Introducing APIs

What is an API?

Application Program Interface which we commonly address as "API" is the special functions which we access via Internat.

Programming Language like Python and JavaScript helps us achieving this easily.

In general API were something we access at our place without its conventional GUI

When to Create an API

In general, consider an API if:

1. Your data set is large, making download via FTP unwieldy or resource-intensive.
2. Your users will need to access your data in real time, such as for display on another website or as part of an application.
3. Your data changes or is updated frequently.
4. Your users only need access to a part of the data at any one time.
5. Your users will need to perform actions other than retrieve data, such as contributing, updating, or deleting data.

If you have data you wish to share with the world, an API is one way you can get it into the hands of others.

However, APIs are not always the best way of sharing data with users. If the size of the data you are providing is relatively small, you can instead provide a "data dump" in the form of a downloadable JSON, XML, CSV, or SQLite file. Depending on your resources, this approach can be viable up to a download size of a few gigabytes.

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Implementing Our API

Overview

This section will show you how to build a prototype API using Python and the Flask web framework. Our example API will take the form of a distant reading archive—a book catalog that goes beyond standard bibliographic information to include data of interest to those working on digital projects. In this case, besides title and date of publication, our API will also serve the first sentence of each book. This should be enough data to allow us to envision some potential research questions without overwhelming us as we focus on the design of our API.

We'll begin by using Flask to create a home page for our site. In this step, we'll learn the basics of how Flask works and make sure our software is configured correctly. Once we have a small Flask application working in the form of a home page, we'll iterate on this site, turning it into a functioning API.

Creating a Basic Flask Application

Flask is a web framework for Python, meaning that it provides functionality for building web applications, including managing HTTP requests and rendering templates. In this section, we will create a basic Flask application. In later sections, we'll add to this application to create our API. Don't worry if you don't understand each individual line of code yet—explanations will be forthcoming once you have this initial version of the application working.

```
import flask

app = flask.Flask(__name__)
app.config["DEBUG"] = True


@app.route('/', methods=['GET'])
def home():
    return "<h1>Distant Reading Archive</h1><p>This site is a prototype API for distant reading of science fiction novels.</p>"

app.run()
```

Save this code as `api.py` in the `api` folder you created for this tutorial.

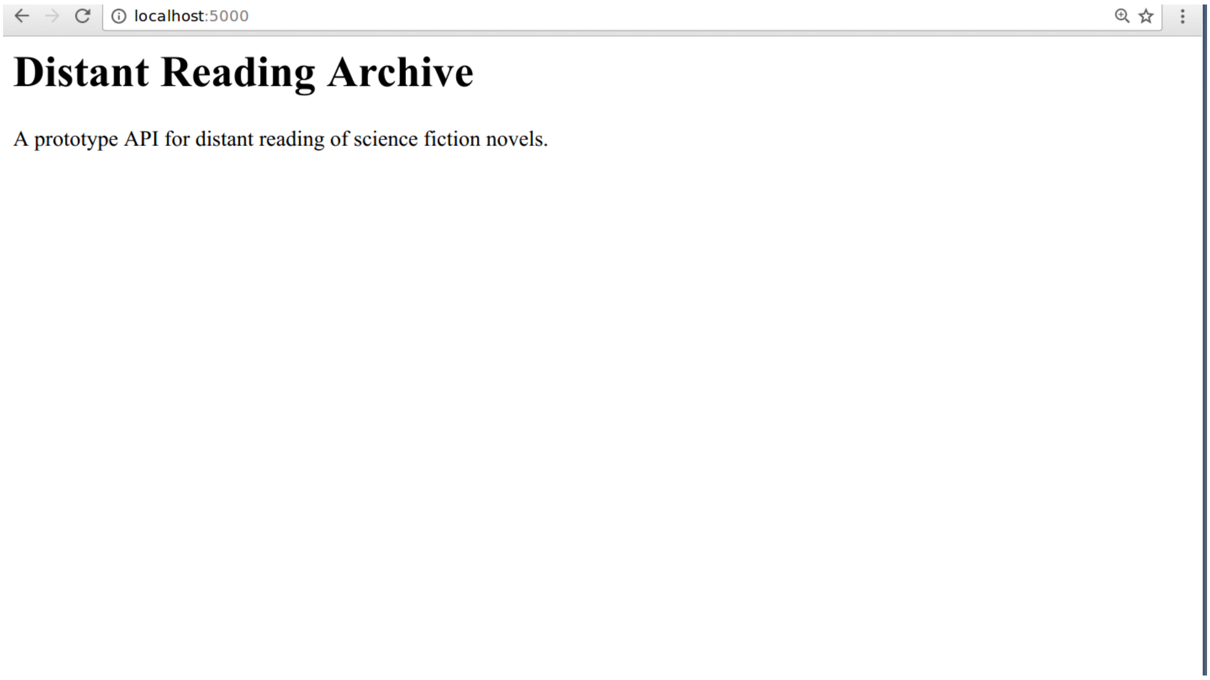
Running the Application

```
python <file_name>.py
```

You should see output similar to this:

```
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

You may also see some lines related to debugging. This message means that Flask is running your application locally (on your computer) at that address. Follow the link above, http://127.0.0.1:5000/, using your web browser to see the running application:



Distant Reading Archive

A prototype API for distant reading of science fiction novels.

The home page when rendered in a browser.

Congratulations, you've created a working web application!

Flask Working Functionality:

Now that we have a homepage for our archive, let's talk about how Flask works and what the above code is doing.

Flask maps HTTP requests to Python functions. In this case, we've mapped one URL path ('`/`') to one function, `home`. When we connect to the Flask server at http://127.0.0.1:5000/, Flask checks if there is a match between the path provided and a defined function. Since `/`, or no additional provided path, has been mapped to the `home` function, Flask runs the code in the function and displays the returned result in the browser. In this case, the returned result is HTML markup for a home page welcoming visitors to the site hosting our API.

The process of mapping URLs to functions is called **routing**. The

```
@app.route('/', methods=['GET'])
```

syntax is the part of the program that lets Flask know that this function, `home`, should be mapped to the path `/`. The `methods` list (`methods=['GET']`) is a keyword argument that lets Flask know what kind of HTTP requests are allowed. We'll only be using `GET` requests in this tutorial, but many web applications need to use both `GET` requests (to send data from the application to the user) and `POST` requests (to receive data from a user).

Below are brief explanations of the other components of the application:

`import flask` — Imports the Flask library, making the code available to the rest of the application.

`app = flask.Flask(__name__)` — Creates the Flask application object, which contains data about the application and also methods (object functions) that tell the application to do certain actions. The last line, `app.run()`, is one such method.

`app.config["DEBUG"] = True` — Starts the debugger. With this line, if your code is malformed, you'll see an error when you visit your app. Otherwise you'll only see a generic message such as `Bad Gateway` in the browser when there's a problem with your code.

`app.run()` — A method that runs the application server.

While it's useful to have a familiarity with what's going on in the script, don't worry if you don't understand precisely what every element is doing at this stage. If you understand the general outline of how this portion works, the details of how Flask renders pages are likely to become more understandable as we continue to develop our API.

API Inception:

Now that we have a running Flask application and know a little about what Flask does, we're finally ready to implement a small API with data that we'll define right in our application.

We'll be adding our data as a list of Python dictionaries. Dictionaries in Python group pairs of keys and values, like this:

```
{
    'key': 'value',
    'key': 'value'
}
```

The key identifies the type of information represented, such as `title` or `id`. The value is the actual data. For example, a short telephone book might take this format:

```
[
    {
        'name': 'Alexander Graham Bell',
        'number': '1-333-444-5555'
    },
    {
        'name': 'Thomas A. Watson',
        'number': '1-444-555-6666'
    }
]
```

The above phone book is a list of two dictionaries. Each dictionary is a phone book entry consisting of two keys, `name` and `number`, each paired with a value that provides the actual information.

Let's add some data (entries on three science fiction novels) as a list of dictionaries. Each dictionary will contain ID number, title, author, first sentence, and year of publication for each book. Finally, we'll add a new function: a route that will allow a visitor to access our data.

Replace our previous code in `api.py` with the code below:

```
import flask
from flask import request, jsonify

app = flask.Flask(__name__)
app.config["DEBUG"] = True

# Create some test data for our catalog in the form of a list of
dictionaries.
books = [
    {'id': 0,
     'title': 'A Fire Upon the Deep',
     'author': 'Vernor Vinge',
     'first_sentence': 'The coldsleep itself was dreamless.',
     'year_published': '1992'},
    {'id': 1,
     'title': 'The Ones Who Walk Away From Omelas',
     'author': 'Ursula K. Le Guin',
     'first_sentence': 'With a clamor of bells that set the swallows
soaring, the Festival of Summer came to the city Omelas, bright-towered by
the sea.',
     'published': '1973'},
    {'id': 2,
     'title': 'Dhalgren',
     'author': 'Samuel R. Delany',
     'first_sentence': 'to wound the autumnal city.',
     'published': '1975'}
]


@app.route('/', methods=['GET'])
def home():
    return '''<h1>Distant Reading Archive</h1>
<p>A prototype API for distant reading of science fiction novels.</p>'''


# A route to return all of the available entries in our catalog.
@app.route('/api/v1/resources/books/all', methods=['GET'])
def api_all():
    return jsonify(books)

app.run()
```

Run the code (navigate to your `api` folder in the command line and enter `python api.py`). Once the server is running, visit our route URL to view the data in the catalog:

http://127.0.0.1:5000/api/v1/resources/books/all

You should see JSON output for the three entries in our test catalog. Flask provides us with a `jsonify` function that allows us to convert lists and dictionaries to JSON format. In the route we created, our book entries are converted from a list of Python dictionaries to JSON before being returned to a user.

At this point, you've created a working, if limited, API. In the next section, we'll allow users to find books via more specific data, such as an entry's ID.

Finding Specific Resources:

Right now, users can only view our entire database—they can't filter or find specific resources. While this isn't a problem with our test catalog, this will quickly become less useful as we add data. In this section, we'll add a function that allows users to filter their returned results using a more specific request.

Below is the code for our new application with filtering capability. As before, we'll examine the code more carefully once you have it running.

```
import flask
from flask import request, jsonify

app = flask.Flask(__name__)
app.config["DEBUG"] = True

# Create some test data for our catalog in the form of a list of
dictionaries.
books = [
    {'id': 0,
     'title': 'A Fire Upon the Deep',
     'author': 'Vernor Vinge',
     'first_sentence': 'The coldsleep itself was dreamless.',
     'year_published': '1992'},
    {'id': 1,
     'title': 'The Ones Who Walk Away From Omelas',
     'author': 'Ursula K. Le Guin',
     'first_sentence': 'With a clamor of bells that set the swallows
soaring, the Festival of Summer came to the city Omelas, bright-towered by
the sea.',
     'published': '1973'},
    {'id': 2,
     'title': 'Dhalgren',
     'author': 'Samuel R. Delany',
     'first_sentence': 'to wound the autumnal city.',
     'published': '1975'}
]


@app.route('/', methods=['GET'])
def home():
    return '''<h1>Distant Reading Archive</h1>
<p>A prototype API for distant reading of science fiction novels.</p>'''


@app.route('/api/v1/resources/books/all', methods=['GET'])
def api_all():
    return jsonify(books)


@app.route('/api/v1/resources/books', methods=['GET'])
def api_id():
    # Check if an ID was provided as part of the URL.
    # If ID is provided, assign it to a variable.
    # If no ID is provided, display an error in the browser.
    if 'id' in request.args:
        id = int(request.args['id'])
    else:
        return "Error: No id field provided. Please specify an id."

    # Create an empty list for our results
    results = []

    # Loop through the data and match results that fit the requested ID.
    # IDs are unique, but other fields might return many results
    for book in books:
        if book['id'] == id:
            results.append(book)

    # Use the jsonify function from Flask to convert our list of
    # Python dictionaries to the JSON format.
    return jsonify(results)

app.run()
```

Once you've updated your API with the `api_id` function, run your code as before (`python api.py` from your `api` directory) and visit the below URLs to test the new filtering capability:

127.0.0.1:5000/api/v1/resources/books?id=0 127.0.0.1:5000/api/v1/resources/books?id=1 127.0.0.1:5000/api/v1/resources/books?id=2 127.0.0.1:5000/api/v1/resources/books?id=3

Each of these should return a different entry, except for the last, which should return an empty list: `[]`, since there is no book for which the id value is 3. (Counting in programming typically starts from 0, so id=3 would be a request for a nonexistent fourth item.) In the next section, we'll explore our updated API in more detail.

Deep Drive into Updated API

In this code, we first create a new function, called `api_id`, with the `@app.route` syntax that maps the function to the path `/api/v1/resources/books`. That means that this function will run when we access http://127.0.0.1:5000/api/v1/resources/books. (Note that accessing this link without providing an ID will give the error message we provided in the code: `Error: No id field provided. Please specify an id.`)

Inside our function, we do two things:

First, examine the provided URL for an id and select the books that match that id. The id must be provided like this: `?id=0`. Data passed through URLs like this (after the `?`) are called **query parameters**—we've seen them before when we worked with the Chronicling America API. They're a feature of HTTP used for filtering for specific kinds of data.

This part of the code determines if there is a query parameter, like `?id=0`, and then assigns the provided ID to a variable.

```
    if 'id' in request.args:
        id = int(request.args['id'])
    else:
        return "Error: No id field provided. Please specify an id."
```

Then this section moves through our test catalog of books, matches those books that have the provided ID, and appends them to the list that will be returned to the user:

```
    for book in books:
        if book['id'] == id:
            results.append(book)
```

Finally, the `return jsonify(results)` line takes the list of results and renders them in the browser as JSON.

If you've gotten this far, you've created an actual API. Celebrate! At the end of this lesson, you'll be exposed to a somewhat more complex API that uses a database, but most of the principles and patterns we've used so far will still apply. In the next section, we'll discuss some guidelines for creating a well-designed API that others will actually want to use. In the last section of the tutorial, we'll apply these principles to a version of our API that pulls in results from a database.

API Design Principles

Thus far, we've created a working API with test data that we've provided right in our application. Our next version of our API will pull in data from a database before providing it to a user. It will also take additional query parameters, allowing users to filter by fields other than ID.

Before building more functionality into our application, let's reflect on some of the API design decisions that we've made so far. Two aspects of a good API are usability and maintainability, and as we build more functionality into our API, we'll be keeping many of the following considerations in mind.

Designing Requests:

The prevailing design philosophy of modern APIs is called REST. For our purposes, the most important thing about REST is that it's based on the four methods defined by the HTTP protocol: POST, GET, PUT, and DELETE. These correspond to the four traditional actions performed on data in a database: CREATE, READ, UPDATE, and DELETE. In this tutorial, we'll only be concerned with GET requests, which correspond to reading from a database.

Because HTTP requests are so integral to using a REST API, many design principles revolve around how requests should be formatted. We've already created one HTTP request, which returns all books provided in our sample data. To understand the considerations that go into formatting this request, let's first consider a weak or poorly-designed example of an API endpoint:

```
http://api.example.com/getbook/10
```

The formatting of this request has a number of issues. The first is semantic—in a REST API, our verbs are typically `GET`, `POST`, `PUT`, or `DELETE`, and are determined by the request method rather than in the request URL. That means that the word "get" should not appear in our request, since "get" is implied by the fact that we're using a

HTTP GET method. In addition, resource collections such as `books` or `users` should be denoted with plural nouns. This makes it clear when an API is referring to a collection (`books`) or an entry (`book`). Incorporating these principles, our API would look like this:

```
http://api.example.com/books/10
```

The above request uses part of the path (`/10`) to provide the ID. While this is not an uncommon approach, it's somewhat inflexible—with URLs constructed in this manner, you can generally only filter by one field at a time. Query parameters allow for filtering by multiple database fields and make more sense when providing "optional" data, such as an output format:

```
http://api.example.com/books?author=Ursula+K.+Le
Guin&published=1969&output=xml
```

When designing how requests to your API should be structured, it also makes sense to plan for future additions. Even if the current version of your API serves information on only one type of resource—`books`, for example—it makes sense to plan as if you might add other resources or non-resource functionality to your API in the future:

```
http://api.example.com/resources/books?id=10
```

Adding an extra segment on your path such as "resources" or "entries" gives you the option to allow users to search across all resources available, making it easier for you to later support requests such as these:

```
https://api.example.com/v1/resources/images?id=10
https://api.example.com/v1/resources/all
```

Another way to plan for your API's future is to add a version number to the path. This means that, should you have to redesign your API, you can continue to support the old version of the API under the old version number while releasing, for example, a second version (`v2`) with improved or different functionality. This way, applications and scripts built using the old version of your API won't cease to function after your upgrade.

After incorporating these design improvements, a request to our API might look like this:

```
https://api.example.com/v1/resources/books?id=10
```

Connecting Our API to a Database

This last example of our Distant Reading Archive API pulls in data from a database, implements error handling, and can filter books by publication date. The database used is SQLite, a lightweight database engine that is supported in Python by default. SQLite files typically end with the `.db` file extension.

Before we modify our code, first download the example database from this location and copy the file to your `api` folder using your graphical user interface. The final version of our API will query this database when returning results to users.

Copy the below code into your text editor. As before, we'll examine the code more closely once you have it running.

```
import flask
from flask import request, jsonify
import sqlite3

app = flask.Flask(__name__)
app.config["DEBUG"] = True

def dict_factory(cursor, row):
    d = {}
    for idx, col in enumerate(cursor.description):
        d[col[0]] = row[idx]
    return d


@app.route('/', methods=['GET'])
def home():
    return '''<h1>Distant Reading Archive</h1>
<p>A prototype API for distant reading of science fiction novels.</p>'''


@app.route('/api/v1/resources/books/all', methods=['GET'])
def api_all():
    conn = sqlite3.connect('books.db')
    conn.row_factory = dict_factory
    cur = conn.cursor()
    all_books = cur.execute('SELECT * FROM books;').fetchall()

    return jsonify(all_books)



@app.errorhandler(404)
def page_not_found(e):
    return "<h1>404</h1><p>The resource could not be found.</p>", 404


@app.route('/api/v1/resources/books', methods=['GET'])
def api_filter():
    query_parameters = request.args

    id = query_parameters.get('id')
    published = query_parameters.get('published')
    author = query_parameters.get('author')

    query = "SELECT * FROM books WHERE"
    to_filter = []

    if id:
        query += ' id=? AND'
        to_filter.append(id)
    if published:
        query += ' published=? AND'
        to_filter.append(published)
    if author:
        query += ' author=? AND'
        to_filter.append(author)
    if not (id or published or author):
        return page_not_found(404)

    query = query[:-4] + ';'

    conn = sqlite3.connect('books.db')
    conn.row_factory = dict_factory
    cur = conn.cursor()

    results = cur.execute(query, to_filter).fetchall()

    return jsonify(results)

app.run()
```

Save the code as `api_final.py` in your `api` folder and run it by navigating to your project folder in the terminal and entering the command:

```
python api_final.py
```

Note that if a previous version of the code is still running, you will first need to end that process by pressing `Control-C` before executing the new code. Once this example is running, try out the filtering functionality with these HTTP requests:

http://127.0.0.1:5000/api/v1/resources/books/all http://127.0.0.1:5000/api/v1/resources/books?author=Connie+Willis http://127.0.0.1:5000/api/v1/resources/books?author=Connie+Willis&published=1999 http://127.0.0.1:5000/api/v1/resources/books?published=2010

The database downloaded for this lesson has 67 entries, one for each of the winners of the Hugo Award for best science fiction novel between 1953 and 2014 (avoiding the voting controversy of 2015). The data set includes the novel's title, author, year of publication, and first sentence. Our API allows users to filter by three fields: `id`, `published` (year of publication), and `author`.

The first request returns all entries in the database, similar to the `/all` request we implemented for the last version of our API. The second request returns all books by the author Connie Willis (`?author=Connie+Willis`). Note that, within a query parameter, spaces between words are denoted with a `+` sign, hence `Connie+Willis`. The third request filters by two fields—author and year of publication. Instead of the three books returned by requesting `?author=Connie+Willis`, this request returns only the entry to *The Doomsday Book*, published in 1993. The last request returns all Hugo winners from the year 2010 (note that, in some years, more than one Hugo is awarded).

As we can see this version of our API serves a larger number of results, results that are stored in an SQLite database (`books.db`). When our user requests an entry or set of entries, our API pulls that information from the database by building and executing an SQL query. This iteration of our API also allows for filtering by more than one field. We'll discuss potential uses for this functionality after examining our code more closely.

Understanding Our Database-Powered API

Relational databases allow for the storage and retrieval of data, which is stored in tables. Tables are similar to spread sheets in that they have columns and rows—columns indicate what the data representes, such as “title” or “date.” Rows represent individual entries, which could be books, users, transactions, or any other kind of entity.

The database we’re working with has five columns `id`, `published`, `author`, `title`, and `first_sentence`. Each row represents one book that won the Hugo award in the year under the `published` heading, and the text of which begins with the sentence in the `first_sentence` column.

Rather than use test data defined in the application, our `api_all` function pulls in data from our Hugo database:

```
def api_all():
    conn = sqlite3.connect('books.db')
    conn.row_factory = dict_factory
    cur = conn.cursor()
    all_books = cur.execute('SELECT * FROM books;').fetchall()

    return jsonify(all_books)
```

First, we connect to the database using our `sqlite3` library. An object representing the connection to the database is bound to the `conn` variable. The `conn.row_factory = dict_factory` line lets the connection object know to use the `dict_factory` function we’ve defined, which returns items from the database as dictionaries rather than lists—these work better when we output them to JSON. We then create a cursor object (`cur = conn.cursor()`), which is the object that actually moves through the database to pull our data. Finally, we execute an SQL query with the `cur.execute` method to pull out all available data (`*`) from the `books` table of our database. At the end of our function, this data is returned as JSON: `jsonify(all_books)`. Note that our other function that returns data, `api_filter`, will use a similar approach to pull data from the database.

The purpose of our `page_not_found` function is to create an error page seen by the user if the user encounters an error or inputs a route that hasn’t been defined:

```
@app.errorhandler(404)
def page_not_found(e):
    return "<h1>404</h1><p>The resource could not be found.</p>", 404
```

In HTML responses, the code `200` means “OK”(the expected data transferred), while the code `404` means “Not Found” (there was no resource available at the URL given). This function allows us to return 404 pages when something goes wrong in the application.

Our `api_filter` function is an improvement on our previous `api_id` function that returns a book based on its ID. This new function allows for filtering by three different fields: `id`, `published`, and `author`. The function first grabs all the query parameters provided in the URL (remember, query parameters are the part of the URL that follows the `?`, like `?id=10`).

```
query_parameters = request.args
```

It then pulls the supported parameters id, published, and author and binds them to appropriate variables:

```
id = query_parameters.get('id')
published = query_parameters.get('published')
author = query_parameters.get('author')
```

The next segment begins to build an SQL query that will be used to find the requested information in the database. SQL queries used to find data in a database take this form:

```
`SELECT <columns> FROM <table> WHERE <column=match> AND <column=match>;
```

To get the correct data, we need to build both an SQL query that looks like the above and a list with the filters that will be matched. Combined, the query and the the filters provided by the user will allow us to pull the correct books from our database.

We begin to define both the query and the filter list:

```
query = "SELECT * FROM books WHERE"
to_filter = []
```

Then, if id, published, or author were provided as query parameters, we add them to both the query and the filter list:

```
    if id:
        query += ' id=? AND'
        to_filter.append(id)
    if published:
        query += ' published=? AND'
        to_filter.append(published)
    if author:
        query += ' author=? AND'
        to_filter.append(author)
```

If the user has provided none of these query parameters, we have nothing to show, so we send them to the “404 Not Found” page:

```
    if not (id or published or author):
        return page_not_found(404)
```

To perfect our query, we remove the trailing` AND  and cap the query with the ;` required at the end of all SQL statements:

```
    query = query[:-4] + ';'
```

Finally, we connect to our database as in our api_all function, then execute the query we’ve built using our filter list:

```
conn = sqlite3.connect('books.db')
conn.row_factory = dict_factory
cur = conn.cursor()

results = cur.execute(query, to_filter).fetchall()
```

Finally, we return the results of our executed SQL query as JSON to the user:

```
return jsonify(results)
```

Whew! When all is said and done, this section of code reads query parameters provided by the user, builds an SQL query based on those parameters, executes that query to find matching books in the database, and returns those matches as JSON to the user. This section of code makes our API's filtering capability considerably more sophisticated—users can now find books by, for example, Ursula K. Le Guin that were published in 1975 or all books in the database published in 2010.