:
    value = 0
```

- dict.get(key) to retrieve values also:

```
d1.get('Edwards')          # returns 36
d1.get('Green')            # returns None
```

- dict.get(key, default) is safest

```
d1.get('Cramer', 0)        # returns 29
d1.get('Green', 0)         # returns 0
```

student_files/ch05_apdx_A/example03.py

Accessing a dictionary in a for loop will return the keys. It is the same effect as d1.keys(), which is arguably more understandable but also more verbose.

Iterating Dictionaries

```
d1 = {'Smith': 43, 'James': 32, 'Edwards': 36, 'Cramer': 29}
```

- Iterating a dictionary directly returns keys:

```
for item in d1:
    print (item)
```

```
Smith
James
Edwards
Cramer
```

- Iterating a dictionary's values:

```
for val in d1.values():
    print(val)
```

```
43
32
36
29
```

- Accessing both key and value simultaneously:

```
for key, val in d1.items():
    print(f'Key: {key}, Value: {val}')
```

returns a (view of) list of tuples

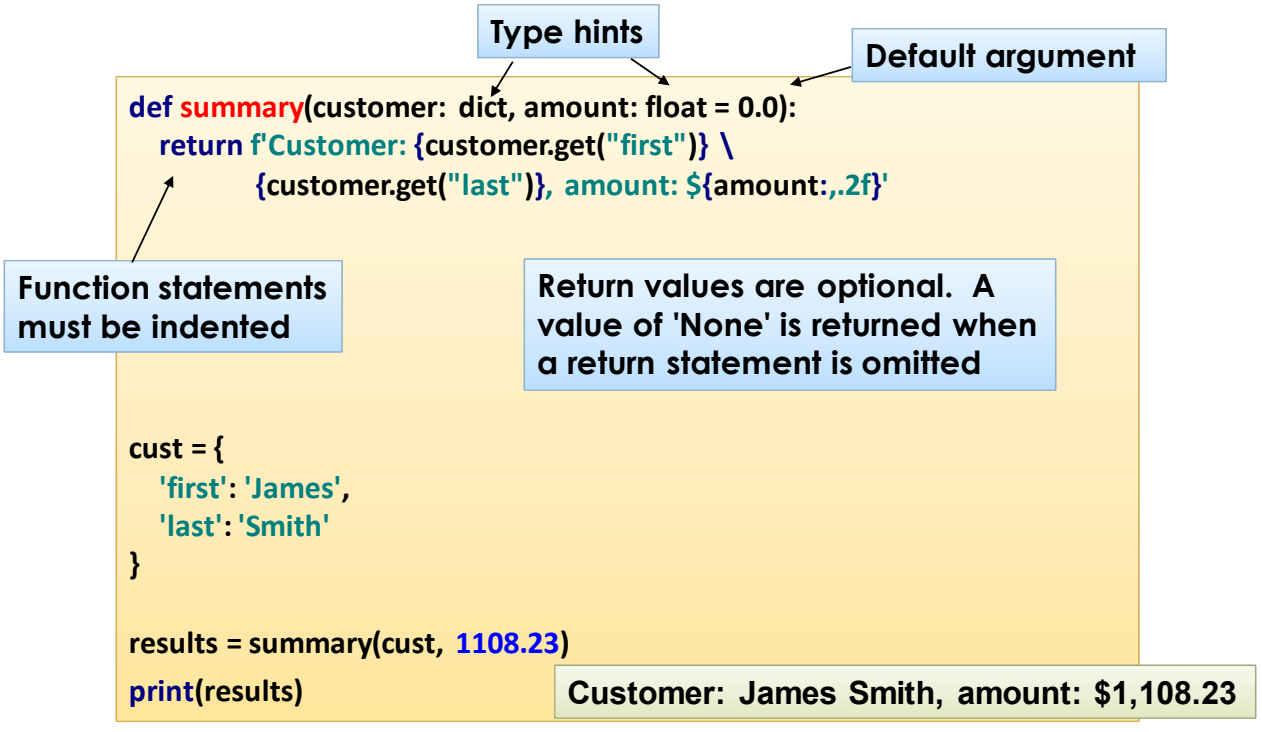
student_files/ch05_apdx_A/example03.py

The above example indicates how a dictionary is used within a `for` control. It always returns the keys.

The items() method returns a "view" object instead of a copy of a list of tuples.

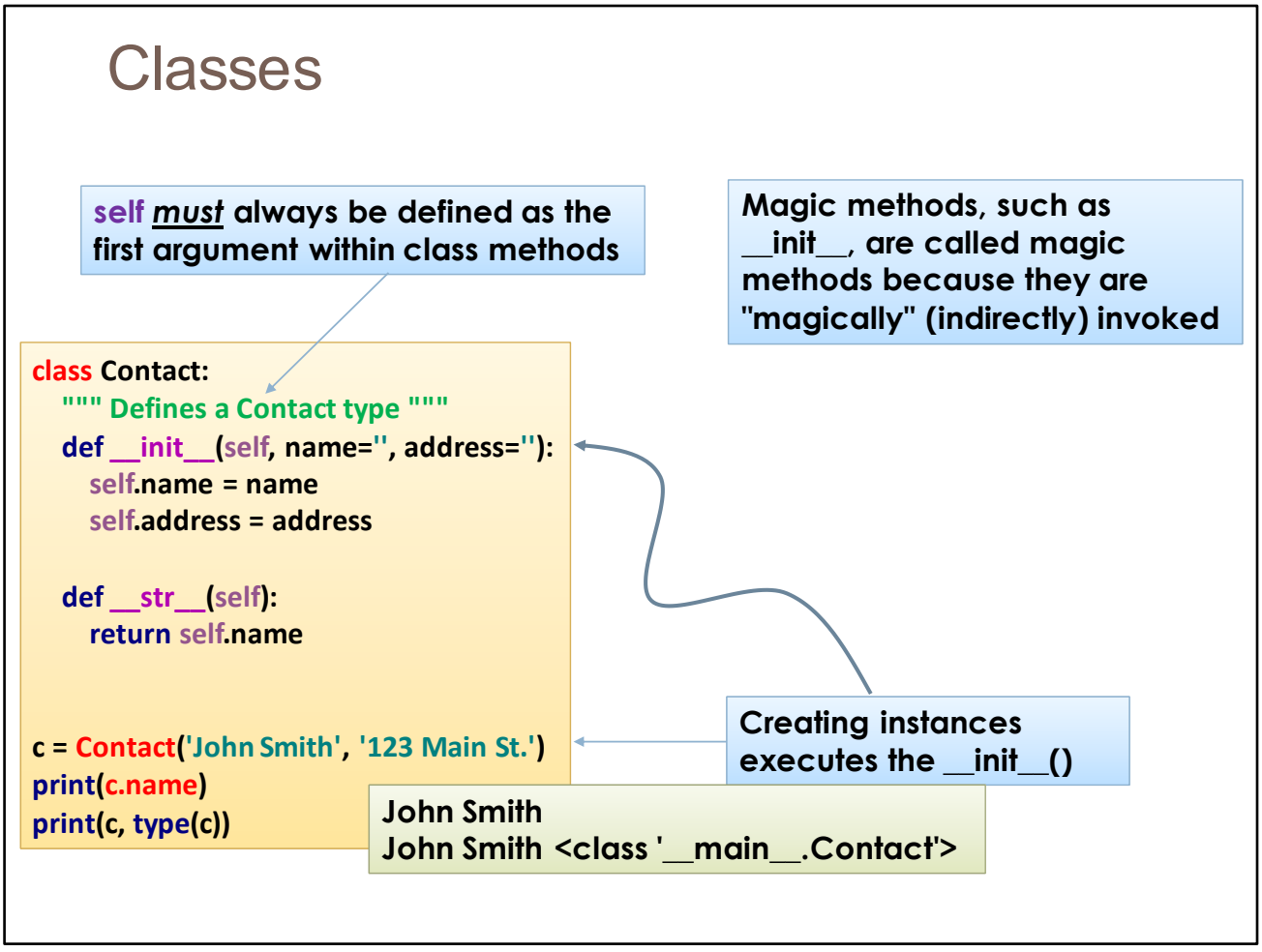
Defining and Calling Functions

- Functions must be defined before they can be called



student_files/ch05_apdx_A/example04.py

Functions must be declared (or imported) before they can be called. Parameters passed into the function must also match what is declared in the function.

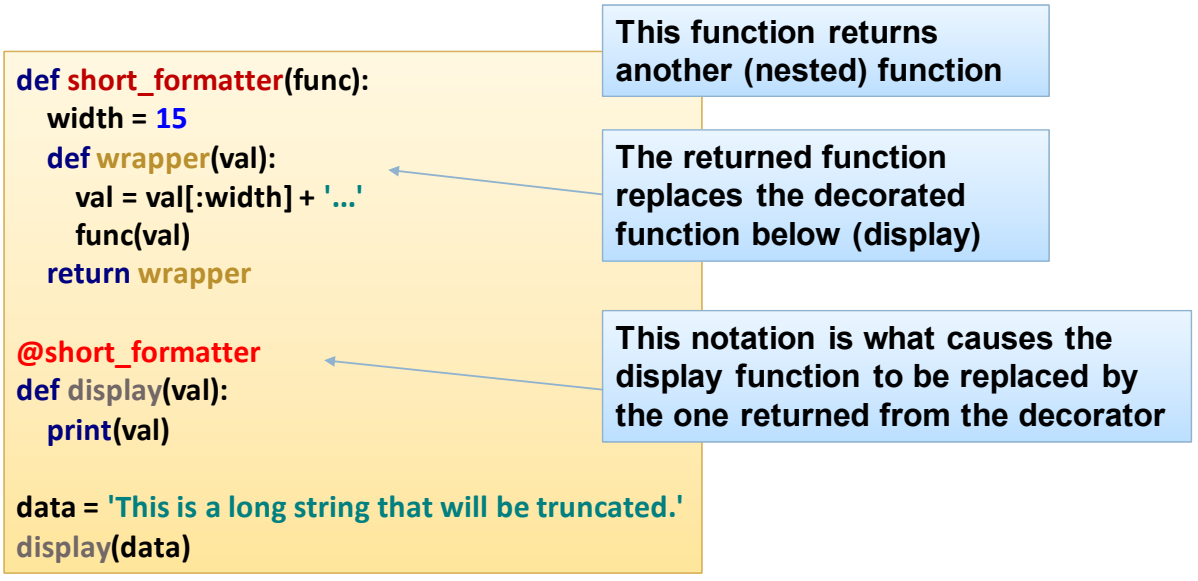


student_files/ch05_apdx_A/example05.py

When an instance (object) is created the constructor is called. In Python, the constructor is always called. Its purpose is to initialize variables and/or code.

The __init__() (constructor essentially) must always define a variable called **self**. Self represents the current object being constructed. In this example, the object called 'c' is being created. In the constructor, the 'c' object is what self is referring to. While theoretically self can be renamed to something else, in Python we ***never*** do this.

Decorators *(in brief)*

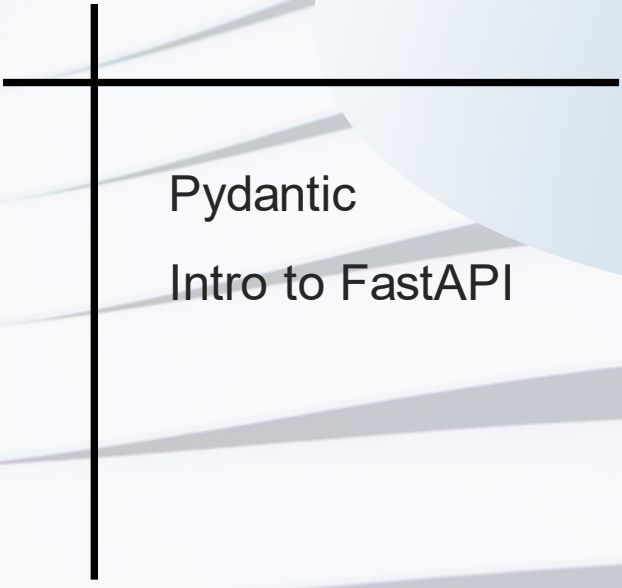



```
def short_formatter(func):
    width = 15
    def wrapper(val):
        val = val[:width] + '...'
        func(val)
    return wrapper

@short_formatter
def display(val):
    print(val)

data = 'This is a long string that will be truncated.'
display(data)
```

student_files/ch05_apdx_A/example06.py

In the example above, the original function (display) is passed into another function called short_formatter(). Short_formatter() returns a nested function called wrapper(). The returned wrapper function replaces the originally passed function (display). Now, any calls to display() are actually calls to wrapper(). Decorators give the library/framework builder control over your code.

Appendix Overview



Pydantic

Intro to FastAPI

What is Pydantic?

- Pydantic is a third-party *validation framework*
  - Capable of performing runtime validation
  - Relies upon Python's type hint system

```
from pydantic import BaseModel

class Celebrity(BaseModel):
    name: str = None
    salary: float = 0.0
    year: int = None
    type: str = None
```

Models should inherit from Pydantic's BaseModel

- Numerous frameworks in Python rely upon Pydantic for validation services: mypy, Transformers, FastAPI!

ch06_fastapi/01_pydantic.py

Pydantic has become a popular framework for use in everything from code quality analysis tools such as mypy to API servers such as FastAPI to natural language processing frameworks such as Transformers.

It uses Python annotations to detect desired types. By default, it will only validate when objects are instantiated.

Pydantic Validations

- Pydantic will validate objects upon instantiation

```
class Celebrity(BaseModel):
    name: str = None
    salary: float = 0.0
    year: int = None
    type: str = None
```

Pydantic models must use keyword arguments to instantiate objects

```
c = Celebrity(name='Oprah Winfrey', salary=225.0,
              year=2005, type='Personalities')
print(f'Celebrity: {c}')
```

```
Celebrity: name='Oprah Winfrey' salary=225.0 year=2005 type='Personalities'
```

ch06_fastapi/01_pydantic.py

The following demonstrates how to instantiate objects that come from BaseModel.

More with Instantiating Objects Using Pydantic

- Several other ways to instantiate using Pydantic

```
data = {
    'name': 'Oprah Winfrey',
    'salary': 225.0,
    'year': 2005,
    'type': 'Personalities'
}
c = Celebrity(**data)
print(f'Celebrity: {c}')


c = Celebrity(name='Oprah Winfrey', salary='225.0',
              year='2005', type='Personalities')
print(f'Celebrity: {c}')
```

A dictionary can be expanded into the initializer

The string value is coerced into an int by Pydantic automatically

ch06_fastapi/01_pydantic.py

A dictionary can be used to expand items into a Pydantic model.

The year in the second example is a string. The class defines the year as an int. But Pydantic is able to coerce the value into an int without an error.

Errors on Validation

- When a validation error occurs, Pydantic raises a ValidationError

```
c = Celebrity(name='Oprah Winfrey', salary='225.0',
              year='some_year', type='Personalities')
```

```
Traceback (most recent call last):
  File "01_pydantic.py", line 34, in <module>
    c = Celebrity(name='Oprah Winfrey', salary='225.0', year='some year',
type='Personalities')
File "main.py", line 176, in __init__
    self.__pydantic_validator__.validate_python(data, self_instance=self)
pydantic_core._pydantic_core.ValidationError: 1 validation error for Celebrity
year
  Input should be a valid integer, unable to parse string as an integer
[type=int_parsing, input_value='some year', input_type=str]
    For further information visit https://errors.pydantic.dev/2.7/v/int_parsing
```

ch06_fastapi/01_pydantic.py

A ValidationError is raised if a value cannot be properly validated or coerced.

Getting FastAPI Up and Running

- FastAPI looks very similar to Flask

```
import uvicorn
from fastapi import FastAPI
from pydantic import BaseModel


app = FastAPI()


@app.get('/api/celebrities/{name}',
                            response_model=list[Celebrity])
def get_celebs(name: str):
    matches = [celeb for celeb in celebs if name.lower()
                                        in celeb.name.lower()]
    return matches


uvicorn.run(app, host='127.0.0.1', port=8000)
```

ch06_fastapi/02_fastapi_celeb.py

FastAPI looks similar to how Flask is started. It also uses a decorator above the methods. The response_model defines what types of objects will be returned.

FastAPI and Pydantic with Celebrity

```
class Celebrity(BaseModel):
    celeb_id: int = None
    name: str = None
    salary: float = 0.0
    year: int = None
    type: str = None


@app.put('/api/celebrities/{celeb_id}')
def modify_celeb(celeb_id: int, celeb: Celebrity):
    celeb.celeb_id = celeb_id
    matches = [c for c in celebs if c.celeb_id == celeb.celeb_id]

    if not matches:
        raise HTTPException(404, detail='No matching items.')

    index = celebs.index(matches[0])
    celebs[index] = celeb
    return celebs[index]
```

ch06_fastapi/03_fastapi_full.py

FastAPI "injects," not only the path parameters sent by the client, but also the object embedded in the body of the request.

This can be tested with an autogenerated client at http://localhost:8000/docs.

Introduction to API Development Using Python

Exercise Workbook

Task 1-1
Setting Up Your Environment

Overview

This task establishes your development environment by setting up a virtual environment, and IDE, and the Python interpreter.

Determine Your Python Command

Every Python environment is just a little different from the next. To perform this task, you need to know which Python is the correct one to use for this course. Open a command window (Windows) or a terminal (Linux/OS X). Find the correct version of Python you intend to use by typing in the following commands:

```
python -V

python3 -V

python3.12 -V
```

(repeat this using 3.11, 3.10, or 3.9 as needed)

One of these commands should work for you. If not, you will need to check your PATH environment variable and double-check the location that Python was installed.

Remember what works for you as it will be used throughout the course!

In this course, replace any Python command-line references (e.g., python, python3, etc.) with the version you just determined works for you!

Create and Activate a Virtual Environment

In this step, we will create a virtual environment to work within. This way, anything we install will only go into the virtual environment and won't affect any of your current Python environments.

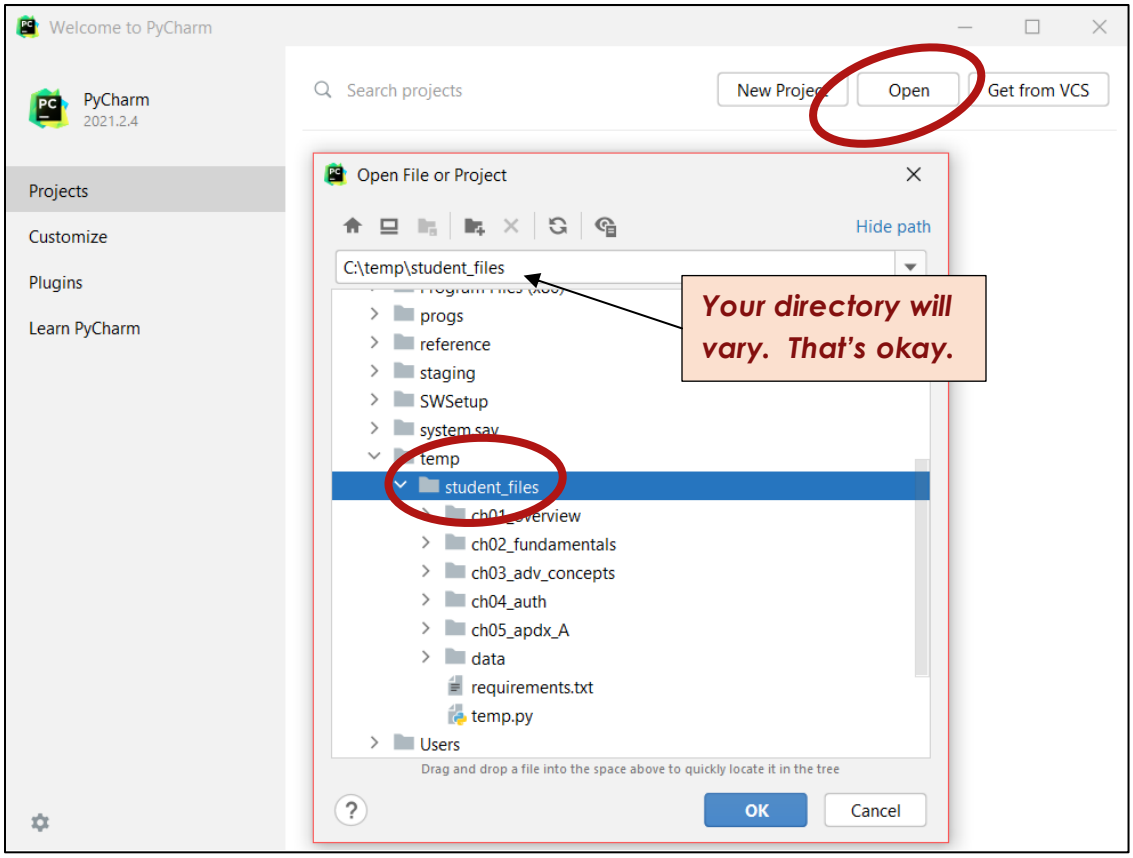
There are two ways to create the virtual environment:

1. Via PyCharm (easier, and our preferred way)
2. Manually from the command line

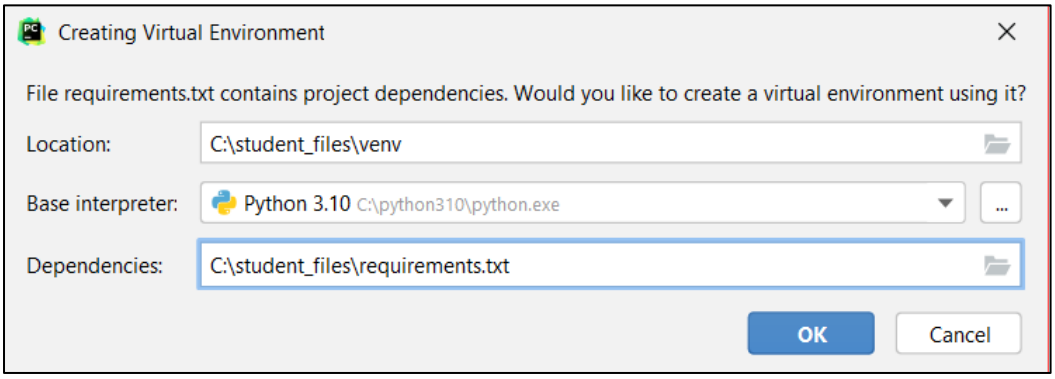
If technique #1 from above doesn't work, skip down to the star shown below and perform a manual creation of the virtual environment.

Creating the Virtual Environment using PyCharm

Launch PyCharm. In the Welcome dialog, select "Open" and browse to your student_files directory (which should be extracted from the provided zip file already).



PyCharm should offer to create a virtual environment for you *AND* should offer to run the file called ***requirements.txt***. Use the defaults that are provided and **click Ok**--*you don't need to match the paths shown below*.



That should be it for this step.

Note: If PyCharm doesn't ask to create a virtual environment for you automatically, double-click the *requirements.txt* file within your student_files folder and choose the option to install dependencies mentioned in the yellow bar that should appear at the top of the editor. If no yellow bar appears, you may have to manually run the requirements.txt file from a Terminal within PyCharm. Ask the instructor for help on how to do this.

Alternatively, Create the Virtual Environment Manually

If PyCharm isn't used to create the virtual environment for you, or PyCharm failed to do this properly, follow this next section instead.

In the same terminal window from step 1, create a directory for your virtual environment. You can create this directory anywhere. A nice possible location for this virtual environment is in a *virtualenv* directory in your home. If you don't have a location to place virtual environments on your system, type the following:

On Windows: **`cd /D %userprofile%`**

On Linux/OS X: **`cd ~`**

Create a directory here called **`virtualenvs`** by typing:

```
mkdir virtualenvs
```

Change into this new directory.

```
cd virtualenvs
```

Now create the Python virtual environment and activate it by typing:

python -m venv api_env

On Windows: **cd api_env\Scripts**
.\activate (or just **activate**)

On Linux/OS X: **cd api_env/bin**
source ./activate

Verify that you have activated the python environment by typing:

On Windows: **where python**

On Linux/OS X: **which python**

Check that the response shows your new virtual Python interpreter listed first.

We are about to install any needed dependencies for the course. Before doing that, you will need to ensure that the student files have been placed on your machine (already extracted from the provided zip file). Take note of the location of your student files. We'll refer to this location as your <student_files_home>.

cd <student_files_home> (this should be your location of the student files)

Install the dependencies:

(from the student_files directory)

pip install -r requirements.txt

Below is a sample screenshot (with slightly different directories used) of what to expect when running this command:

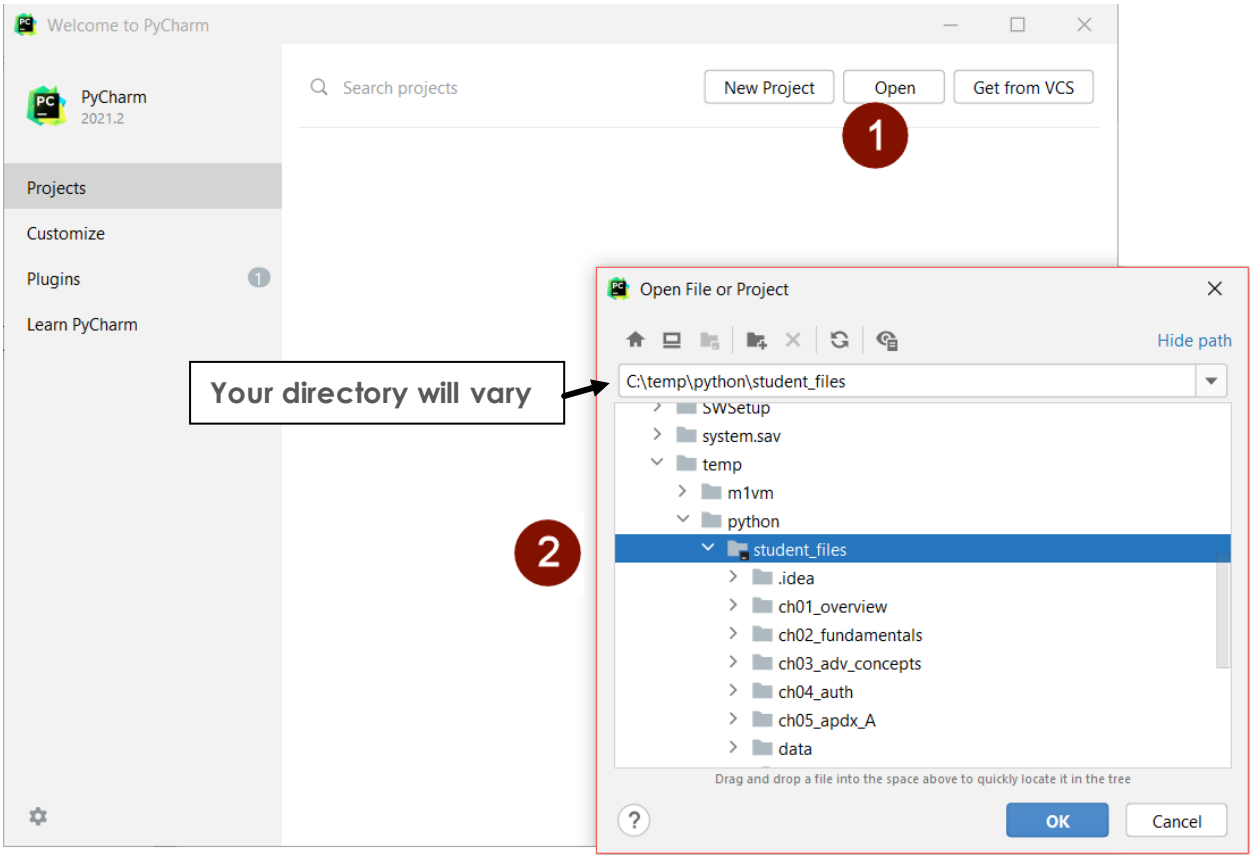
```
(api_env) >pip -V
pip 21.2.4 from c:\virtualenvs\api_env\lib\site-packages\pip (python 3.10)

(api_env) c:\student_files>pip install -r requirements.txt
Collecting Flask==2.0.2
  Using cached Flask-2.0.2-py3-none-any.whl (95 kB)
Collecting SQLAlchemy==1.4.29
  Using cached SQLAlchemy-1.4.29-cp310-cp310-win_amd64.whl (1.5 MB)
Collecting requests==2.27.1
  Using cached requests-2.27.1-py2.py3-none-any.whl (63 kB)
Collecting flask-restx==0.5.1
  Using cached flask_restx-0.5.1-py2.py3-none-any.whl (5.3 MB)
Collecting Flask-sqlalchemy==2.5.1
  Using cached Flask_SQLAlchemy-2.5.1-py2.py3-none-any.whl (17 kB)
Collecting flask-marshmallow==0.14.0
  Using cached flask_marshmallow-0.14.0-py2.py3-none-any.whl (10 kB)
Collecting marshmallow-sqlalchemy==0.27.0
  Using cached marshmallow_sqlalchemy-0.27.0-py2.py3-none-any.whl (15 kB)
Collecting beautifulsoup4==4.10.0
  Using cached beautifulsoup4-4.10.0-py3-none-any.whl (97 kB)
Collecting prettytable
  Using cached prettytable-3.2.0-py3-none-any.whl (26 kB)
Collecting click>=7.1.2
  Downloading click-8.0.4-py3-none-any.whl (97 kB)
     |                                | 97 kB 420 kB/s
Collecting itsdangerous>=2.0
  Downloading itsdangerous-2.1.2-py3-none-any.whl (15 kB)
```

Setup the IDE

Note: This step may be skipped entirely if PyCharm automatically installed the packages for you when you launched the IDE in step 2.

After the packages finish installing (should be relatively quick), **launch PyCharm** if you haven't already.

In the Welcome screen, locate the student_files directory, select this directory and then click **Open**. In some cases, the project may open directly skipping this step. That is okay.

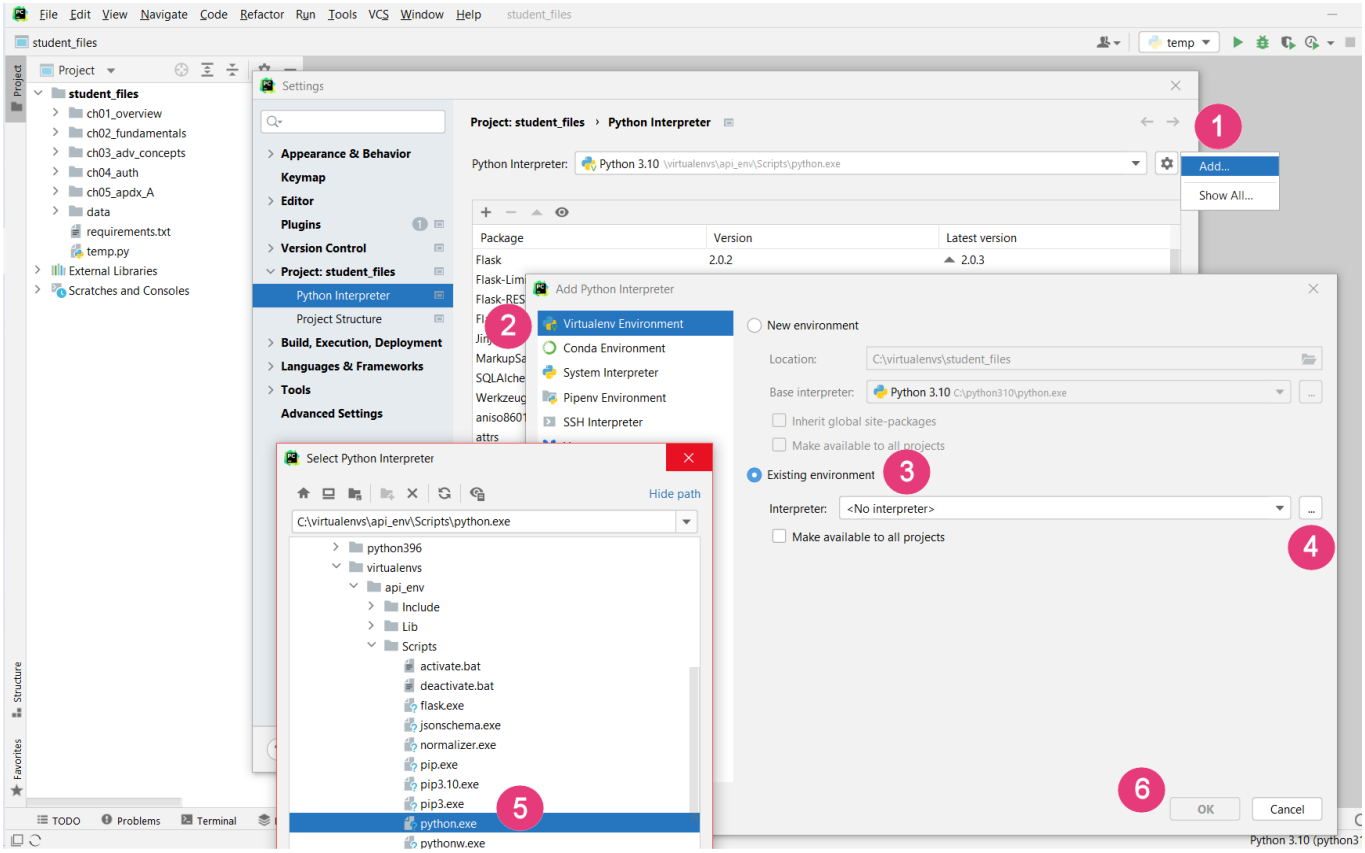


Proceed to the settings to establish which interpreter to use.

OS X: **`PyCharm > Preferences`**

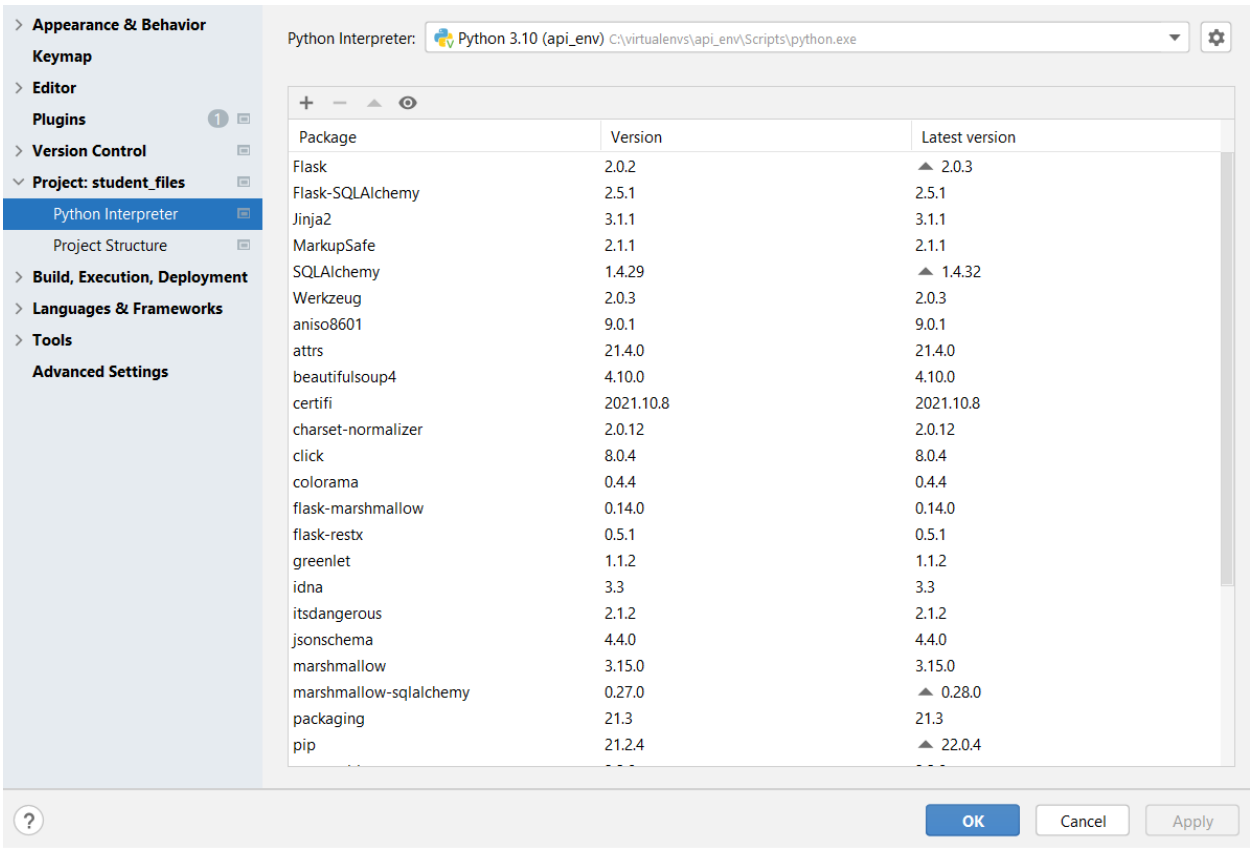
Windows: **`File > Settings`**

Expand the **`Project: student_files`** item. Select **`Project Interpreter`**. On the right side, we'll have to point PyCharm to the newly created virtual environment. Do this as shown below:



1- Select the setting (cog wheel) symbol
2- Leave selected "Virtualenv Environment" option
3- Select "Existing Environment" button
4- Select the ... button (far to the right)
5- Browse to the new Interpreter location (*python.exe* on Windows, *python* or *python3.x* on OS X)
6- Click OK twice.

You should see numerous packages listed here now (See next screen shot)



Test out the new environment by running the file in ch01_overview called **task1_1_starter.py**. To run it, right-click in the source code and select **Run task1_1_starter**.

That's it! If it runs, you're done!

Task 1-3
Creating a Client Using Requests

Overview

This simple task will utilize the Python requests module to make a request and view the results of the URLs encountered in Task1-2.

Work from the provided starter file, task1_3_starter.py, found in the ch01_overview directory.

Create a for-loop. Retrieve the Data.

Create a for-loop to iterate over the URLs. Make a request to the specific URL using the requests module.

```
for url in urls:
    r = requests.get(url)
```

Display the Responses

Display the results from the request using

```
for url in urls:
    r = requests.get(url)

    print(r.url)
    print('-'*len(r.url))
    print(r.text)
```

That's it! Test it out!

Task 2-1
An Initial API

Overview

This task begins the development of our invoicing API. For this first version, you will create the code to initialize the Flask server and set up our first route. Begin by opening the task2_1_starter.py file within ch02_fundamentals.

Create the Flask Server

At the location of step 1 in the source file, instantiate the Flask object passing the name of our module into it.

```
app = Flask(__name__)
```

Define a Route

Define a single route for now. It will only handle "GET" HTTP requests. It will map to: ***/api/invoices/<invoice_num>***. Place this route above the retrieve_invoice() function.

```
@app.route('/api/invoices/<invoice_num>', methods=['GET'])
def retrieve_invoice(invoice_num):
```

Retrieve a Matching Invoice Number

Within the retrieve_invoice() function, write a list comprehension that builds a list (called results) by iterating through the list of invoices (called data) and checking for any invoice numbers (invoice_num) that match the invoice id (row[0]).

```
results = [row[1:] for row in data if invoice_num == row[0]]
```

JSONify a Response

Pass the results back in a jsonify call along with the invoice number. Use **results=** and **invoice=** as the keys in the jsonify() call.

```
resp = jsonify(results=results, invoice=invoice_num)
```

That's it! Test it out within your browser for now by starting the server and navigating your browser to: **`http://localhost:8051/api/invoices/536365`**.

Task 2-2
An API Client

Overview

This task will allow us to interact with our invoice API via a Python-based client. We'll work from the provided task2_2_starter.py file.

Prompt the User for an Invoice Number

Use a simple prompt to ask the user to supply an invoice number. There are many ways to retrieve an input from the user. Below represents only one possible way. Feel free to create your own, otherwise, use the technique shown below:

```
default = '536365'
invoice_num = input('Enter invoice number (def. 536365): ')
if not invoice_num:
    invoice_num = default
```

Construct the URL to Access Our Flask Server

We need to combine the provided base_url, path, and user's input to create the URL. A Python f-string can do this.

```
default = '536365'
invoice_num = input('Enter invoice number (def. 536365): ')
if not invoice_num:
    invoice_num = default

url = f'{base_url}{path}{invoice_num}'
```

Make a Request and Convert the Response

Time to make an HTTP GET request using the requests module and the URL created in step 2. Convert the returned response to JSON using the .json() method:

```
default = '536365'
invoice_num = input('Enter invoice number (def. 536365): ')
if not invoice_num:
    invoice_num = default

url = f'{base_url}{path}{invoice_num}'


results = requests.get(url).json()
```

Display the Retrieved Results

Use json.dumps() to take the returned dictionary and output it as a string.

```
default = '536365'
invoice_num = input('Enter invoice number (def. 536365): ')
if not invoice_num:
    invoice_num = default

url = f'{base_url}{path}{invoice_num}'

results = requests.get(url).json()
print(json.dumps(results, indent=4))
```

That's it! Test it out by:

1. Making sure you are running the task2_1_starter.py server.
2. Running the task2_2_starter.py file after the server is already running.

Task 2-3
Using Flask-RESTX

Overview

This task will implement the Flask-RESTX plugin (that should already be installed from Task1-2). You will create two classes: Invoice and Invoices. You will implement several RESTful methods within them. You will run the server and finally test out your solution using the provided task2_3_client.py file.

Import Needed Items

Add the imports needed to work with the Flask-RESTX plugin. These are **Resource** and **API**.

```
from flask import Flask, jsonify, Response
from flask_restx import Resource, Api
```

Create the Primary Flask-RESTX Object

Create the Api() object. You can also specify a prefix that will be expected within all URLs. We'll use "/api" for the prefix:

```
from flask import Flask
from flask_restx import Resource, Api

app = Flask(__name__)
api = Api(app, prefix='/api')
```

Create Invoice and Invoices

Create the two classes with pass statements for now. The two classes are Invoice and Invoices. They should each inherit from Flask-RESTX's Resource class.

```
data_file = '../../data/customer_purchases.csv'
data = [line.strip().split(',') for line in
        Path(data_file).open(encoding='unicode_escape')][1:]
print('Customer purchase data read.')
```

```
class Invoices(Resource):
    pass
```

```
class Invoice(Resource):
    pass
```

Register the Classes with Flask-RESTX

After the class definitions, add two lines to register our classes with Flask-RESTX. This way we won't have to do it with a decorator.

```
class Invoice(Resource):
    pass

api.add_resource(Invoice, '/invoices/<invoice_num>')
api.add_resource(Invoices, '/invoices/')
```

Refactor the retrieve_invoice() Method

Create a get() method in the Invoice class. Code created in Task 2-1 in the retrieve_invoice() method can be moved into the Invoice class get() method. *Be careful not to put it in the Invoices class get() method.* The jsonify() and Response lines of code do not need to transfer. Remove the decorator. Remove the retrieve_invoice() method once the get() is complete

```
class Invoice(Resource):
    def get(self, invoice_num):
        results = [row[1:] for row in data
                                            if invoice_num == row[0]]
```

Create get() and post() within Invoices

Create get() and post() methods within Invoices. For now, remove the pass statement from the class and add pass into each of the two new methods.

```
class Invoices(Resource):
    def get(self):
        pass

    def post(self):
        pass
```

Create put() and delete() within Invoice

In the Invoice class, add a put() and delete() method that each take an invoice_num parameter after self. Have each return pass for now.

```
class Invoice(Resource):
    def get(self, invoice_num):
        results = [row[1:] for row in data
                                        if invoice_num == row[0]]

    def put(self, invoice_num):
        pass

    def delete(self, invoice_num):
        pass
```

Return Temporary Sample Responses

In the post(), put(), and delete() methods, remove the pass statements, have these methods return temporary objects as shown. In the Invoices get(), have it return the first 99 invoices. Have the Invoice get() method return the *results* data.

```
class Invoices(Resource):
    def get(self):
        return {'results100': data[1:100]}

    def post(self):
        return {'action': 'post'}
```

```
class Invoice(Resource):
    def get(self, invoice_num):
        results = [row[1:] for row in data if invoice_num ==
row[0]]
        return {'results': results}

    def put(self, invoice_num):
        return {'action': 'put'}

    def delete(self, invoice_num):
        return {'action': 'delete'}
```

That's it! Test it out by:

1. Ensuring no other servers are running. Be sure to stop them.
2. Starting the task2_3_starter.py server.
3. Using the provided client (task2_3_client.py) to access the server.

Task 2-4
Using Postman (Optional)

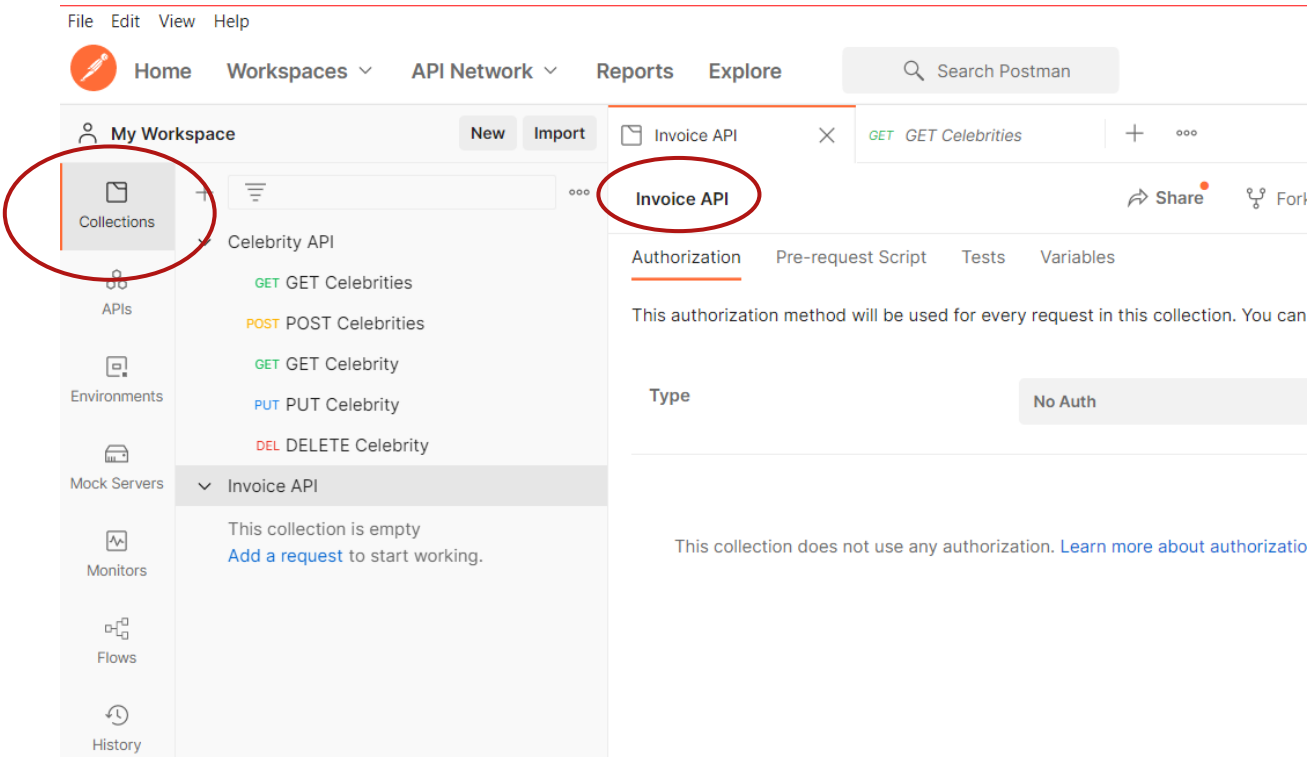
Overview

This task will use (or demonstrate the use of) Postman. If you don't have Postman installed on your working machine, this is okay. The exercise provides screen shots to demonstrate its capabilities.

You will need Postman desktop for this task as it is required for localhost testing. Open Postman desktop app if you have it.

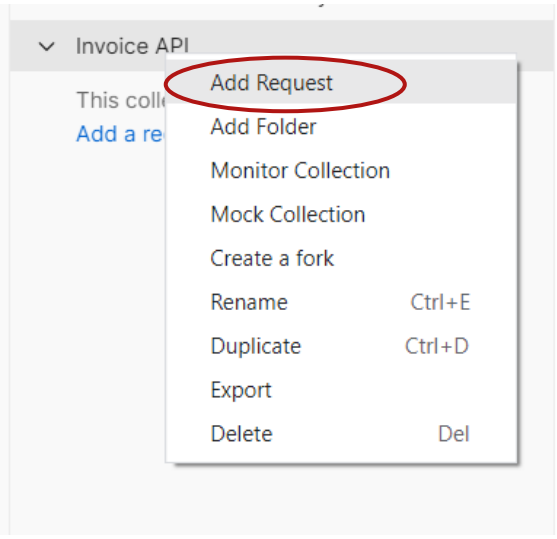
Create the Invoice Collection

Open the Postman desktop app. In the ***My Workspace*** section on the left, select ***Collections***. Then, in the field to the right, define the name ***Invoice API***. (See the screen shot).

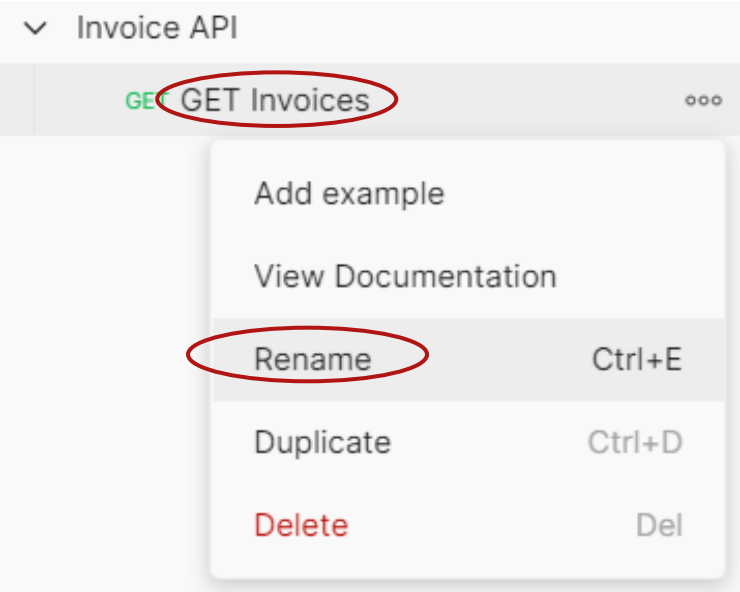


2 Add the Five Requests

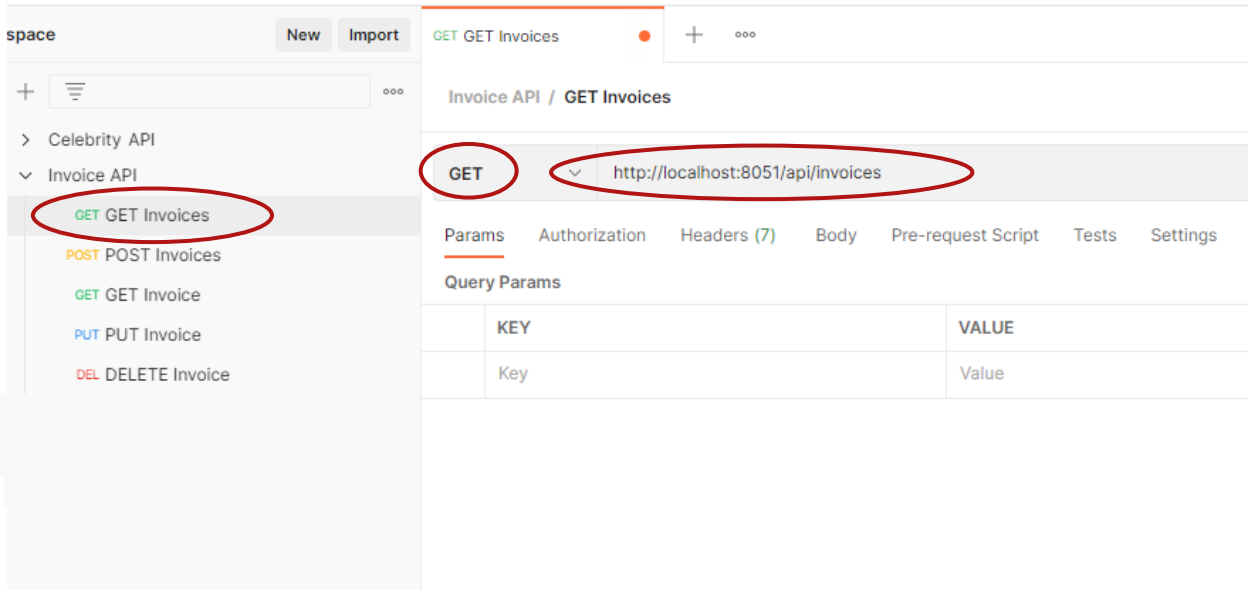
Next, add a request to the collection as shown below.



Give the request a new name.



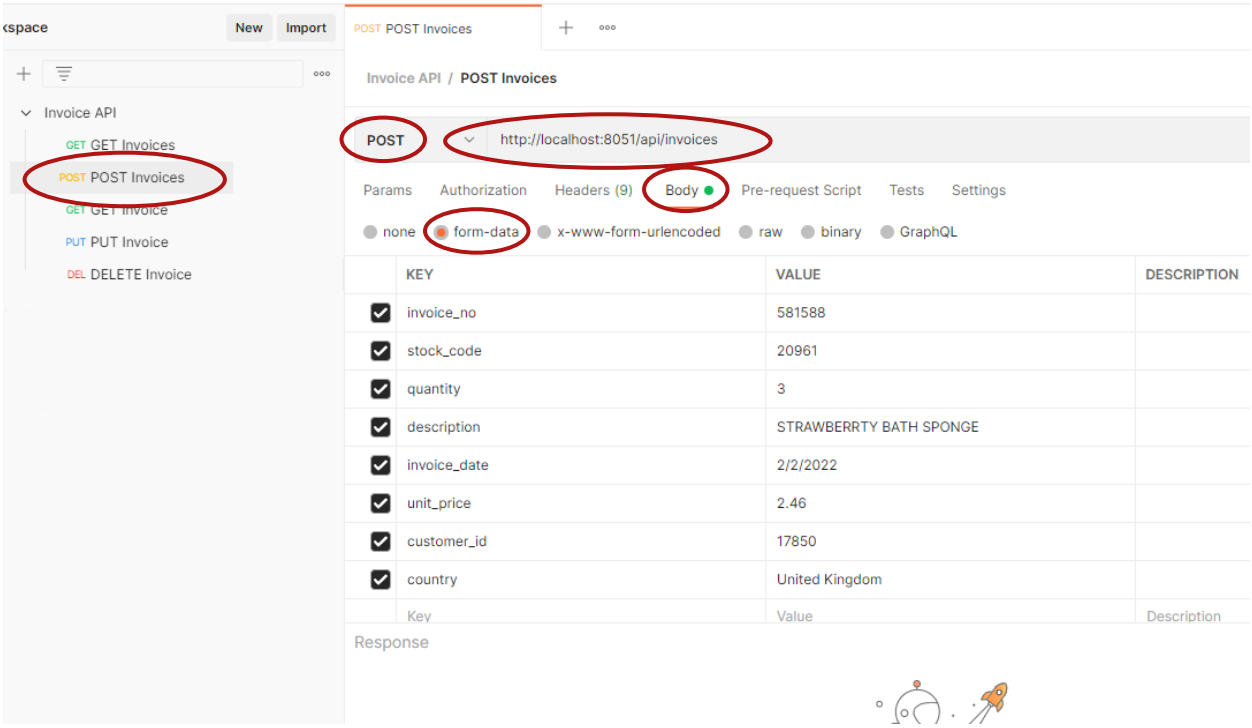
Supply the URL of **`http://localhost:8051/api/invoices`**.
Select the HTTP method type as shown.



Save the tab (request) using CTRL-S.

Do this again this time for the **POST** request next:

1. Create a new request.
2. Rename it.
3. Use the same URL from the previous step.
4. Be sure to select POST type.
5. Save the tab (request) using CTRL-S.

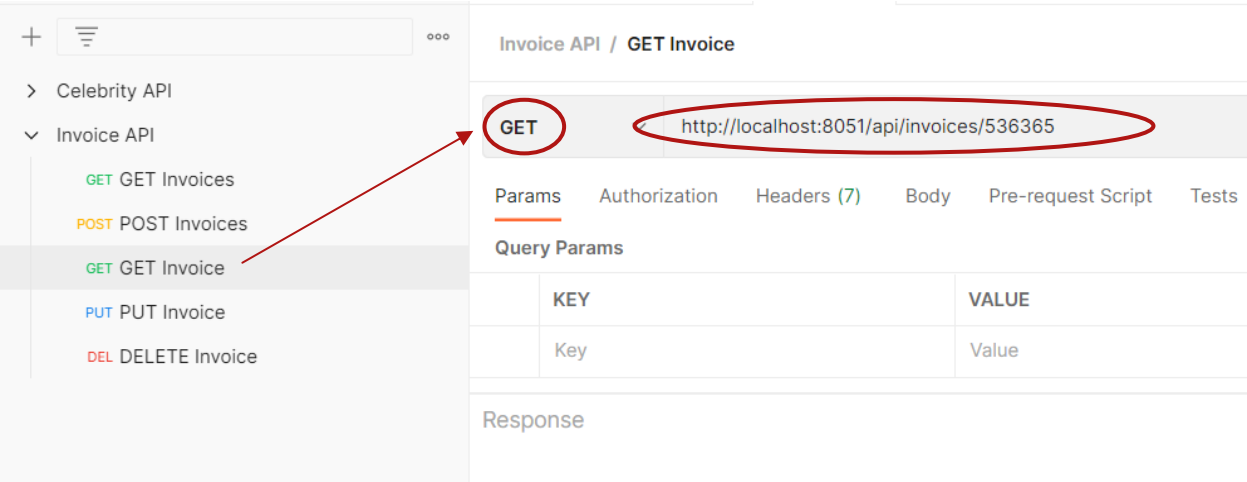


Add parameters by selecting the Body tab and then the form-data radio button as shown above. Add in values: **invoice_no**: 581588, **stock_code**: 20961, **quantity**: 3, **description**: STRAWBERRY BATH SPONGE, **invoice_date**: 2/2/2022, **unit_price**: 2.46, **customer_id**: 17850, **country**: United Kingdom.

Save the request again.

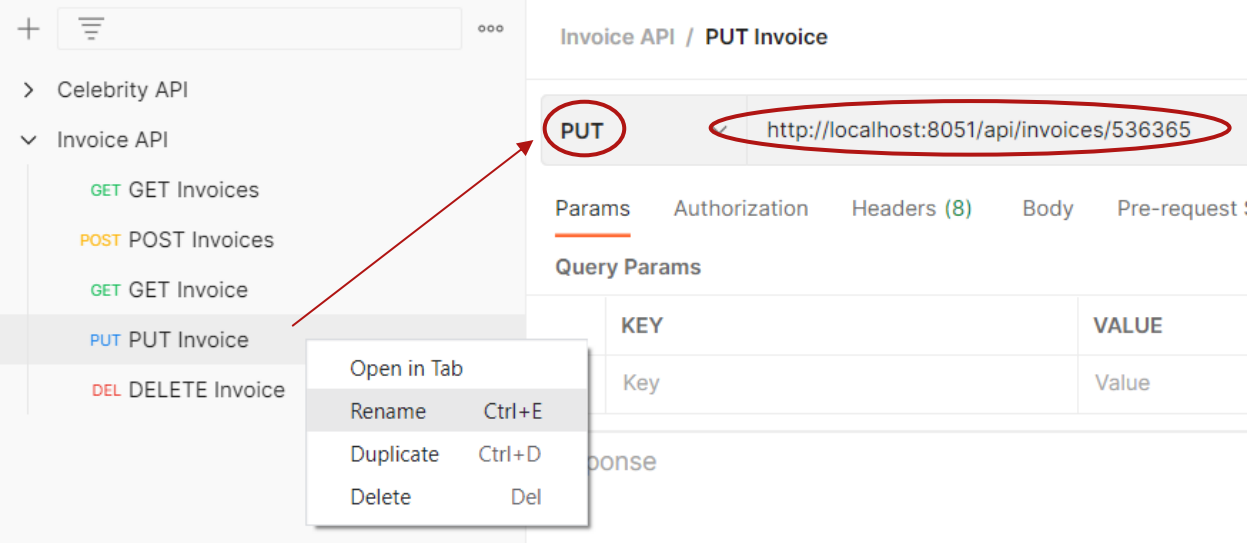
Now for the GET (singular) request:

1. Create a new request.
2. Rename it.
3. Select a specific invoice to test (see screen shot). We used **536365**.



Be sure to save the tab (request) with CTRL-S.

Implement the PUT and DELETE requests (as shown below) using the same technique as the GET (singular) shown above. Don't forget to save the new requests each time. For the PUT request, add the form parameters into the Body > Form Data section as we did for the PUT request.

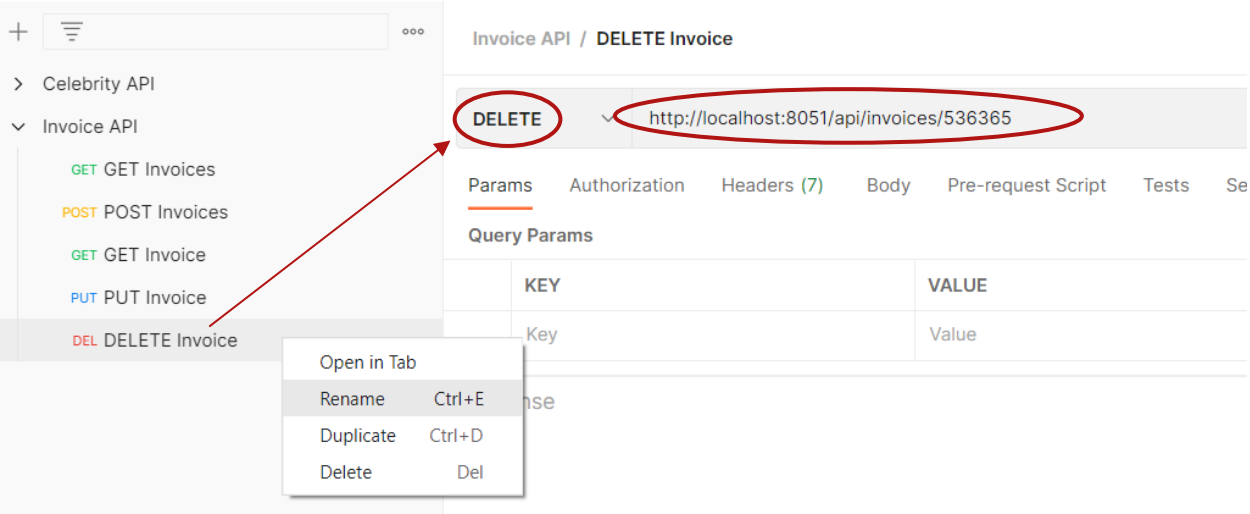


Again, for the PUT, add Body parameters as we did for the POST request (not pictured this time).

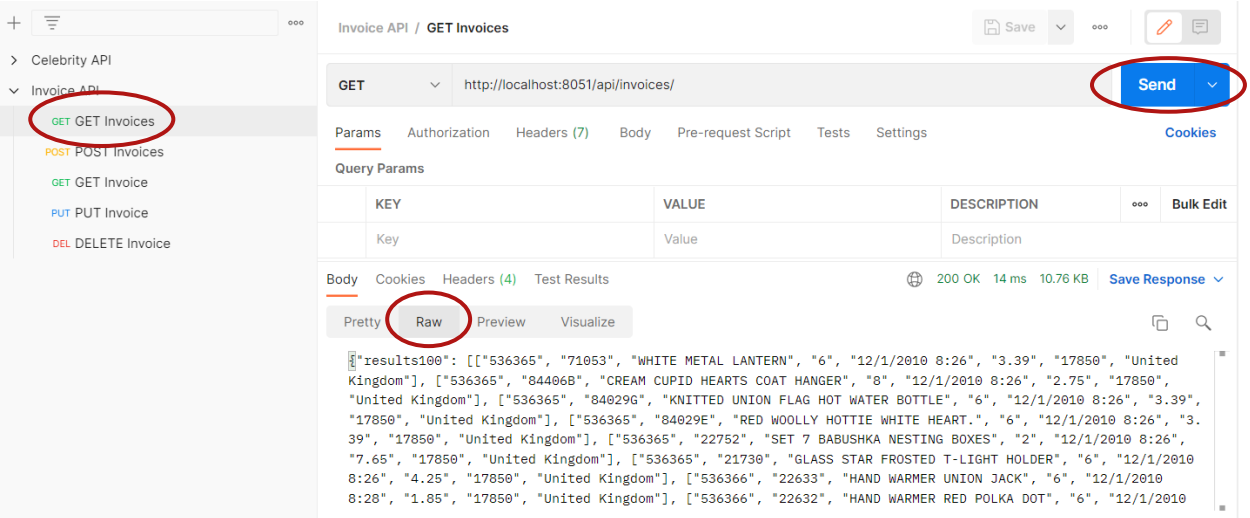
Add parameters by selecting the Body tab and then the form-data radio button as shown above. Add in values: **invoice_no**: 581588, **stock_code**: 20961, **quantity**: 3, **description**: STRAWBERRY BATH SPONGE, **invoice_date**: 2/2/2022, **unit_price**: 2.46, **customer_id**: 17850, **country**: United Kingdom.

Save the request again.

Create the DELETE request. No body parameters are needed in this case.



Test it out by running your task2_3_starter.py server. Then, for each request in the collection, select it. Press send and view the output results, as shown:



Task 2-5
Adding Flask-SQLAlchemy

Overview

This task incorporates the database using a plugin called Flask-SQLAlchemy. You will add the plugin into our on-going invoice API, create a database model object, write and test the post() method.

Add Imports

Add an import for the Flask-SQLAlchemy plugin.

```
from flask import Flask, request
from flask_restx import Resource, Api
from flask_sqlalchemy import SQLAlchemy
```

Take Note of the Paths Used

There's no code to write for this step, just understand how the Path() objects are being used here.

```
student_files_dir = Path(__file__).parents[1]
db_file = student_files_dir / 'data/course_data.db'
if not db_file.exists():
    print(f'Database file does not exist.', file=sys.stderr)
    sys.exit()

app.config['SQLALCHEMY_DATABASE_URI'] =
                                  'sqlite:///' + str(db_file)
app.config['SQLALCHEMY_ECHO'] = False
```

Create (Instantiate) the SQLAlchemy Object

Pass the Flask app object into the SQLAlchemy plugin object.

```
db = SQLAlchemy(app)
```

Create the Database Model Class

Build the model class. It's a bit lengthy and you can use the commented fields in the source file to shorten it. You will still have to create the __init__() manually.

```
class InvoiceModel(db.Model):
    __tablename__ = 'purchases'
    id = db.Column(db.Integer, primary_key=True)
    invoice_no = db.Column('InvoiceNo', db.String(30))
    stock_code = db.Column('StockCode', db.String(30))
    quantity = db.Column(db.Integer)
    description = db.Column(db.String(150))
    invoice_date = db.Column('InvoiceDate', db.String(50))
    unit_price = db.Column('UnitPrice', db.Float)
    customer_id = db.Column('CustomerID', db.String(50))
    country = db.Column(db.String(50))

    def __init__(self, invoice_no, stock_code, quantity,
                 description, invoice_date, unit_price,
                 customer_id, country):
        self.invoice_no = invoice_no
        self.stock_code = stock_code
        self.quantity = quantity
        self.description = description
        self.invoice_date = invoice_date
```

```
        self.unit_price = unit_price
        self.customer_id = customer_id
        self.country = country

    def __str__(self):
        return f'({self.invoice_no}) {self.stock_code} Qty:
                  {self.quantity} - {self.description}'
```

Write the post() Method

Create the post() method to insert a new object in the database. It must first extract the fields out of the request.form dictionary. Then it will use them to instantiate and insert a new database model object (InvoiceModel). For now, we will manually return a dictionary object created the hard way.

```
class Invoices(Resource):
    def get(self):
        return {'action': 'get all'}

    def post(self):
        invoice_no = request.form.get('invoice_no')
        stock_code = request.form.get('stock_code')
        quantity = int(request.form.get('quantity'))
        description = request.form.get('description')
        invoice_date = request.form.get('invoice_date')
        unit_price = float(request.form.get('unit_price'))
        customer_id = request.form.get('customer_id')
        country = request.form.get('country')

        new_purchase = InvoiceModel(invoice_no, stock_code,
                           quantity, description, invoice_date,
                           unit_price, customer_id, country)
        db.session.add(new_purchase)
```

```
    db.session.commit()

    return {'id': new_purchase.id,
            'invoice_no': new_purchase.invoice_no,
            'stock_code': new_purchase.stock_code,
            'quantity': new_purchase.quantity,
            'description': new_purchase.description,
            'invoice_date': new_purchase.invoice_date,
            'unit_price': new_purchase.unit_price,
            'customer_id': new_purchase.customer_id,
            'country': new_purchase.country }
```

That's it! Test it out by:

1. Ensuring no other servers are running
2. Starting the task2_5_starter.py server
3. Run the task2_5_client.py file to test the post operation

Task 2-6
Adding Flask-Marshmallow

Overview

This last task in the chapter completes our Invoice API. In this task, you will incorporate Marshmallow, the object serialization library. You will also complete the remaining API methods in the Invoice and Invoices classes Work from the provided task2_6_starter.py in the ch02_fundamentals folder.

Import Marshmallow

Import Marshmallow from flask-marshmallow. This should already be available for you from our Task 1-2 setup exercise. You just need to import it now.

```
from flask import Flask, request
from flask_restx import Resource, Api
from flask_sqlalchemy import SQLAlchemy
from flask_marshmallow import Marshmallow
```

Instantiate Marshmallow

Instantiate the plugin passing the Flask object into it.

```
app = Flask(__name__)
api = Api(app, prefix='/api')
ma = Marshmallow(app)
```

Create a Marshmallow Schema

We won't have to create the Marshmallow schema class from scratch. It is provided for us at the bottom of the source file. Locate step 3 in the source file and uncomment the Schema class and the associated lines (see below for which lines to uncomment).

```
class InvoiceSchema(ma.Schema):
    class Meta:
        fields = ('id', 'invoice_no', 'stock_code', 'quantity',
                  'description', 'invoice_date', 'unit_price',
                  'customer_id', 'country')


invoice_schema = InvoiceSchema()
invoices_schema = InvoiceSchema(many=True)

api.add_resource(Invoice, '/invoices/<id>')
api.add_resource(Invoices, '/invoices/')
```

Complete the Invoices get() ALL Method

The get() method of the Invoices class will require two statements. The first queries the database, returning all records. The second returns the results from the function in a JSON format. We'll use the Marshmallow Invoices schema for that. Replace the current return statement in this function and implement these statements as shown:

```
class Invoices(Resource):
    def get(self):
        invoices = InvoiceModel.query.all()
        return {'results': invoices_schema.dump(invoices)}
```

Complete the Invoice get() Method

Remove the current return value in this method. Complete it by using SQLAlchemy to retrieve one object by its primary key. We'll use the query.get(id) method for this. Return this object from the function using Marshmallow as shown:

```
class Invoice(Resource):
    def get(self, id):
        invoice = db.session.execute(
          db.select(InvoiceModel).filter_by(id=id)).scalar_one()

        return invoice_schema.jsonify(invoice)
```

Complete the Invoice put() Method

Remove the current return value. Because the put() method is a little longer, some of it has been completed for us. Since PUT performs an update, we'll first retrieve the object from the database and then update the fields to the values sent by the user (in the form). Don't forget to commit this interaction and finally return the object as JSON using Marshmallow. Do all of this as shown below:

```
def put(self, id):
    invoice_no = request.form.get('invoice_no')
    stock_code = request.form.get('stock_code')
    quantity = int(request.form.get('quantity'))
    description = request.form.get('description')
    invoice_date = request.form.get('invoice_date')
    unit_price = float(request.form.get('unit_price'))
    customer_id = request.form.get('customer_id')
    country = request.form.get('country')
```

```
    invoice = db.session.execute(
          db.select(InvoiceModel).filter_by(id=id)).scalar_one()
    invoice.invoice_no = invoice_no
    invoice.stock_code = stock_code
    invoice.quantity = quantity
    invoice.description = description
    invoice.invoice_date = invoice_date
    invoice.unit_price = unit_price
    invoice.customer_id = customer_id
    invoice.country = country

    db.session.commit()

    return invoice_schema.jsonify(invoice)
```

Complete the Invoice delete() Method

The delete() method will be easier than the put() method. Remove the current return value. Replace it with the code to retrieve the specific Invoice object from the database. Invoke the db.session object's delete(). Finally, return a schema object of the deleted Invoice.

```
def delete(self, id):
    invoice = db.session.execute(
          db.select(InvoiceModel).filter_by(id=id)).scalar_one()
    db.session.delete(invoice)
    db.session.commit()
    return invoice_schema.jsonify(invoice)
```

That's it! Test it out by running task2_6_starter.py as a server and then running the provided client, task2_6_client.py.

Task 3-1
Pagination

Overview

This task adds a pagination feature into the API service. To do this, you will only need to modify the Invoices get() method. We'll make use of the SQLAlchemy plugin's Paginate object. Begin by working from your task3_1_starter.py file in the ch03_adv_concepts folder.

Define a Page Size

In the Invoices class, add a class-level parameter to define the page size. The suggested value was 50.

```
class Invoices(Resource):
    page_size = 50
    def get(self):
```

Retrieve the Page Arg From the Request

Use Flask's request.args object to retrieve the submitted query string parameter. We'll use a default of 1 if nothing is submitted.

```
class Invoices(Resource):
    page_size = 50
    def get(self):
        page = request.args.get('page') or '1'
```

Invoke the SQLAlchemy paginate() Method

Use SQLAlchemy's paginate() method, passing the page number and the page_size. Don't forget to convert the page argument to an int. Take the ***items*** attribute of this entire object.

```
class Invoices(Resource):
    page_size = 50
    def get(self):
        page = request.args.get('page') or '1'
        query = db.select(InvoiceModel)
        paged_invoices = db.paginate(query, page=int(page),
                                     per_page=self.page_size,
                                     error_out=False).items
```

Return the Paginate Object's Items

Use the returned paginate object from step 3 (we called it paged_invoices above). Use the invoices_schema object created previously to do this.

```
class Invoices(Resource):
    page_size = 50
    def get(self):
        page = request.args.get('page') or '1'
        paged_invoices = db.paginate(query, page=int(page),
              per_page=self.page_size, error_out=False).items
        return
         {'results': invoices_schema.dump(paged_invoices)}
```

That's it! Test it out by running task3_1_starter.py and then running task3_1_client.py.