Taxi Booking System Design Consideration and Deployment

1. Implementation

I have used **.NET Core** which is a **cross-platform** version of .NET for building websites, **services**, and console apps **(.Net Core 3.1** with **C#** as the development language)
https://dotnet.microsoft.com/download

I have implemented and exposed **REST endpoints** using .Net core **Web API** which helps in building **RESTful** web **services**.

2. Design Constraints

APIs
service is running on PORT **8080**.

- **As requested ,** the service **does not** implement any form **persistent storage**. The service uses **In memory** data structures to process and handle the requests.
- **As requested,** the **service does not** handle **concurrent API calls**/data races , as The APIs will be triggered **serially**.

3. Algorithm and data structures

I have created a *User defined* ***In Memory data structure*** to hold the details of the API operation and sub sequent information

A Taxi class holds the information related to a single taxi.

```
namespace TaxiBookingAPI.Model
{
    /// <summary>
    ///  In Memory Model for the Taxi , Which Holds the three taxi details
    /// </summary>
    public class Taxi
    {
        /// <summary>
        ///  car id either 1 , 2 , 3
        /// </summary>
        public int CarId { get; set; }

        /// <summary>
        ///  current location of the car
        /// </summary>
        public LocationCoordinates Location { get; set; }

        /// <summary>
        ///  Is car already booked
        /// </summary>
        public bool IsBooked { get; set; }

        /// <summary>
        ///  if car is booked , BookedUntilTime will tell you until what time it is booked
        /// </summary>
        public int BookedUntilTime { get; set; }

    }
}
```

And a LocationCoordinates for holding X and Y coordinates of the taxi.

```
namespace TaxiBookingAPI.Model
{
    /// <summary>
    /// Location Model for the JSON
    /// </summary>
    public class Location
    {
        /// <summary>
        /// Passenger's initial Position
        /// </summary>
        [Required]
        public LocationCoordinates Source { get; set; }

        /// <summary>
        /// Passenger's destination Position
        /// </summary>
        [Required]
        public LocationCoordinates Destination { get; set; }
    }

    /// <summary>
    /// Location Coordinates X,Y
    /// </summary>
    public class LocationCoordinates
    {
        /// <summary>
        ///  X coordinate of the Location
        /// </summary>
        [Required]
        public int X { get; set; }

        /// <summary>
        /// Y coordinate of the Location
        /// </summary>
        [Required]
        public int Y { get; set; }
    }
}
```

3.1 Manhattan Distance

The distance between two points x = (a,b) and y = (c,d) is calculated using

$$Manhattan\ Distance = |a - c| + |b - d|$$

3.2 Algorithm

Time to travel between point **x = (a,b)** to point **y = (c,d)** is **|(a-c)| + |(b-d)|**

Main algorithm is divided in two steps and which is in ***FindNearestTaxiToCustomer*** function,

Step 1: Loop through the current position of all taxi's from the customer's initial position and also calculate the time for each car to reach to the customer. **O(n**)

It will look something like this after the step 1. I am holding this information in a dictionary for the faster retrieval (performance for the **O(1)** retrieval)

```
// Dictionary to hold the car ID and Time to travel to customer
//
// car ID     | Time required to reach Customer
// ------------------------------------------
//   1        |       3
//   2        |       6
//   3        |       8
```

Step 2: Sort the dictionary based on the 'nearest car to the customer' and the 'smallest car id; **O(nlogn) in worst case**.

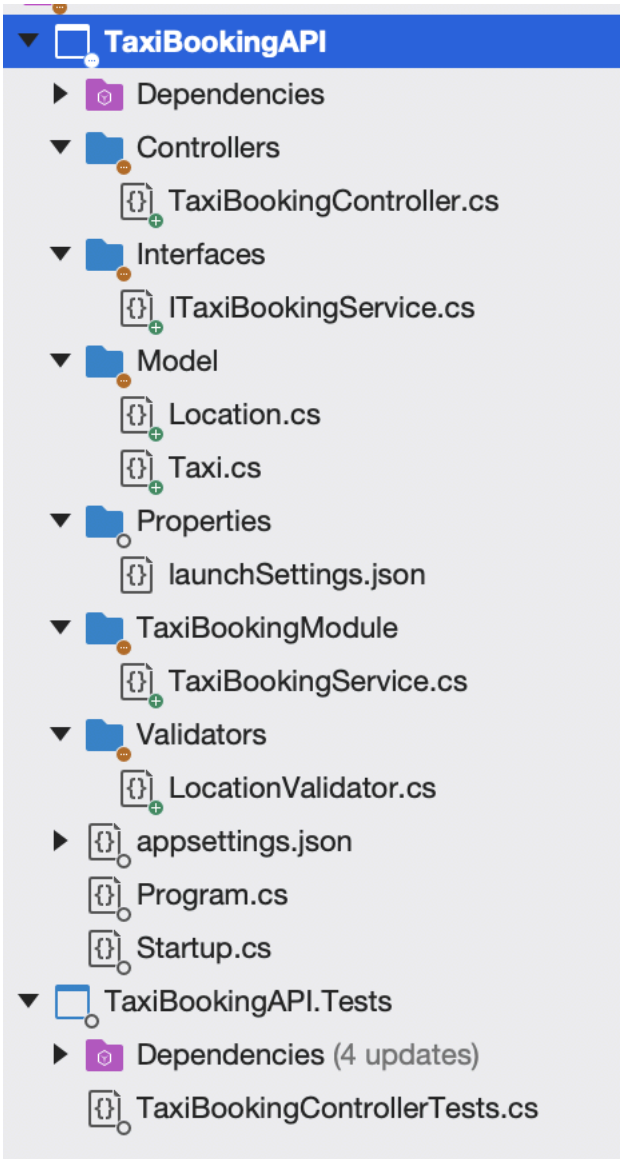
Overall time complexity of the algorithm is **O(nlogn)**

4. Software design and engineering practices

TaxiBooking API service tries to capture the best design and engineering practices. I have kept in mind the basics of ***SOLID Principles*** and other architecture constraints to make system extensible.

a. Separation of concerns

Clear separation of building blocks to make sure different concerns are separated (***Separation of Concerns*** which gives us a ***Highly cohesive*** and ***loosely coupled*** systems)



b. Interface segregation and Open/Close Principles

I have created an **Interface** for TaxiBooking API, which is **extensible** and *new functionalities can be easily added later in future without modifying and changing existing architecture which makes the system extensible (open for new extension)*

```
namespace TaxiBookingAPI.Interfaces
{
    /// <summary>
    /// Interface for the Taxi Booking Service API
    /// </summary>
    public interface ITaxiBookingService
    {
        /// <summary>
        ///
        /// </summary>
        public void ResetTaxiBookingSystem();

        /// <summary>
        ///
        /// </summary>
        public void IncrementServiceTimeStamp();

        /// <summary>
        ///
        /// </summary>
        /// <param name="location"></param>
        /// <returns></returns>
        public (int, int) BookTaxi(Location location);
    }
}
```

c. Dependency Injection (Inversion of Control)

ASP.NET Core framework includes built-in ***IoC container*** for automatic ***dependency injection***. The built-in IoC container is a simple yet effective container.

I have Register and injected the ***TaxiBookingService*** in the IOC Container, which takes care of the object creation and the object life cycle. I have register as a ***singleton*** instance as I wanted to make sure I have only single instance across different requests

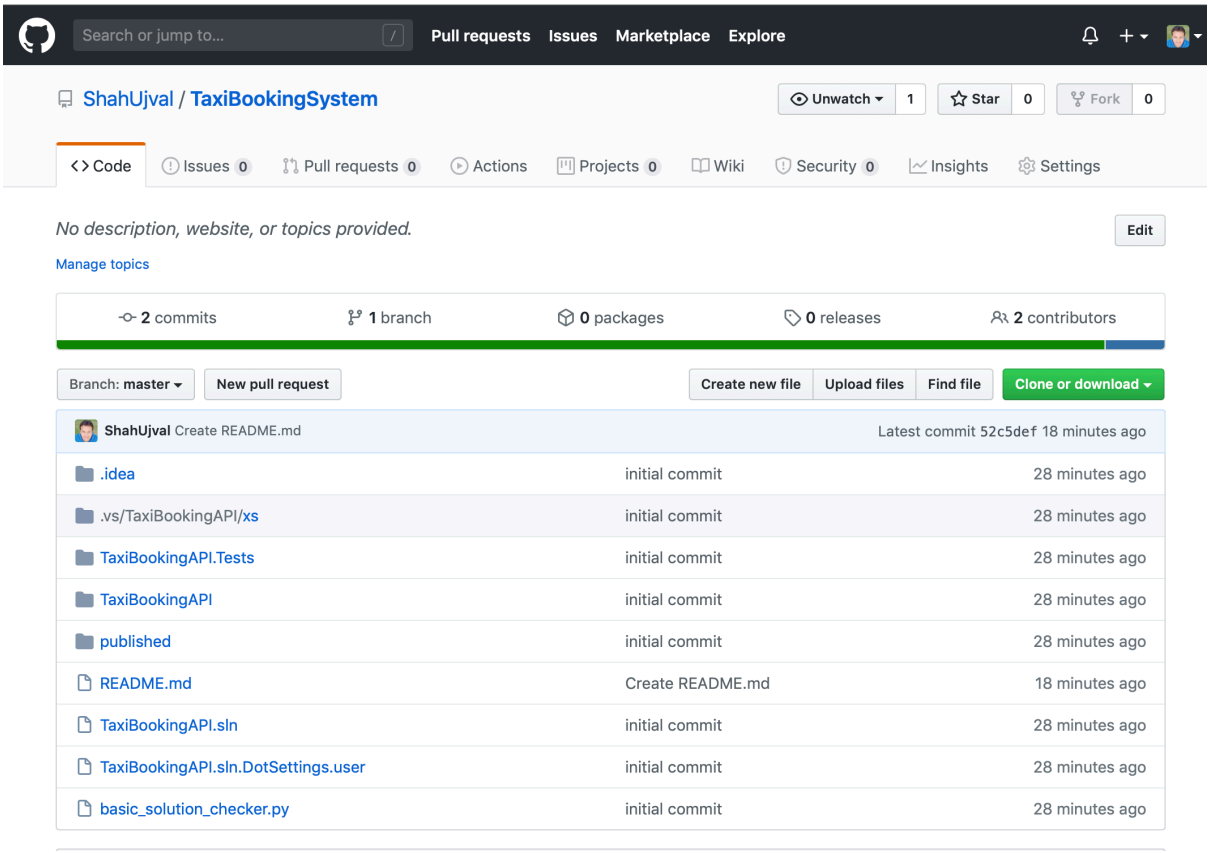
```
// This method gets called by the runtime. Use this method to add services to the container.
public void ConfigureServices(IServiceCollection services)
{
    services.AddControllers();

    services.AddMvc().AddFluentValidation();

    services.AddTransient<IValidator<Location>, LocationValidator>();
    // Inject the Taxi Booking Service in Default IOC Container Service Collection
    services.AddSingleton<ITaxiBookingService,TaxiBookingService>();
```

5. Build and Deployment

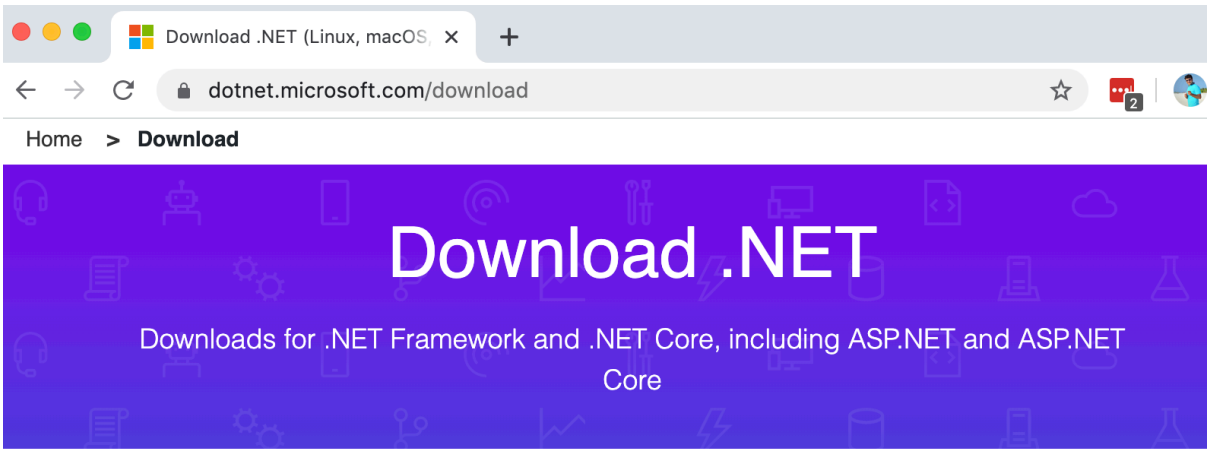
Clone the repo from
https://github.com/ShahUjval/TaxiBookingSystem.git



There are several ways to run the application, I will list down few.

Prerequisite:

Download and install the latest version of the .Net Core SDK for your Linux machine.



Not sure where to start? See the Hello World in 10 minutes tutorial to install .NET and build your first app.

Windows | Linux | macOS | Docker

.NET Core

.NET Core 3.1

.NET Core is a cross-platform version of .NET for building websites, services, and console apps.

Build Apps | Download .NET Core SDK

a. Using '***dotnet run'*** command (command line)

1. Open the Terminal/Console and Navigate to '**TaxiBookingAPI'** folder
2. **Run 'dotnet run'**
3. You can see 'Now listening on: http://localhost:8080'

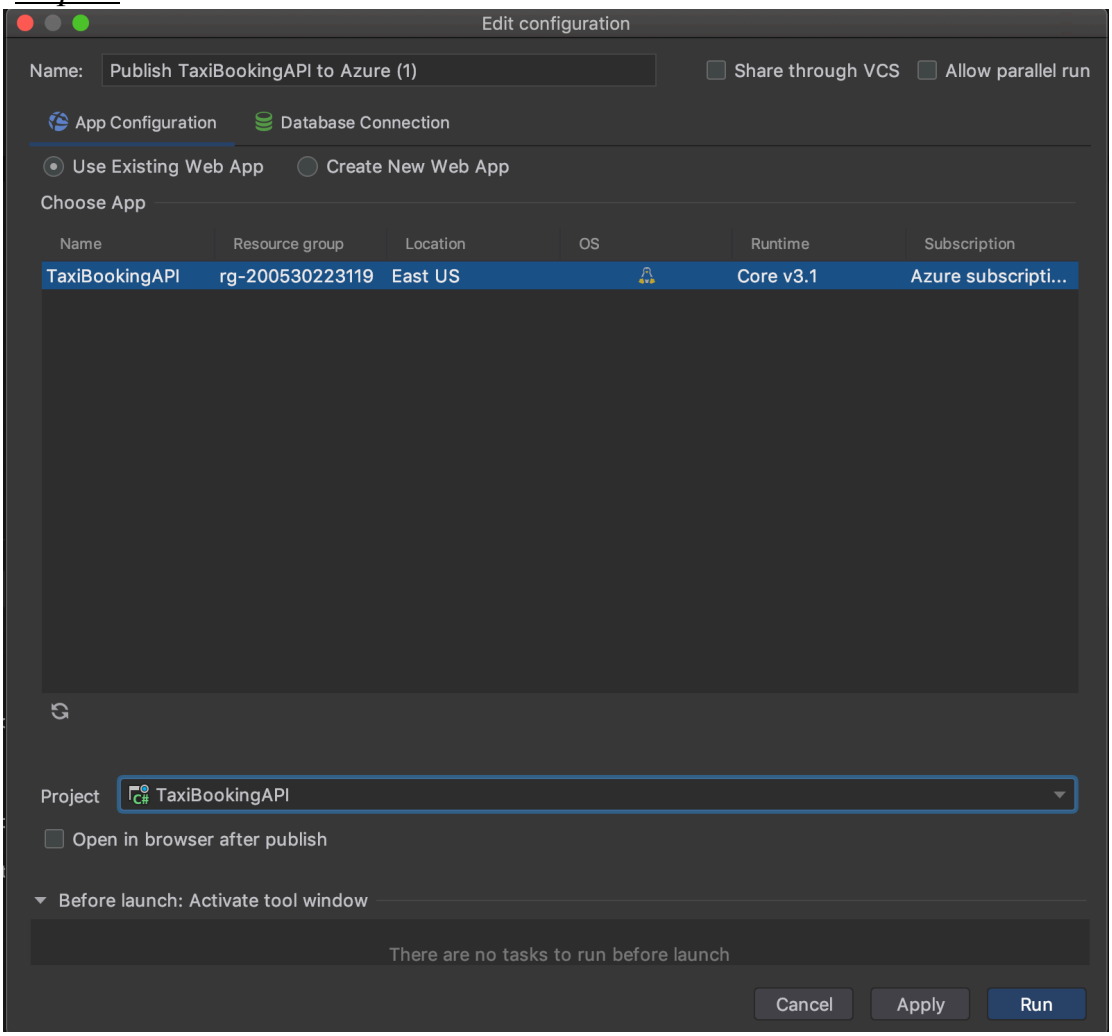
b. Using '***dotnet publish'*** command

On your local machine, you can prepare the application for deployment by running "dotnet publish". This builds the application artifacts, does any minification and so forth.

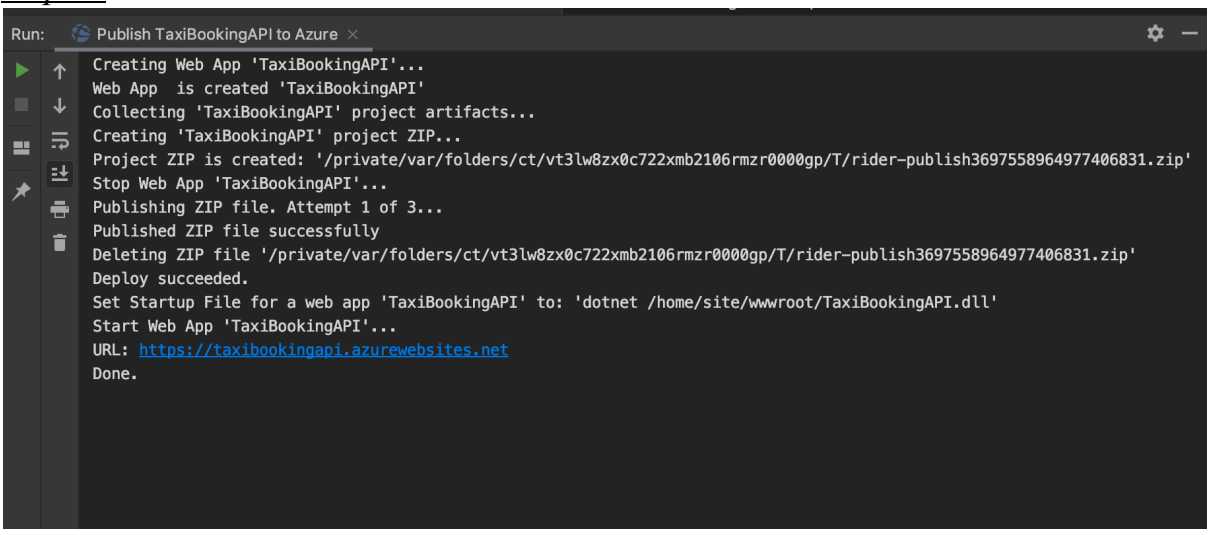
1. Open the Terminal/Console and Navigate to '**TaxiBookingAPI'** folder
2. Run command '***dotnet publish -c Release -o published'*** – this publish the application to 'published' folder (I have published one for example)
3. 'Cd published'
4. Run 'dotnet TaxiBookingAPI.dll'
5. You can see 'Now listening on: http://localhost:8080'

C. Using ***Azure Web Apps*** to publish our service ***to Azure cloud***

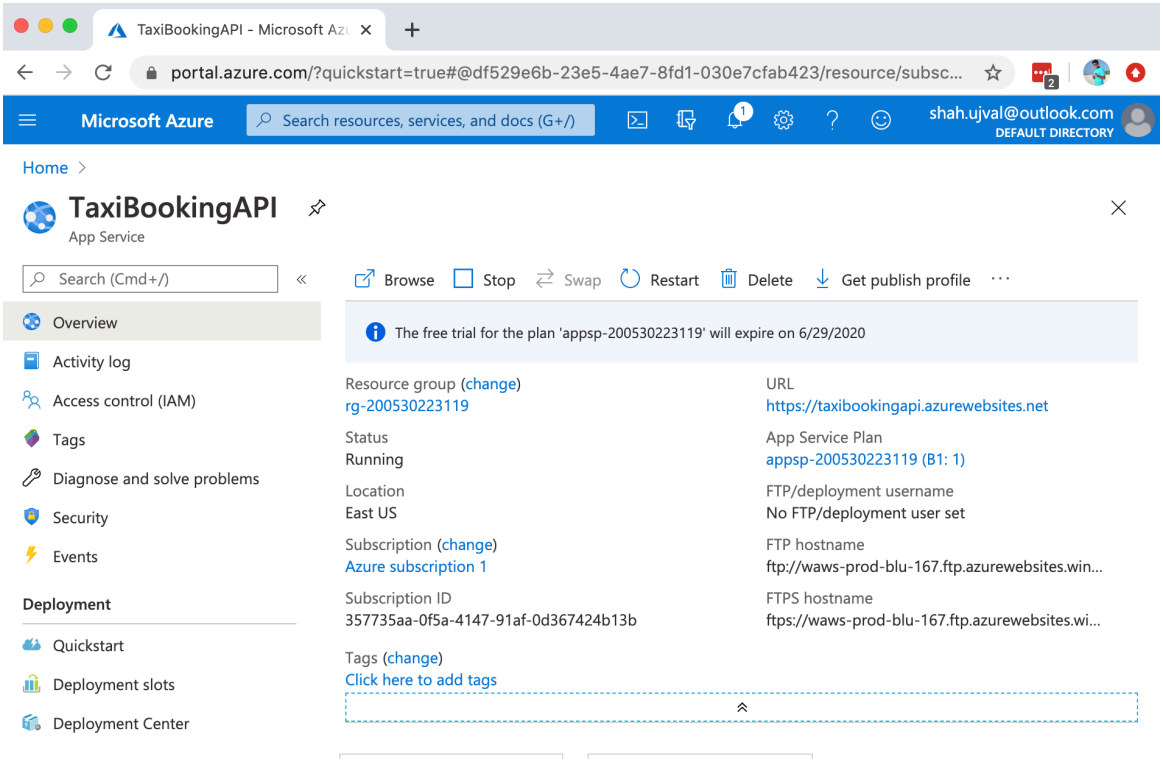
Step 1:



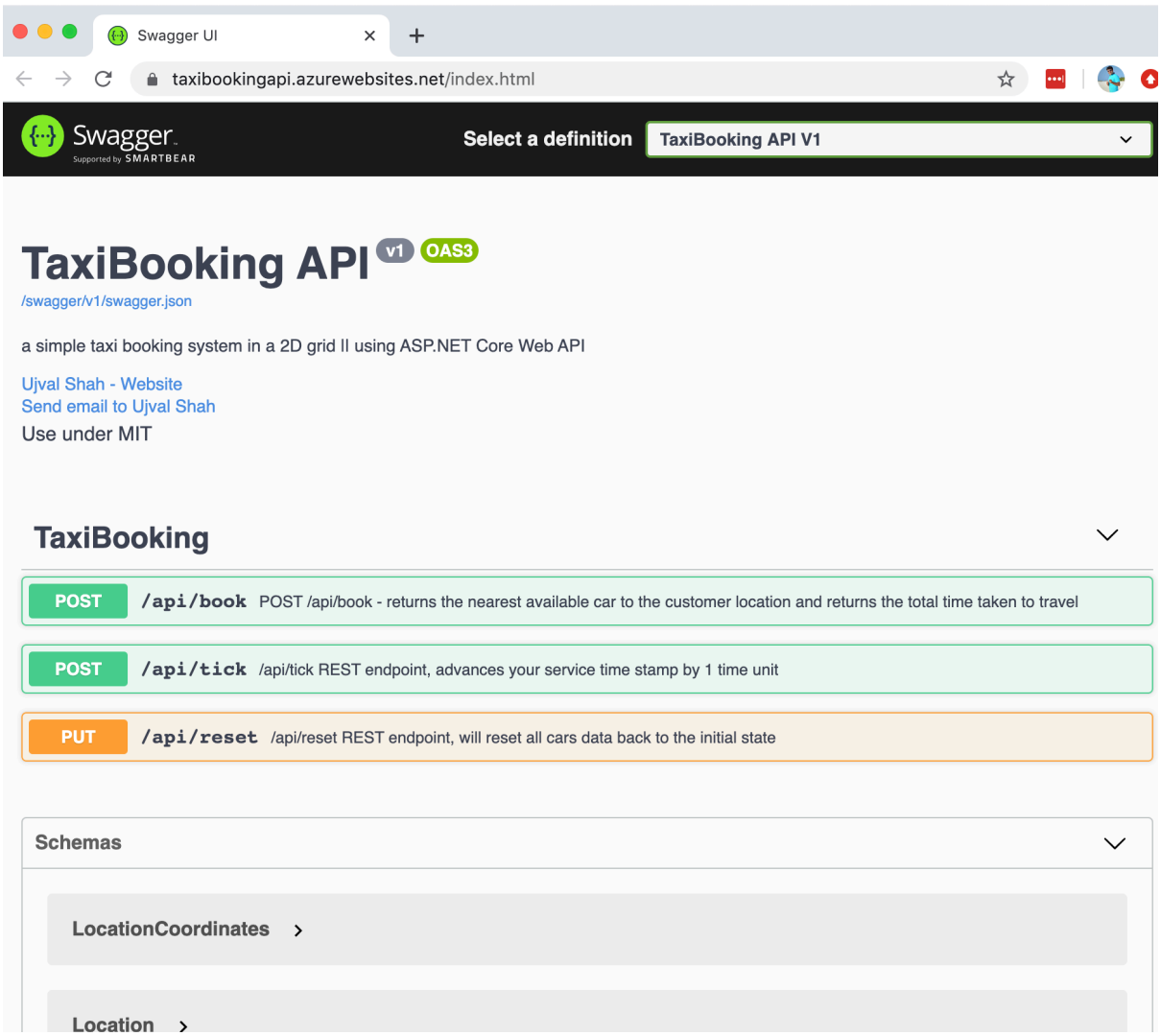
Step 2:



Step 3:



Run https://taxibookingapi.azurewebsites.net


Swagger UI
taxibookingapi.azurewebsites.net/index.html
Swagger
Supported by SMARTBEAR
Select a definition
TaxiBooking API V1
TaxiBooking API
v1
OAS3
/swagger/v1/swagger.json
a simple taxi booking system in a 2D grid II using ASP.NET Core Web API
Ujval Shah - Website
Send email to Ujval Shah
Use under MIT
TaxiBooking
POST
/api/book
POST /api/book - returns the nearest available car to the customer location and returns the total time taken to travel
POST
/api/tick
/api/tick REST endpoint, advances your service time stamp by 1 time unit
PUT
/api/reset
/api/reset REST endpoint, will reset all cars data back to the initial state
Schemas
LocationCoordinates
Location

6. Unit Testing and Execution

1. Using '***dotnet test'*** command (command line)
2. Open the Terminal/Console and Navigate to '**TaxiBookingAPI'** folder
3. **Run 'dotnet test'**

Output

Starting test execution, please wait...

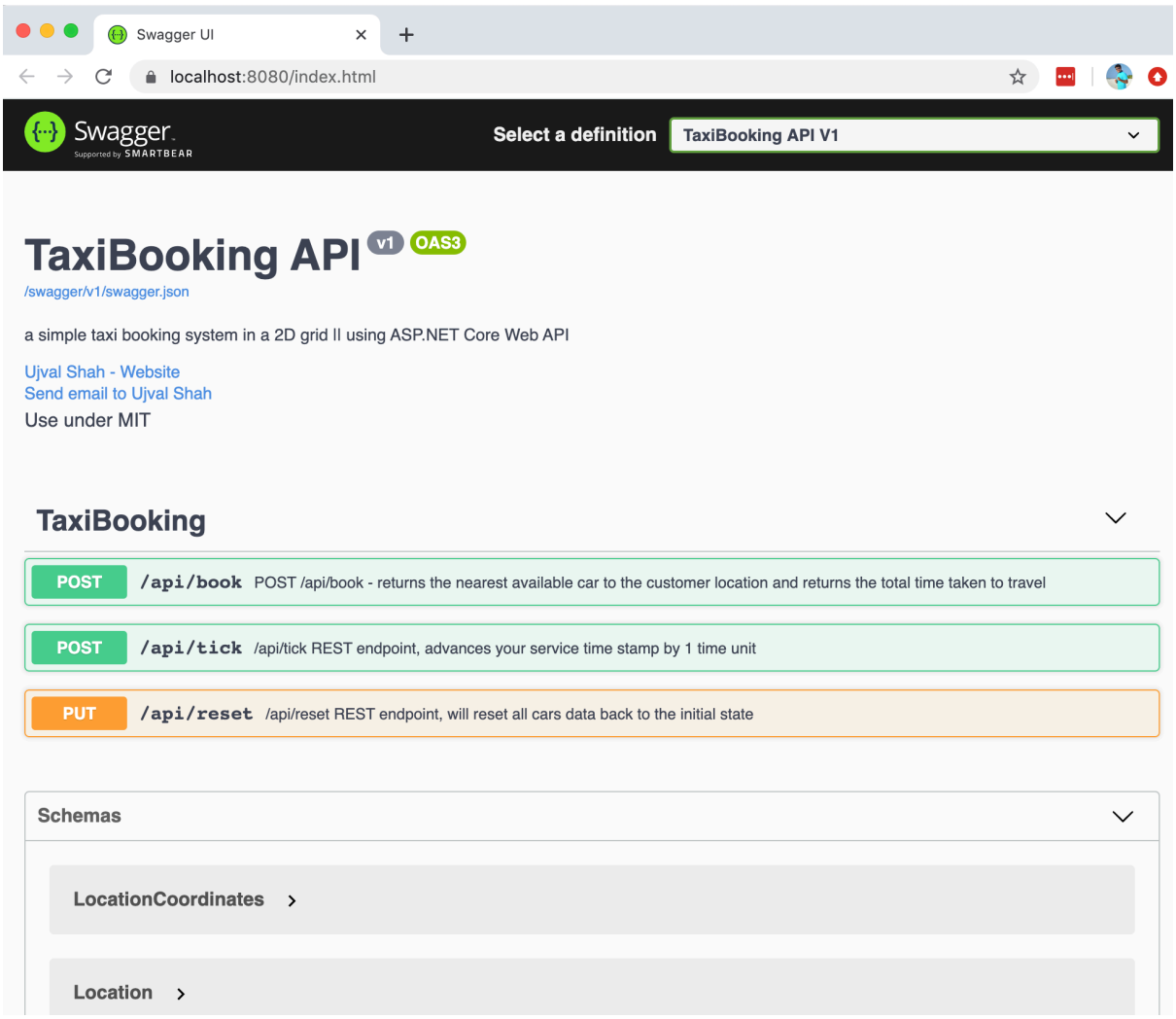
A total of 1 test files matched the specified pattern.

Test Run Successful.
Total tests: 3
Passed: 3
Total time: 1.4735 Seconds

7. API Documentation

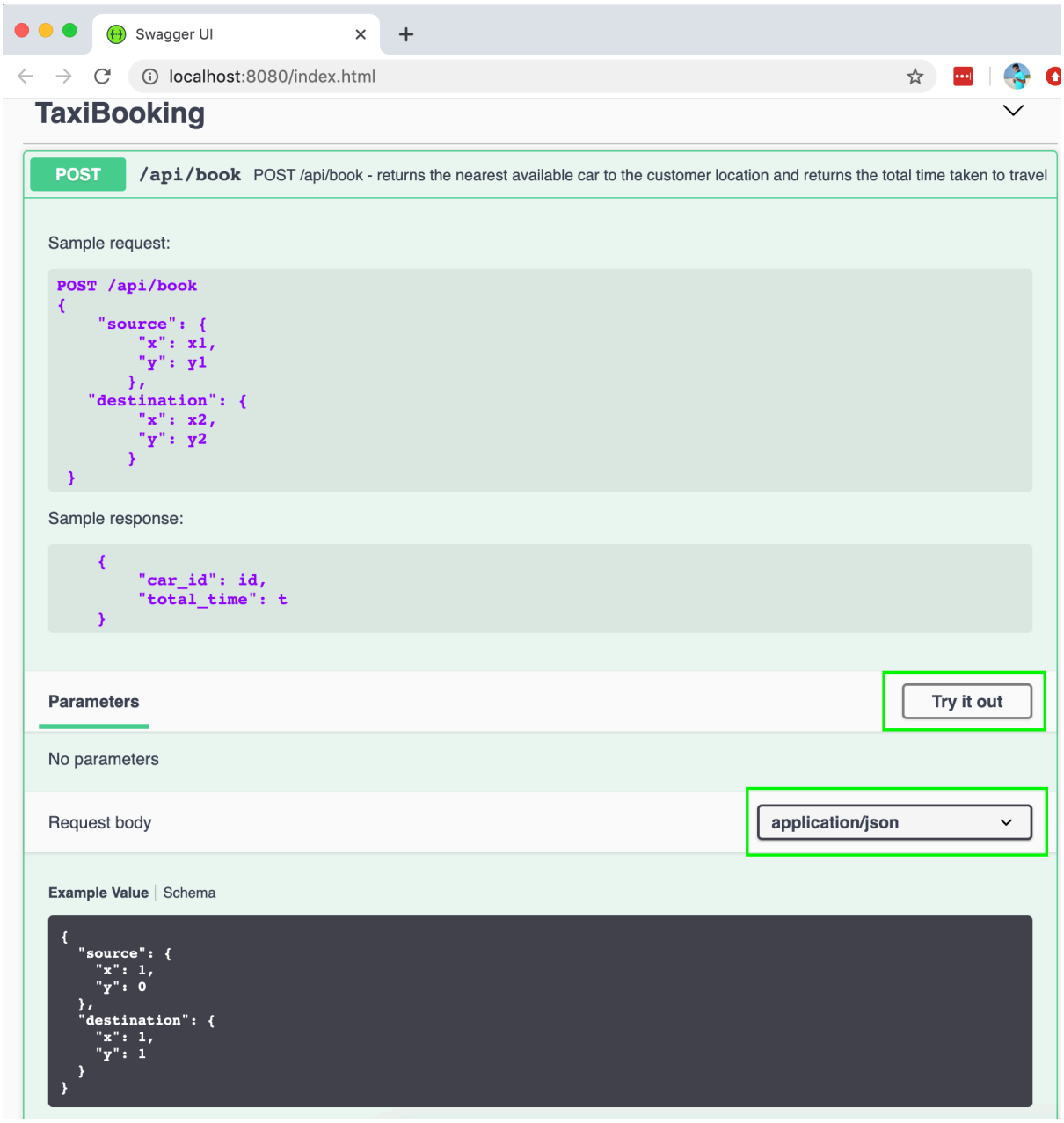
For API Documentation I have used ***Swagger***, which reads your API's structure, and automatically builds beautiful and interactive API documentation.

And I am using Swagger UI to generate **interactive API documentation** that lets you try out the API calls directly in the browser (no need of any third party REST Client like Postman)

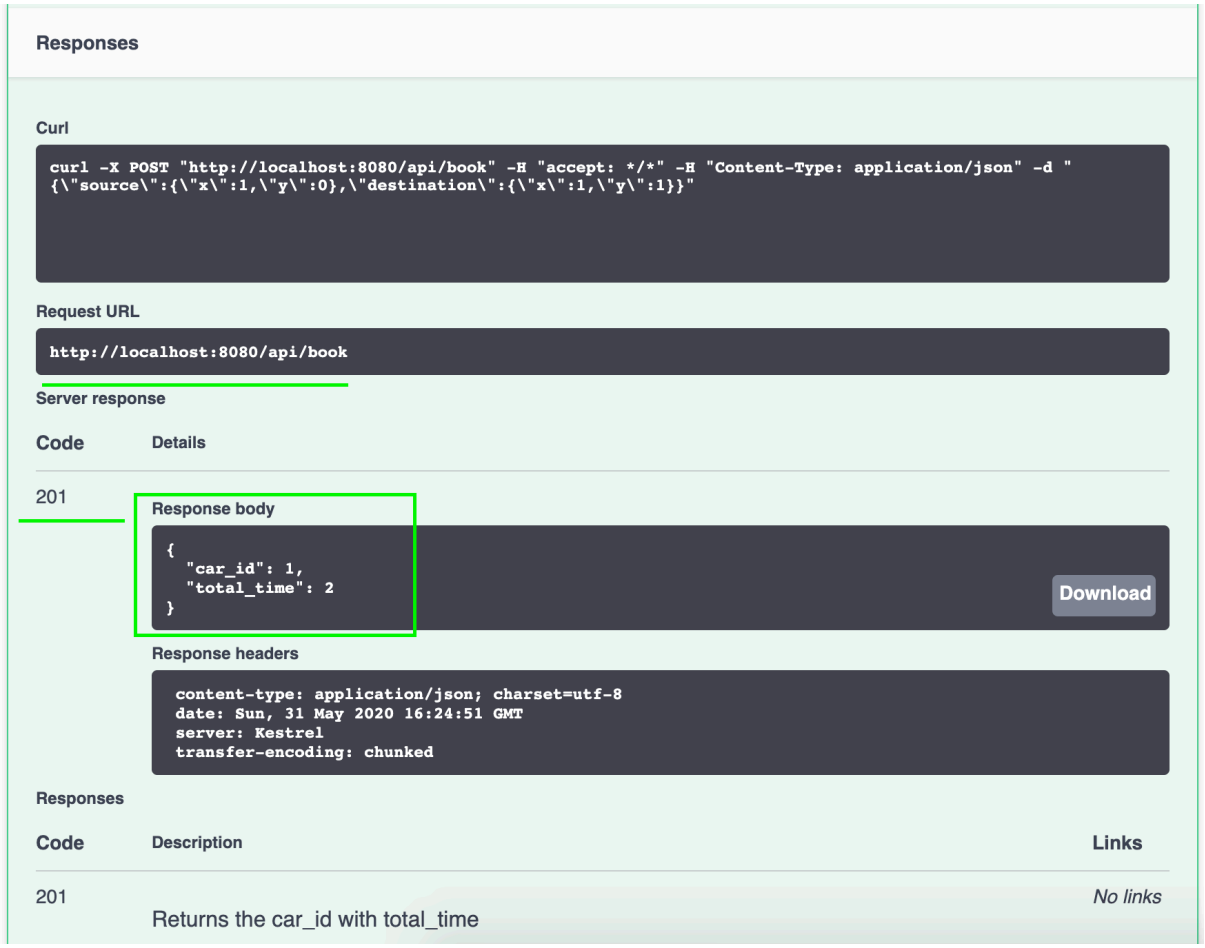


You can try different option and test the API directly from here.

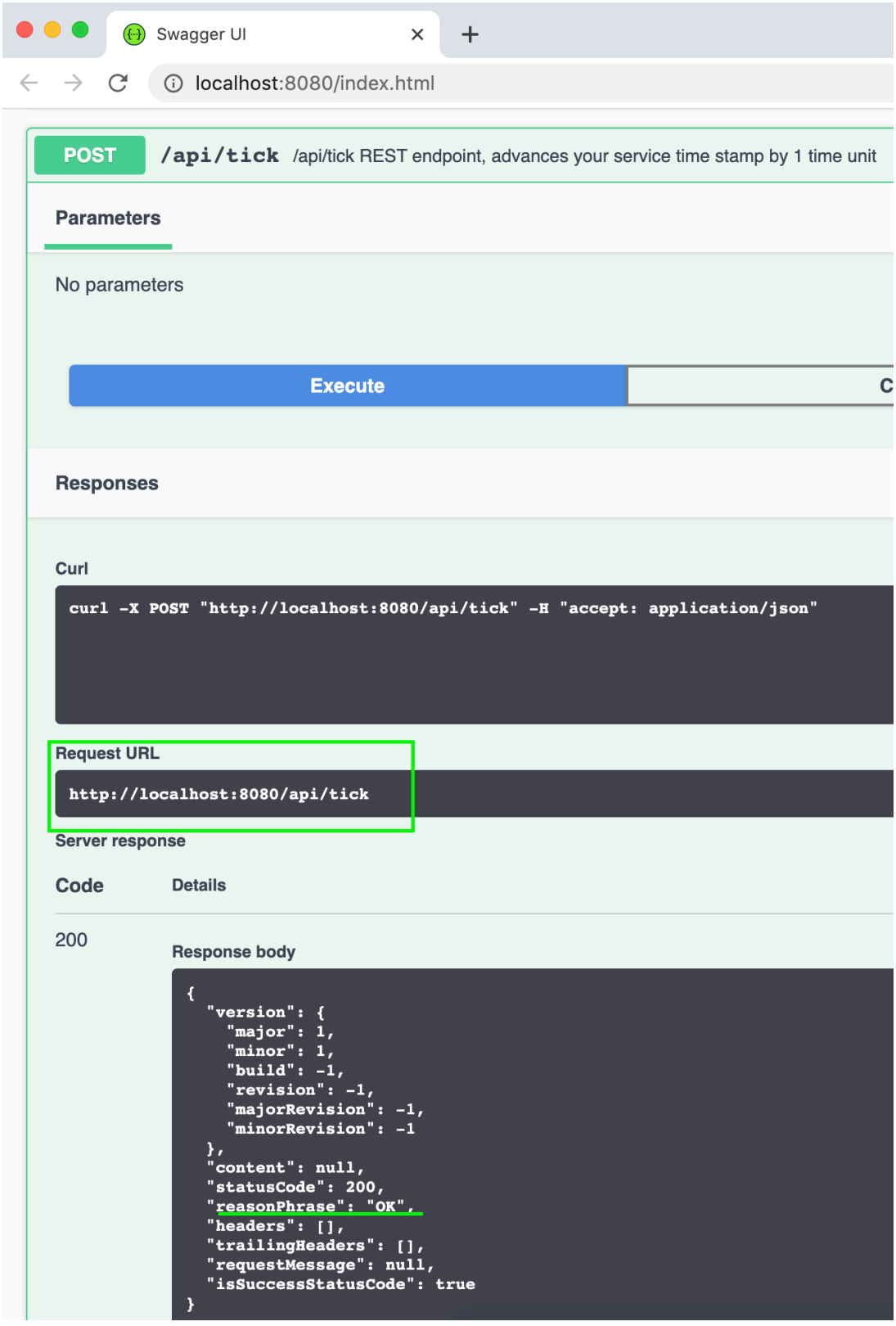
a. POST api/book


Swagger UI
localhost:8080/index.html
TaxiBooking
POST
/api/book
POST /api/book - returns the nearest available car to the customer location and returns the total time taken to travel
Sample request:
POST /api/book
{
"source": {
"x": x1,
"y": y1
},
"destination": {
"x": x2,
"y": y2
}
}
Sample response:
{
"car_id": id,
"total_time": t
}
Parameters
Try it out
No parameters
Request body
application/json
Example Value
Schema
{
"source": {
"x": 1,
"y": 0
},
"destination": {
"x": 1,
"y": 1
}
}

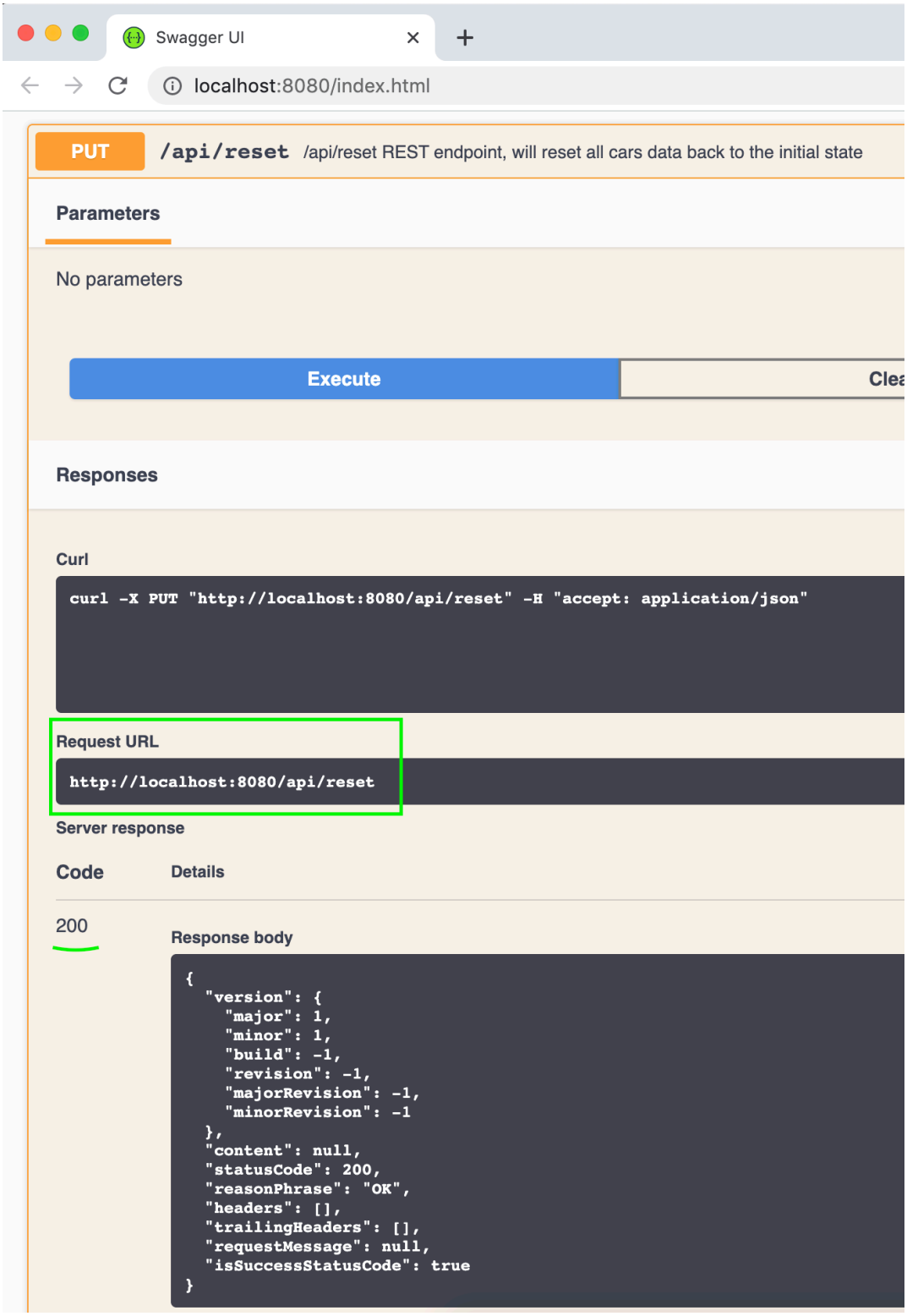
Response


Responses
Curl
curl -X POST "http://localhost:8080/api/book" -H "accept: */*" -H "Content-Type: application/json" -d "{\"source\":{\"x\":1,\"y\":0},\"destination\":{\"x\":1,\"y\":1}}"
Request URL
http://localhost:8080/api/book
Server response
Code
Details
201
Response body
{
"car_id": 1,
"total_time": 2
}
Download
Response headers
content-type: application/json; charset=utf-8
date: Sun, 31 May 2020 16:24:51 GMT
server: Kestrel
transfer-encoding: chunked
Responses
Code
Description
Links
201
Returns the car_id with total_time
No links

b. POST api/tick



C. PUT api/reset



8. Future Work

1. Using **persistent** memory storage like RDBMS like **PostgreSQL**, AWS **Aurora**, DynamoDB
2. Adding the **concurrency**
3. Implement **micro service**-based architecture to scale the application
4. Adding either the **InMemory** Cache or **distributed** Cache to increase the performance
5. Use **OAuth** 2.0 for the **authentication**
6. Securing a RESTful web services by using **HTTPS** instead of **HTTP**