Advanced C#

Exercise Workbook

Lab 00: Introduction to Git and GitHub (OPTIONAL)

Use these instructions to familiarize yourself with GitHub (if you have not used GitHub previously)

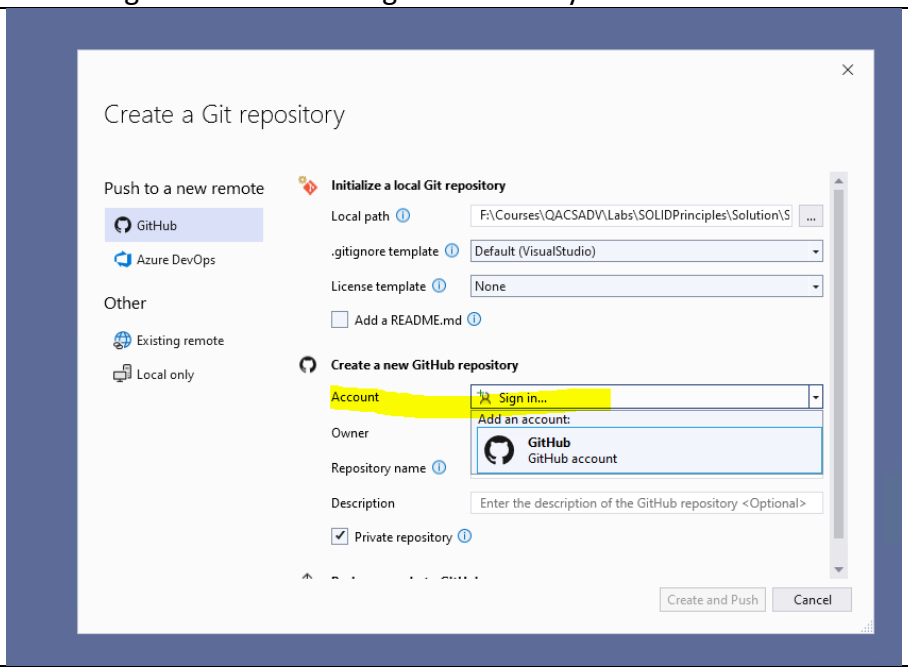
Objective

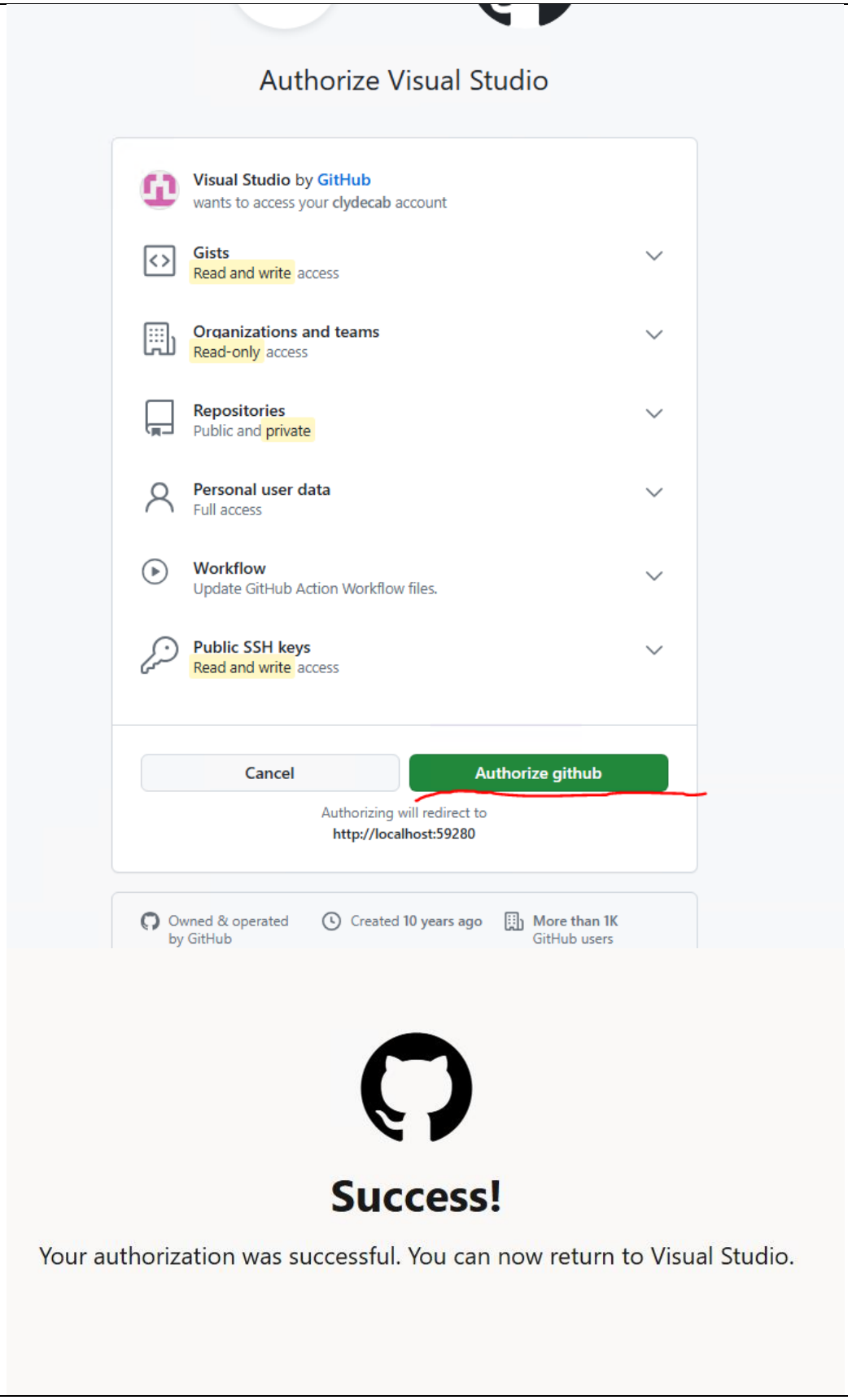
Gain an understanding of how GitHub can be used to work on projects in a collaborative environment. You are encouraged to use GitHub as a repository for **ALL** the code you work on as part of this course. Using it means you are less likely to be impacted on a virtual machine timing out at some point. This is especially true of LOD machines and less so if you are using GoToMyPC. However, **ALL** VM's will be reset at the course's conclusion so **backing things up is a really good idea**.

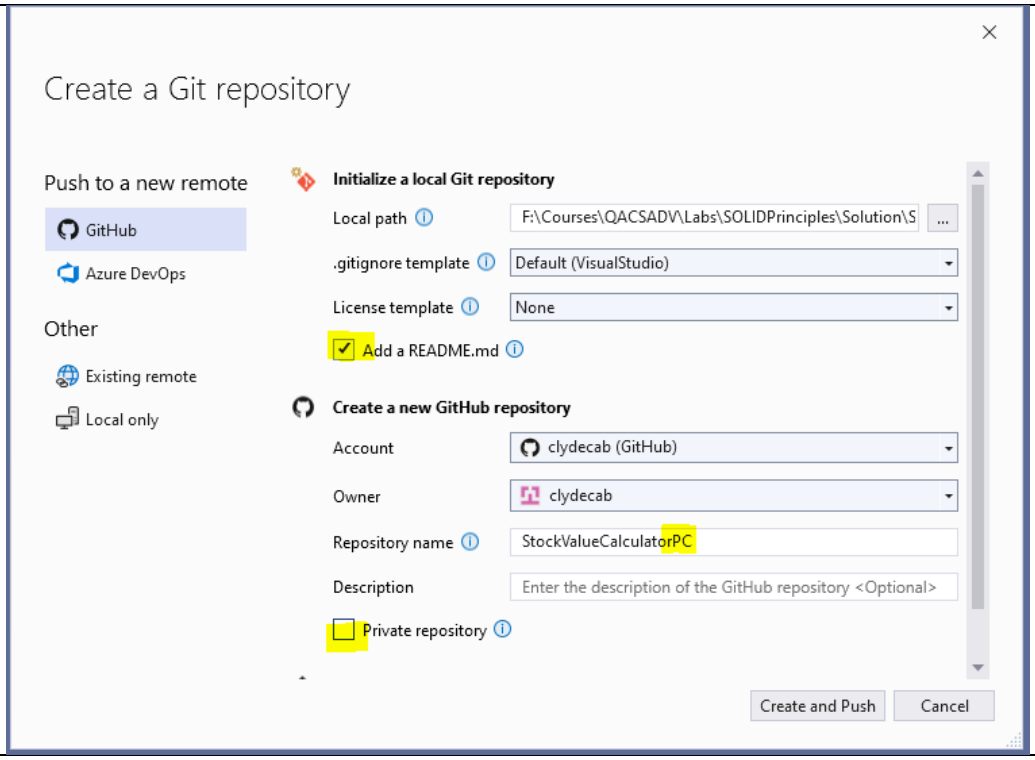
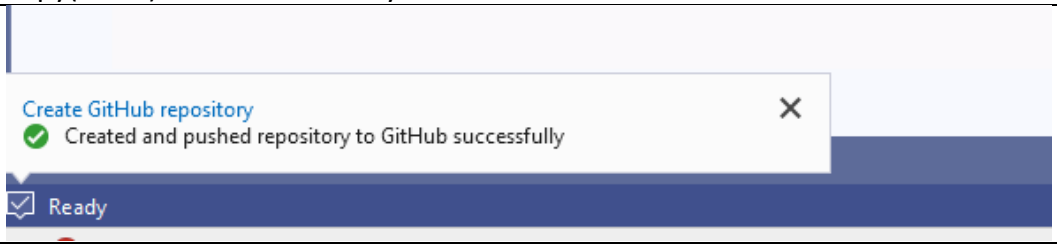
Requirements

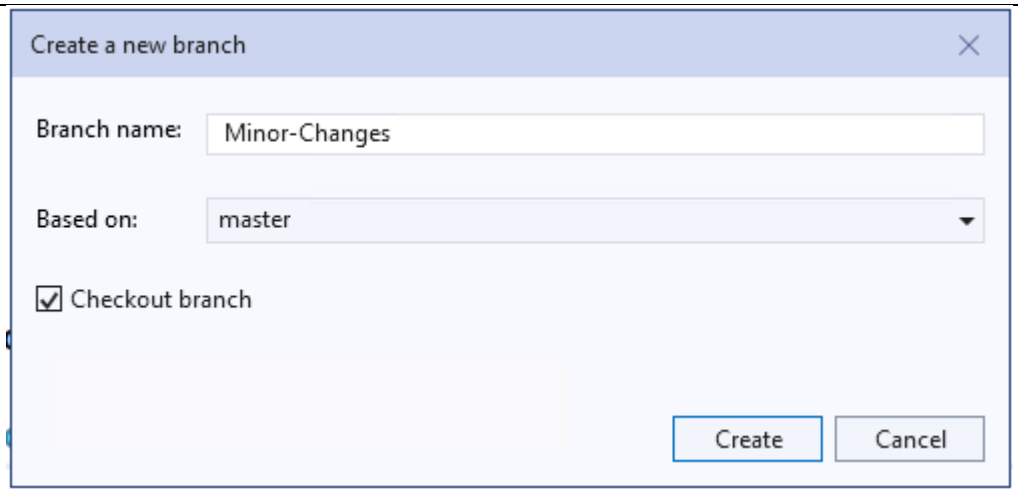
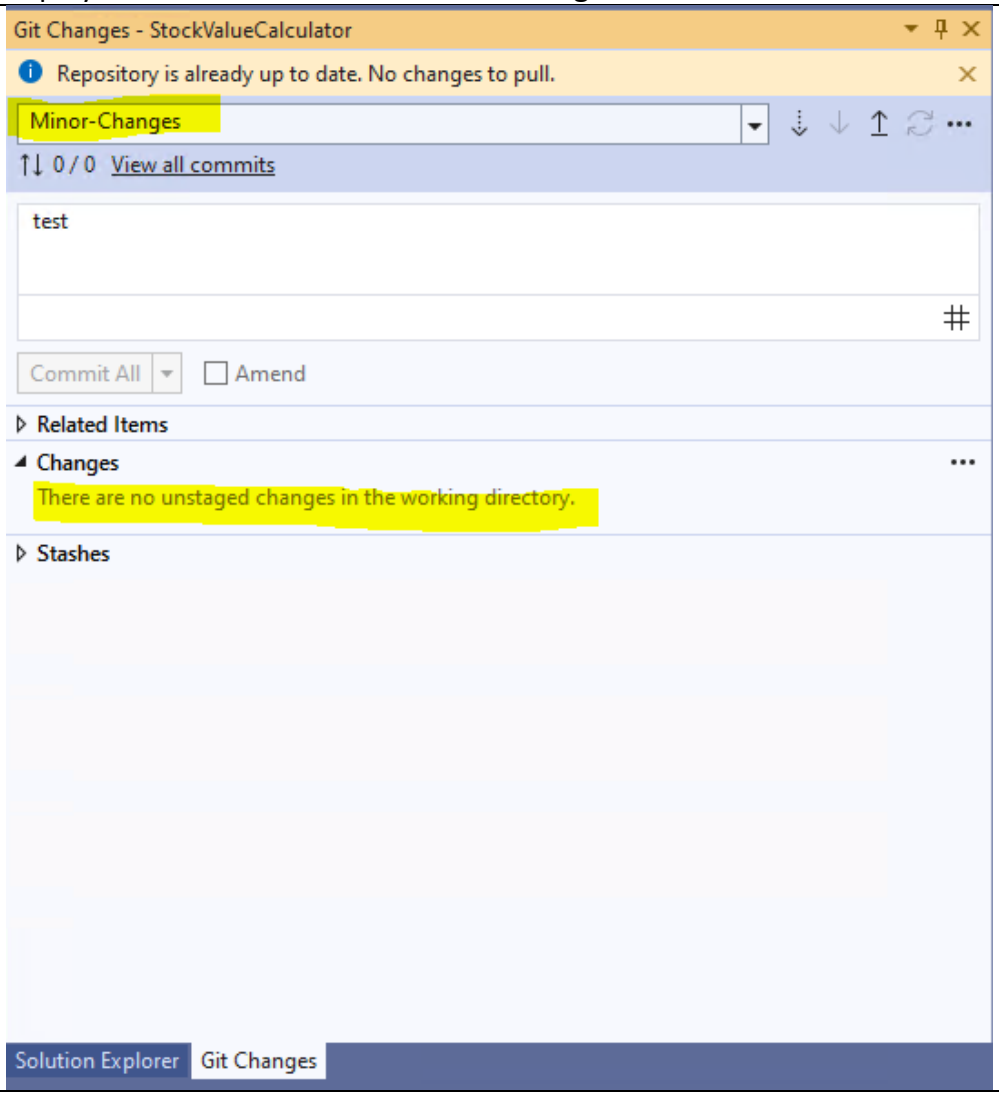
Create a GitHub account (if necessary) and then follow a the “hello world intro to GitHub” on the GitHub portal. Then use Visual Studio in conjunction with Github to manage versioning.

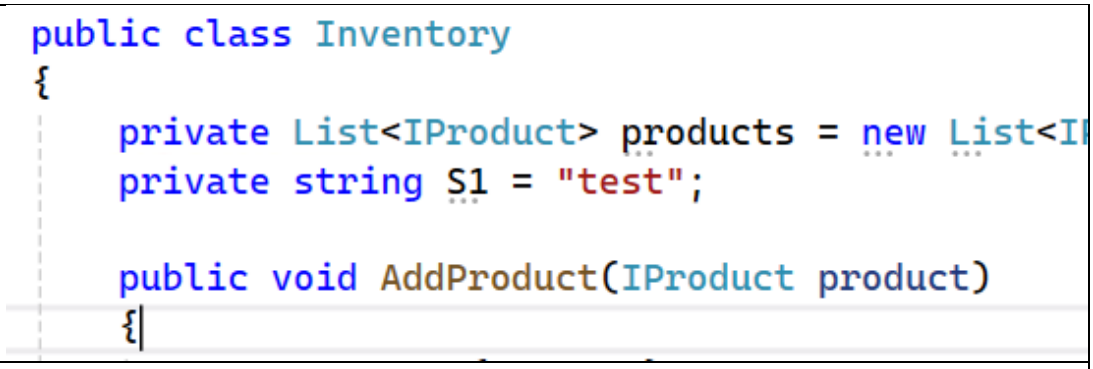
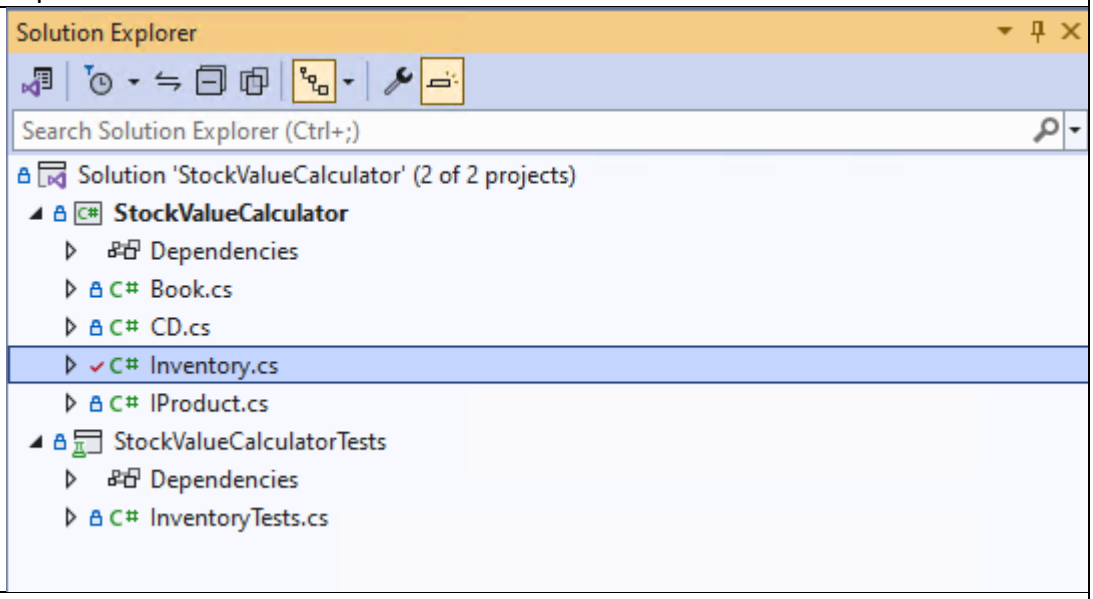
Steps to Complete

1	**Create your GitHub account** https://docs.github.com/en/get-started/start-your-journey/creating-an-account-on-github
2	**Create a repository and use it to merge changes into the main branch from a another** https://docs.github.com/en/get-started/start-your-journey/hello-world
3	**Using GitHub with Visual Studio** a. Using Visual Studio Open the Solution called StockValueCalculator.sln located in Labs\00 Introduction to Git and GitHub\Starter folder b. Under the Git item on the main menu select Create Git Repository c. Sign in to GitHub using the account you used earlier.
4	

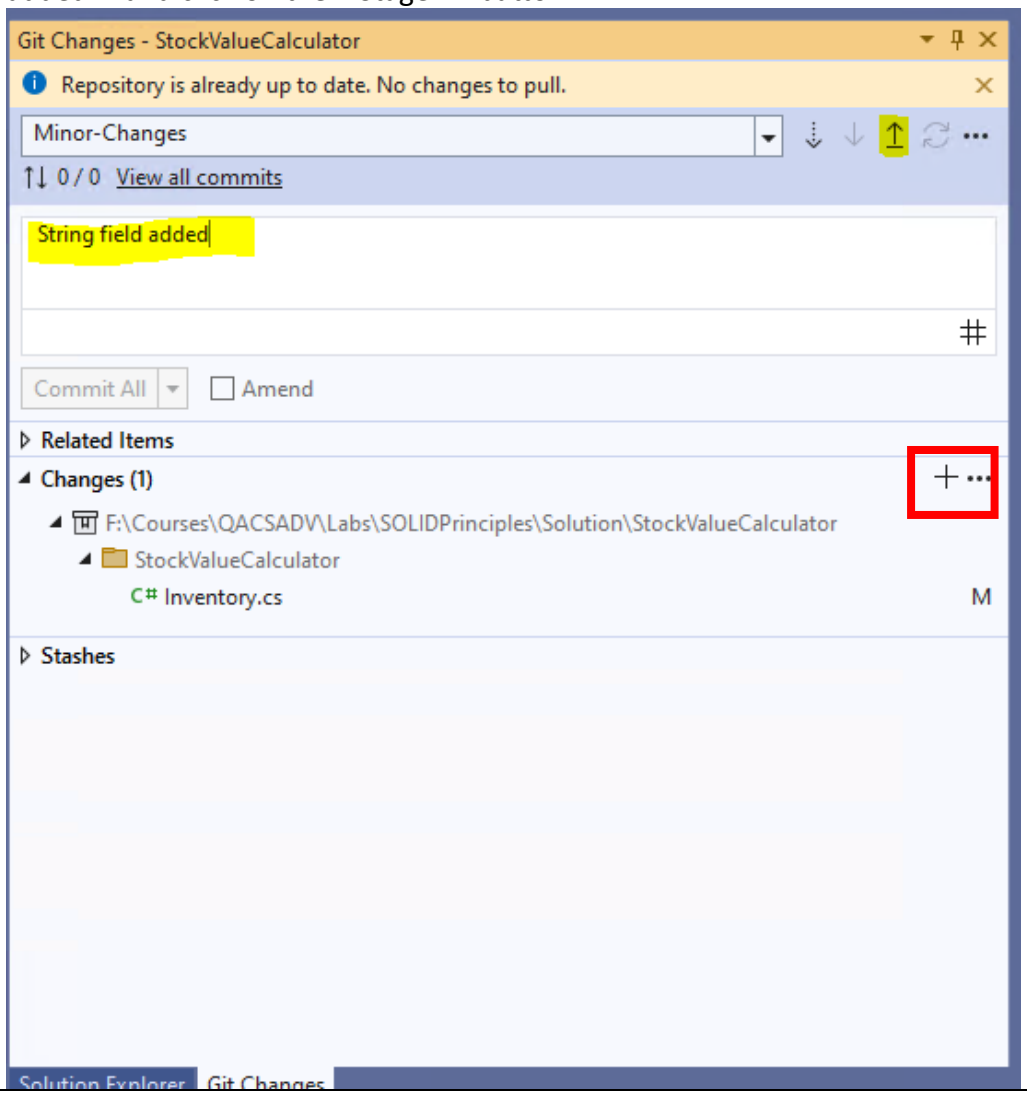

Authorize Visual Studio
Visual Studio by GitHub
wants to access your clydecab account
Gists
Read and write access
Organizations and teams
Read-only access
Repositories
Public and private
Personal user data
Full access
Workflow
Update GitHub Action Workflow files.
Public SSH keys
Read and write access
Cancel
Authorize github
Authorizing will redirect to
http://localhost:59280
Owned & operated by GitHub
Created 10 years ago
More than 1K GitHub users
Success!
Your authorization was successful. You can now return to Visual Studio.

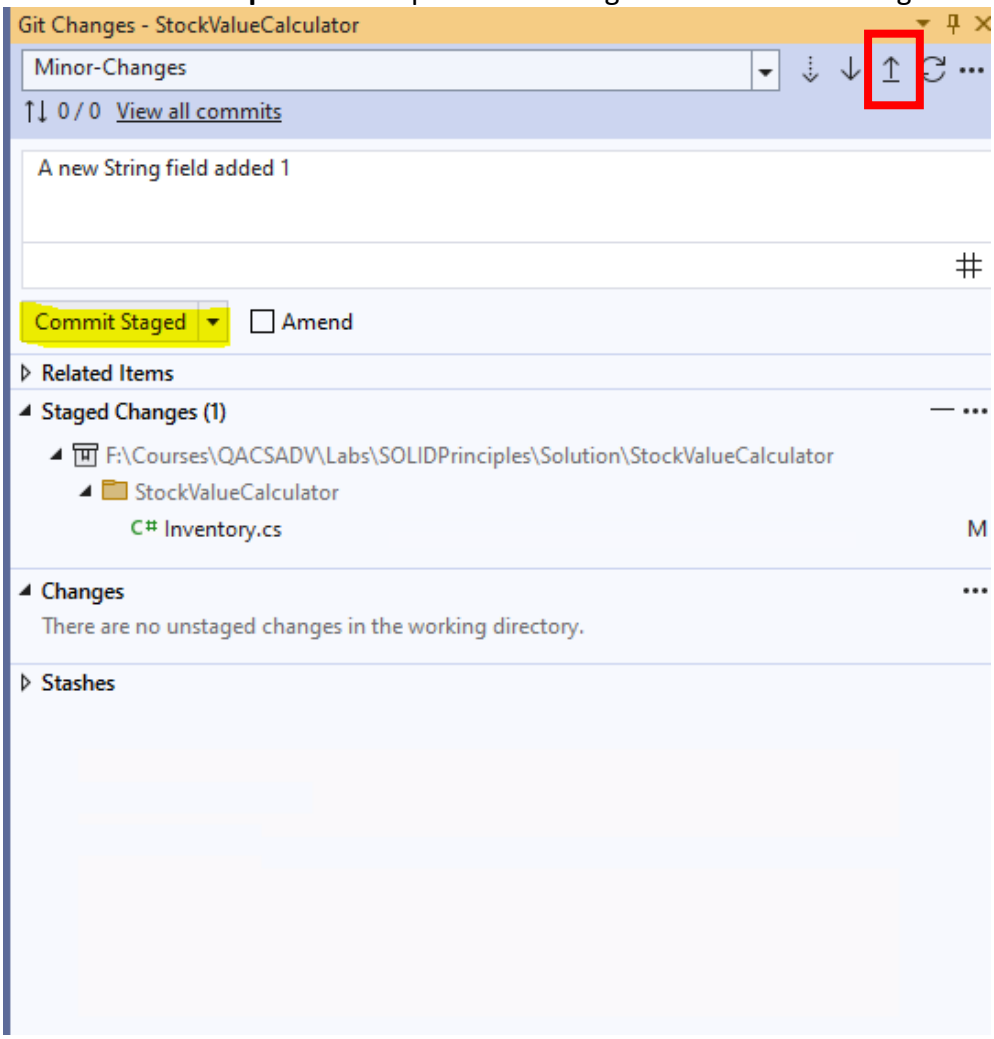
5	Add your initials to the end of the auto-generated repository name ("PC" in the example below), deselect the Private repository option and select the Add a README.md
6	
7	Then click on the Create and Push button
8	Your project has now been uploaded to GitHub and you also have a local copy(clone) on the local file system.
9	
10	Now make a branch to support updates to the current project. Click on the Git item in the main menu of Visual Studio and select the **New Branch** Item. Name the branch **Minor-Changes** and confirm that the **Checkout branch** option is selected

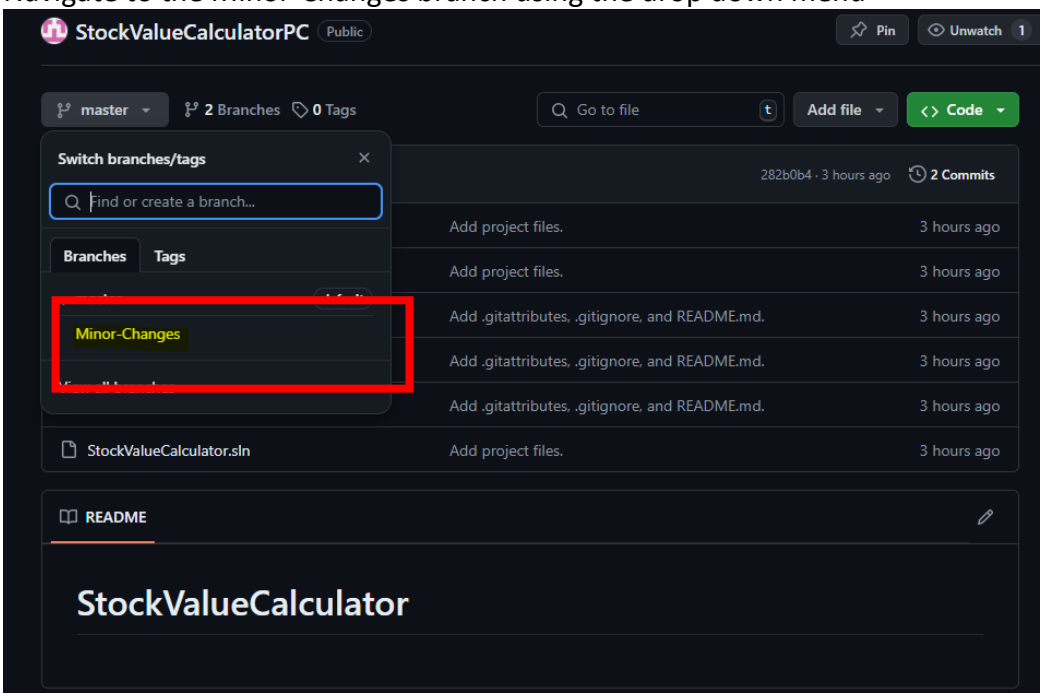
11	
12	Click on create, and if prompted for further input, accept the defaults and continue.
13	The **Git Changes** window should show that there are currently no changes deployed to the branch named **Minor-Changes**
14	
15	Open the Inventory.cs file and declare a private field of type string named S1 and initialise this to have a default value of “test”

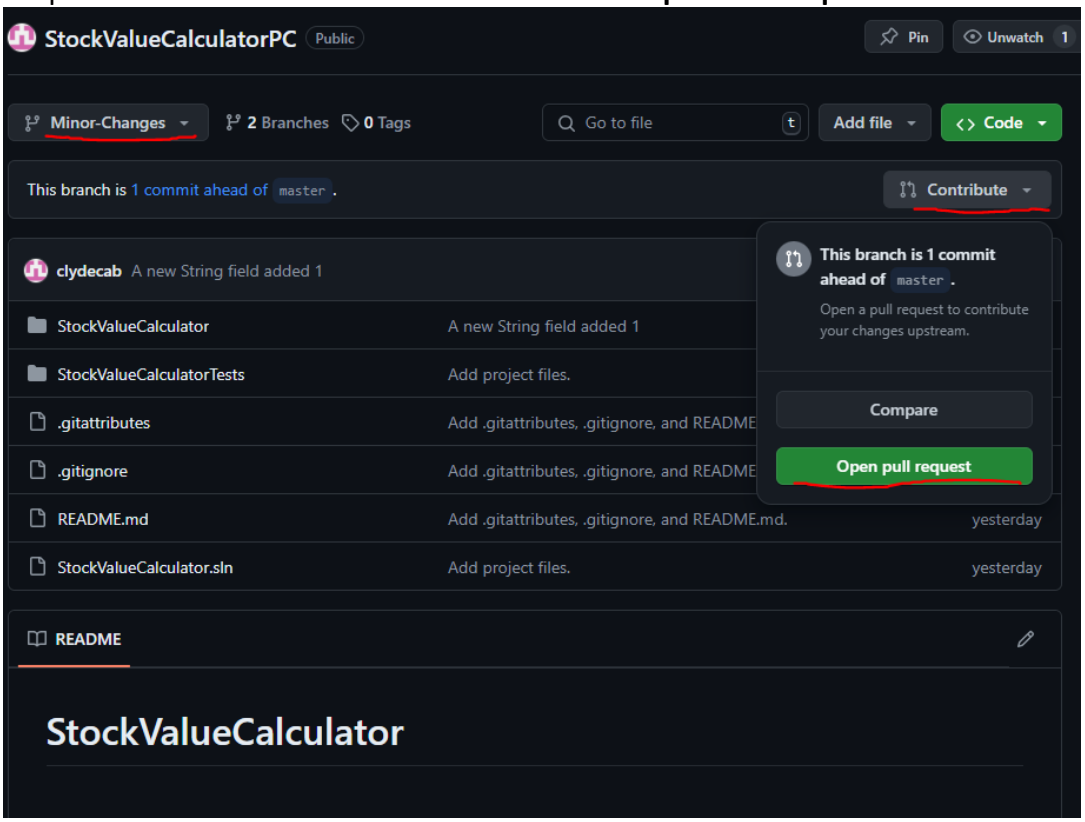
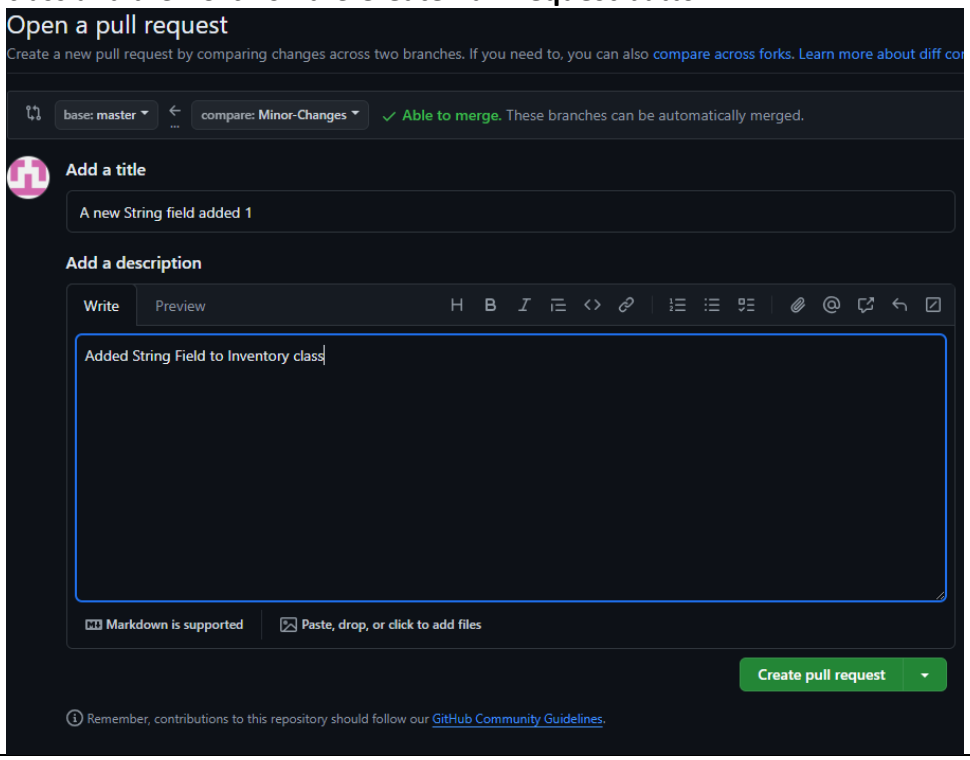
16	
17	Notice that the modified file has a red tick associated with it in the Solution Explorer window
18	
19	Open the Git Changes tab and **double click** on the Inventory.cs file. The diff view appears highlighting the change (Additional line) added to the source code
20	Additionally, the status bar at displayed at the bottom of the Visual Studio window displays 1 change to the file associated with the branch named Minor-Changes

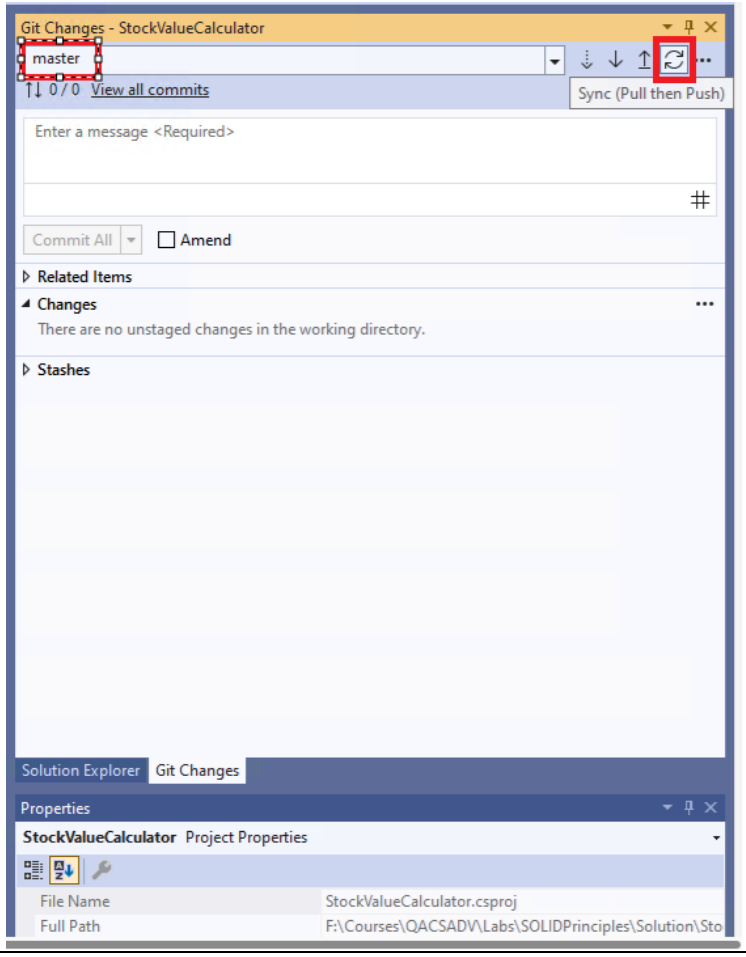
21	 Properties 0 / 0 1 Minor-Changes StockValueCalculator

22	Now we will commit the changes to the GitHub Repo. In solution explorer right click on the Inventory.cs file select the Git menu item and then select the Commit or Stash item. Enter a description in the input text field, such as “string field added”. and click on the + Stage All button 

23	The UI should now display as shown below. Click on the **Commit Staged** button. Then click on the **up arrow** to upload the changes to the Minor-Changes Branch 
24	Check that the changes have been pushed to the repo by using a browser to navigate to https://github.com/ and select the StockValueCalculatorXX repo.

25	Navigate to the Minor-Changes branch using the drop down menu 
26	Open the StockValue calculator folder that contains the Inventory.cs file. You should see the modifications have been pushed to the branch named Minor-Changes. The master branch should still have the original version. We will now merge the changes recorded in the Minor-Changes branch with the master branch

27	In the GitHub Portal ensure the Minor-Changes branch is selected in the dropdown. Then from the Contribute menu click **Open Pull Request** 
28	In the form that appears add a description e.g. Added String Field to Inventory class and then Click on the **Create Pull Request** button. 

29	On the next page click on the **Merge pull request** and then **Confirm merge** buttons in order to commit the changes with the master branch
30	Go back to Visual Studio select the **master** branch from the dropdown in the **Git Changes** tab and click on the **Sync (Push and Pull)** button 
31	The graph displaying the updates to the master branch will now include the change you recorded the Minor-Changes branch. 
32	Feel free to use GitHub when working on other exercises in the labs that follow this one.

Lab 01: SOLID Principles

Objective

Your goal is to refactor code so that adheres to SOLID principles by implementing an inventory system for a bookstore.

Overview

You are provided with a "Starter" program that manages an inventory system for a bookstore. The system allows adding books and CDs to the inventory and calculating the total stock value. The original code violates multiple SOLID principles. Your task is to refactor this code to make it more modular, maintainable, and extensible.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

Steps

Open the StockValueCalculator solution in Visual Studio. It contains two projects one called StockValueCalculator that contains functioning code that keeps track of a collection of products and their collective value and the other called StockValueCalculatorTests that hosts a single unit test that validates the functionality of the StockValueCalculator project.

Run the test to ensure the code functions correctly.

Problems in the Starter Code:

Single Responsibility Principle: The Product class is managing products without distinction between types.

Open/Closed Principle: Adding a new product type (like magazines or DVDs) would require modifying existing methods and possibly the Product class.

Dependency Inversion Principle: There is a direct dependency on low-level module details (like product type checks) in the inventory management.

Requirements

Refactor the Starter code so that it adheres to SOLID principles such that:

- Each product type (Book, CD) has its class that handles its specific attributes. (Single Responsibility Principle)
- The addition of new product types is straightforward and will not require changes to the existing code. (You can achieve this by creating a new class that implements an IProduct interface). (Open/Closed Principle)
- The Inventory class works with the IProduct interface, not concrete classes, which will decouple the code and make it more flexible. (Dependency Inversion Principle).

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 02: Coding Patterns

Exercise: Implement a Vehicle Management System using Design Patterns

Objective

Your goal is to implement the functionality described below using the specified design patterns

Overview

You are tasked with designing and implementing a vehicle management system in C#. This system will allow users to create, manage, and monitor different types of vehicles such as cars, lorries, and motorcycles. To ensure the application is scalable, maintainable, and well-organized, you should employ the following three design patterns: **Factory**, **Composite**, and **Observer**.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

Steps

In this lab you are provided with a starter project that contains a set of relevant code files each of which contain sets of comments that suggest what functionality the classes/interfaces should provide.

Open the starter project and implement the following requirements:

Requirements

1. **Vehicle Creation (Factory Pattern)**
    - Implement a **VehicleFactory** class that creates vehicles like cars, lorries, and motorcycles. This factory will facilitate object creation and can be extended in the future to include more vehicle types without modifying the client code.
    - Each vehicle should be derived from a common interface or abstract class, e.g., **IVehicle**.
2. **Managing Fleets of Vehicles (Composite Pattern)**
    - Use the Composite pattern to treat individual vehicles and groups of vehicles uniformly.
    - Implement a **VehicleGroup** class that can contain individual vehicles or other groups of vehicles. This class should also implement the **IVehicle** interface.
    - Include methods for adding and removing vehicles from groups.
3. **Monitoring Vehicle Status (Observer Pattern)**
    - Implement an Observer pattern where a **VehicleMonitor** class (which displays vehicle statuses) observes changes in the vehicles' properties or compositions (like adding or removing a vehicle in a **VehicleGroup** or starting or stopping a vehicle's engine).
    - Whenever a vehicle's status is updated, the monitor should automatically update to reflect changes.

Steps to Complete

1. **Define IVehicle Interface**
    - Define common operations like **DisplayStatus**, **StartEngine**, and **StopEngine**.
    - The interface should also define a property named **Owner** of type **string**.
2. **Implement Concrete Vehicles**
    - Create classes like **Car**, **Lorry**, and **Motorcycle** that implement the **IVehicle** interface.
    - Add code to the DisplayStatus, StartEngine and StopEngine methods that write appropriate messages to the console.

- For each class add a constructor that has a single string parameter. Use the parameter value passed to initialise the Owner property.

3. **Create Vehicle Factory**
   - Implement the **VehicleFactory** with methods to create different vehicles based on input parameters, such as **CreateVehicle("Car")**.
   - Add code to **Program**.cs that tests what you've done:
     - Create a **Vehicle** Factory.
     - Get the factory to create a car, lorry and motorcycle.
     - Start and stop the engines of the vehicles and display their statuses.
     - Run the program and ensure it works as expected.
4. **Implement the Composite Pattern**
   - Extend the **IVehicle** interface to include **Add** and **Remove** methods that take **IVehicle** as a parameter.
   - Update the **Car**, **Lorry** and **Motorcycle** classes to include the required **Add** and **Remove** methods. We don't want to be able to Add or Remove vehicles to vehicles so leave their code blocks empty.
   - Add a **VehicleGroup** class to the project that implements **IVehicle** and contains a **List<IVehicle>** object called **_vehicles**.
     - Give the **VehicleGroup** class a constructor that accepts a string parameter, which it uses to initialise the Owner property.
     - Implement the required functionality by making the **DisplayStatus**, **StartEngine** and **StopEngine** methods loop round the **_vehicles** collection and invoke the corresponding method on each of its vehicles.
     - Implement the **Add** and **Remove** methods adding or removing the passed in vehicle to the **_vehicles** collection as appropriate.
   - Add code to **Program**.cs that tests what you've done:
     - Create a **VehicleGroup**
     - Add the car, lorry and motorcycle to the group and/or create and add new ones
     - Invoke the **DisplayStatus**, **StartEngine** and **StopEngine** methods of the **VehicleGroup** and ensure all the vehicles in the group perform as expected.
     - Run the program and ensure it works as expected.
5. **Implement VehicleMonitor and Observer Logic**
   - Implement an interface called **IVehicleChangedObserver** with a method called **Update** that takes an **IVehicle** as a parameter.
   - Create a **VehicleMonitor** class that implements **IVehicleChangedObserver**. We want its **Update** method to be triggered when monitored vehicles change their status (e.g. when a vehicle engine starts or stops). Add code to the method that writes one of two alternative messages to the console based on whether the passed in vehicle is a **VehicleGroup** or not.
   - Add an **Action<IVehicle>** delegate to the **IVehicle** interface called OnChange. Declare the delegate as an **event**. Vehicles will notify the **VehicleMonitor** via this event when their status changes.
   - Configure the **Car**, **Lorry**, **Motorbike** and **VehicleGroup** classes to implement the new event.
   - Add code to each of the **Car**, **Lorry**, **Motorbike** and **VehicleGroup** classes that triggers the **OnChange** event (but only if it's not **null**) in the **DisplayStatus**, **StartEngine** and StopEngine methods.

- Add code to Program.cs that tests what you've done:
  - In an appropriate location instantiate a new **VehicleMonitor** object called **monitor**.
  - Hook the car, lorry, motorbike and vehicleGroup's **OnChange** events to the **monitor** object's **Update** handler method.
  - Run the program and ensure it works as expected.

6. **Test Your Application via a set of unit tests**
   - If you have time, create a set of unit tests for your application.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Enhancement (If you have time)

Try to enhance the Vehicle Management System by incorporating the Command Pattern. This pattern will provide a flexible and extendable way to encapsulate all details of operations performed on vehicles, such as starting or stopping engines, into command objects. This will also allow for easier tracking of operations (useful for undo/redo functionalities in more complex applications) and can organize the commands into a queue or a history log.

Steps you will need to take:

1. **Define a Command Interface.**
   - Give the interface a name of ICommand.
   - Get the interface to support Execute and Undo methods. Both methods should be void and take no parameters.
2. **Implement StartEngineCommand and StopEngineCommand classes**.
   - Create concrete command classes for starting and stopping the vehicle engines.
   - Make the classes implement ICommand.
   - Each class's constructor should be passed an IVehicle object that the Execute and Undo methods should use to invoke the StartEngine and StopEngine methods.
3. **Create a CommandInvoker class**. Implement an invoker class that can execute commands and optionally manage a history of commands for undo operations. It is suggested you do this by defining and instantiating a Stack<ICommand> collection within the class. Then implement the following methods:
   - **ExecuteCommand** that takes an **ICommand** object as a parameter, invokes its **Execute** method and then pushes the command onto the Stack.
   - **UndoLastCommand** that takes an **ICommand** object as a parameter, checks to ensure the stack isn't empty and if not pops the last command off the stack and invokes its **Undo** method.
4. **Integrate the Commands into the Main Program.** Modify the main program to use commands for vehicle operations.
   - Declare and instantiate a **CommandInvoker** object.
   - Create some **StartEngineCommand** and **StopEngineCommand** objects passing appropriate parameters to the constructor.

- Call the invoker object's **ExecuteCommand** method a number of times passing in the **ICommand** objects you've just created.
- Call the invoker object's **UndoLastCommand** method.
- Check the programs output to ensure the code is working as expected.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 03: Asynchronous Programming and Concurrency

Exercise: Word Prefixes

Objective

The purpose of this exercise is to experiment with different scenarios mentioned in the asynchronous programming module.

Overview

Word prefixes are also called stems. We have written a starter program, StemsLab, that contains a file (StemsOrig.cs) that reads the contents of a file that contains a large number of words and generates the most popular stems of 2 to n characters long. For example, the most common 2 letter stem is "co" (meaning that most words in the file start with these letters – there are 1793 of them!). The most common 3 letter stem is "con" (occurs 737 times) and 4 letter stem is "inte" (254 times).

The code uses a Timer class that calculates and prints how long a piece of code takes to run.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

Initial Steps

Open the StemsLab **starter** solution in Visual Studio. Build and run the program and note the time it takes to execute. You will note that no word exceeds 28 characters, so n could be 28. However, we can increase the value of n to obtain a longer runtime and demonstrate multiprocessing.

This program could complete more quickly by splitting the searches into separate tasks. Where each task works on a separate stem size (2 chars, 3 chars, up to 28 chars).

Scenarios:

a) ***n*** worker processes.

   This is where we split the task such that each stem length search runs in its own child process.

b) 2 worker processes ***n***/2 stem sizes each.

   This assumes 2 CPU cores. It will require two processes to be launched explicitly, and each to be given a range of stem lengths to handle.

If you have time:

c) 2 worker processes using a queue.

   This assumes 2 CPU cores. As in b), but instead of passing a range, pass the stem lengths through a queue. Make sure you have a protocol for the worker processes to detect that the queue has finished. Note, you can't just use any old queue, you need one that is threadsafe such as a `ConcurrentQueue` located in `System.Collections.Concurrent`.

Part A: Split the searching up into individual tasks one per stem size:

1	Add a new class to the project called StemsA.
2	Copy the code in StemsOrig to the new class.

3	Add a new static function to the StemsA class called StemSearch. The function should take the stems dictionary and an integer that will specify the stem size being searched for (2 chars, 3 chars, etc.). The function should return a Tuple<int, string, int> where the first int will be the stem size, the second value (string) will be the bestStem and the final value (int) will be the bestCount (the number of stem occurrences in the data). Declare a variable of this type called *val* at the top of the function and set its value to null.
4	Cut the code that lies inside the StemsOrig's `for` loop and paste it into the StemSearch function (in StemsA) you just created.
5	Delete or comment out the Console.WriteLine statement that lies within the if expression (that tests to see if bestStem isn't empty) and add a line of code that sets the `val` variable to a new `Tuple<int, string, int>` populating it with the relevant values (`stemSize`, `bestStem` and `bestCount`).
6	Make the function return `val`.

We next need to add code to the StemsA class's `FindStems` function that creates a set of Tasks that each point at the StemSearch function and coordinate their behaviours.

7	Declare and instantiate a variable called `tasks` just before the for loop. Specify its type as `List<Task<Tuple<int, string, int>>>`. This Collection will hold all of the Tasks that will be generated in the loop (each Task will tackle a different stem length).
8	Declare and instantiate a variable called `popularStems` also just before the for loop. Specify its type as `List<Tuple<int, string, int>>`. This Collection will eventually hold all of the `Tuples` returned from the calls to the `FindStems` function.
9	Within the `for` loop declare a integer variable called `size` making it equal to the current value of `stemSize`. We're going to pass this (rather than `stemSize`) to the `StemSearch` function because by the time `stemSearch` functions get up and running there's a strong likelihood the `stemSize` variable (which is driving the `For` loop in the `FindStems` function) will have changed.
10	As the next line of code in the loop declare a `Task<Tuple<int, string, int>>` variable called `task` making it equal to `Task.Run(() => StemSearch(stems, size))`. This will grab a Thread from the ThreadPool and get it running the `StemSearch` function.
11	Add `task` to the `tasks` collection.
12	Beneath the `for` loop, add code that Waits until all the tasks have finished by writing: `Task.WhenAll(tasks).Wait();`
14	Next, add code that iterates around the tasks collection (tasks.ForEach(t => ...)) adding each task's Result to the popularStems collection.
15	Finally, create a loop that iterates around the popularStems collection checking for non-null values before printing each Tuple's information (stem size, stem and number of occurrences.
16	Edit the code in Program Main to call StemsA.FindStems().

17	Run the program and confirm it produces the same output as the original code. You should find the code runs quicker than before. This is because as they say "many hands make light work".

Part B: Rework the logic so there are only 2 tasks which work through a range of stem sizes:

1	Copy your solution to part A into a new class file called `StemsB`.
2	Edit the `StemSearch` method so it takes the stems dictionary and two integers one called `start` and the other called `end`. StemSearch should now have three parameters.
3	**Copy** the declaration of the popularStems variable from the FindStems method and add it to the top of the `StemSearch` method.
4	**Cut** the **declaration** of the `for` loop from the `FindStems` method and paste it immediately below the declaration of the `popularStems` variable but before the declaration of `bestStem`. Edit the declaration so the loop starts with a `stemSize` set to the `start` parameter and change the condition, so the loop runs while `stemSize` is less than the value of the `end` parameter.
5	Change the return type of the `StemSearch` method so it returns a `List<Tuple<int, string, int>>`.
6	At the foot of the method make it return `popularStems` (rather than `var`).
7	Delete the declaration of `val` (located towards the top of the method).
8	Move the variables bestStem and bestCount into the for loop (at the top of the loop)
9	Now move the **foreach loop** and the following **if** statement (inside the StemSearch function) into the same for loop so that they appear below the line that initialises the bestCount variable.
10	Locate the code inside the `if (!string.IsNullOrEmpty(bestStem))` expression. Change it so it adds the new `Tuple` to the `popularStems` collection.
11	Delete the two lines in the StemSearch function that display compiler errors: `Task<Tuple<int, string, int>> task = Task.Run(() => StemSearch(stems, size));` `tasks.Add(task);`
12	Delete the variable named size.

The `StemsSearch` function will now hunt for a range of stems specified by the values passed to the function's `start` and `end` parameters. The function returns a collection of popular stems.

13	In the `FindStems` method just beneath the declaration of the integer variable named `n`, declare, and instantiate a variable of type `Task<List<Tuple<int, string, int>>>` naming the variable `task1` and passing `stems, 2, n/2 + 1` as parameters to the `StemSearch` method. `Task<List<Tuple<int, string, int>>> task1 = Task.Run(() => StemSearch(stems, 2,n/2 + 1));`
14	Copy the newly changed line that declares `task1` and paste it immediately beneath it. Rename it as `task2` and pass `stems, n / 2 + 1, n + 1` as the parameters to the `StemSearch` method.

15	Change the `Task.WhenAll()` to wait for both `task1` and `task2` to complete.
16	Add 2 lines that add the `Results` of each completed `Task` to the `popularStems` collection (by using its `AddRange()` method).
17	Edit the code in `Program Main` to call `StemsB.FindStems()`.
18	Build and run the program. The output should be the same as before, but the code will run more quickly than the original but more slowly than Part A.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If You Have Time:

Part C– Rework the logic so there are 2 tasks that share a queue to work through a range of stem sizes:

You're on your own with this one. You need to use a Thread safe queue such as `System.Collections.Concurrent.ConcurrentQueue`. The queue will need to be filled with a set of stem sizes ranging from 1 to 30. You can use its `Enqueue` method to do this. `ConcurrentQueues` don't support a Dequeue method, but they do have a `TryDequeue` method that returns a `boolean` to indicate success or failure the actual queued value should be passed as an `out` parameter.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 04: A Quick Tour Around ASP.NET Core Web API MVC

Objective

In this exercise we give you a quick tour around the fundamentals of ASP.NET Core Web API MVC.

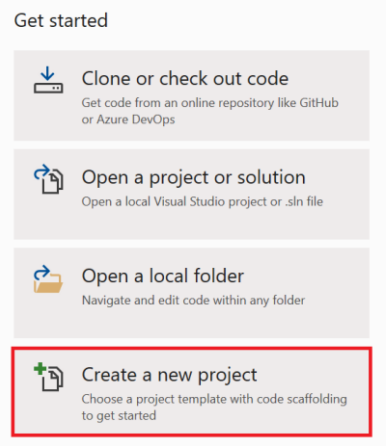
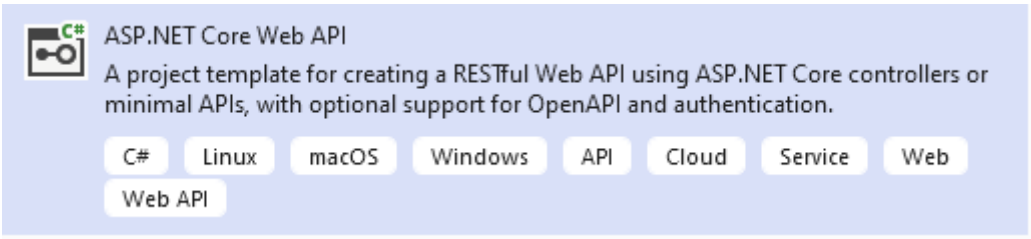
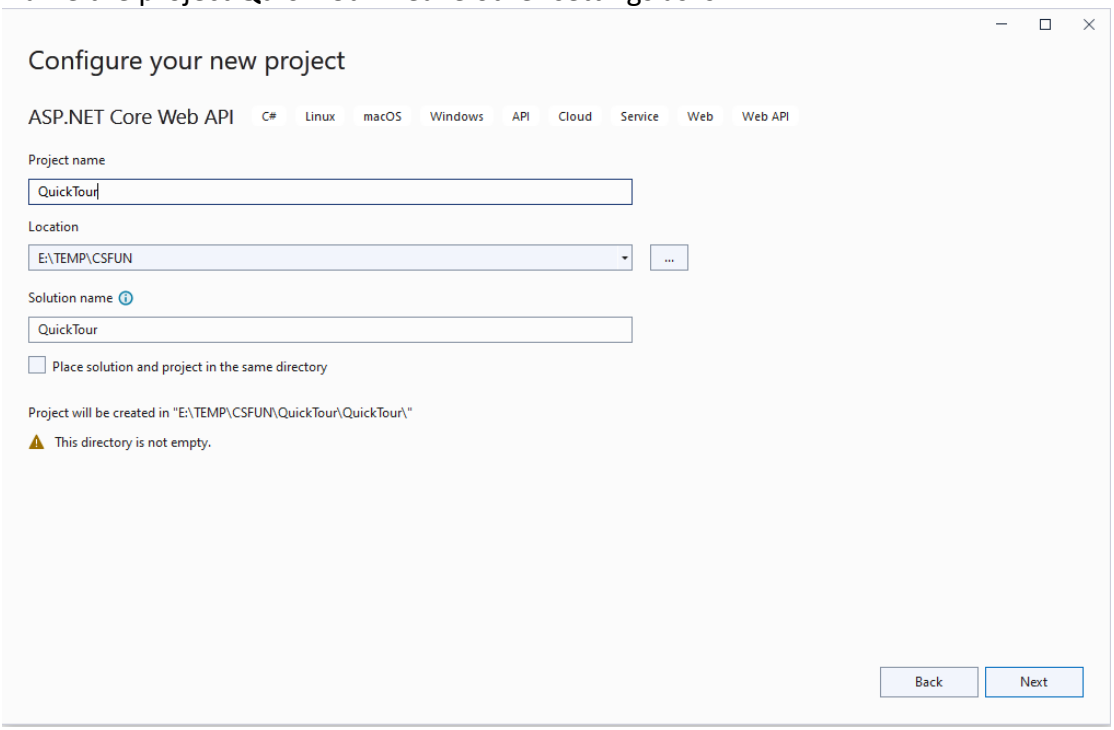
Overview

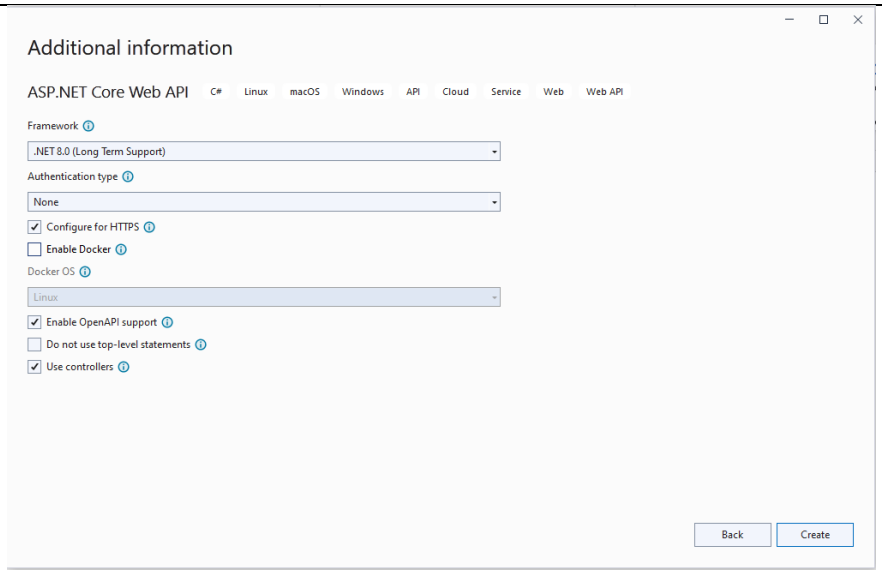
You start out be creating a basic ASP.NET MVC API Core project and then explore how to go about adding a controller and giving it a set of Actions. You will explore how C# method overloading causes issues that can be overcome by adding routing via HttpGet attributes. You will test the applications by using the built in Swagger capabilities and also take a look at using Postman as an alternative.

This exercise will take around 30 minutes.

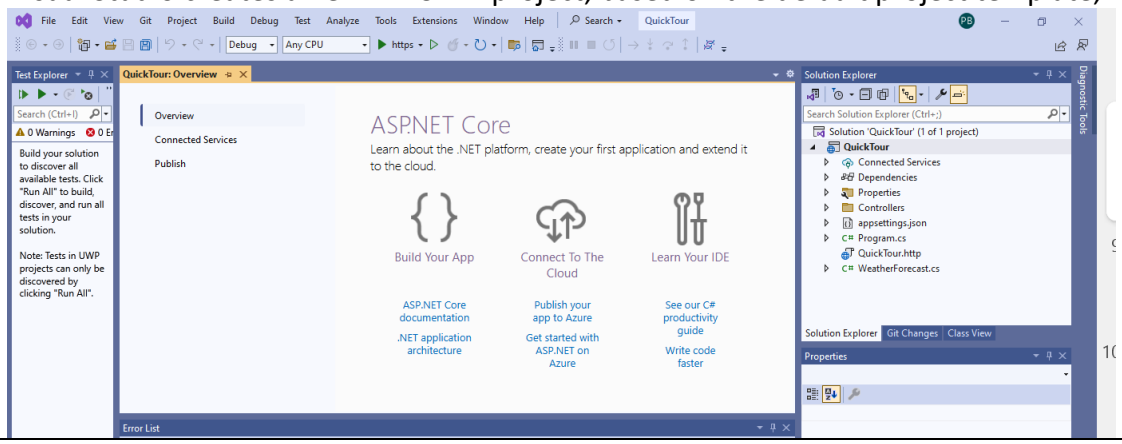
GITHUB

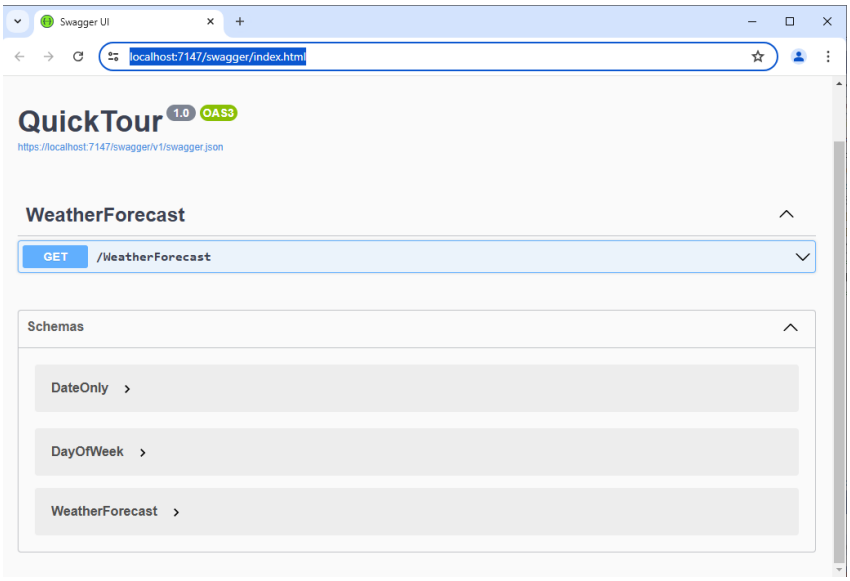
Before starting on the lab please think seriously about using GitHub as a repository for the code.

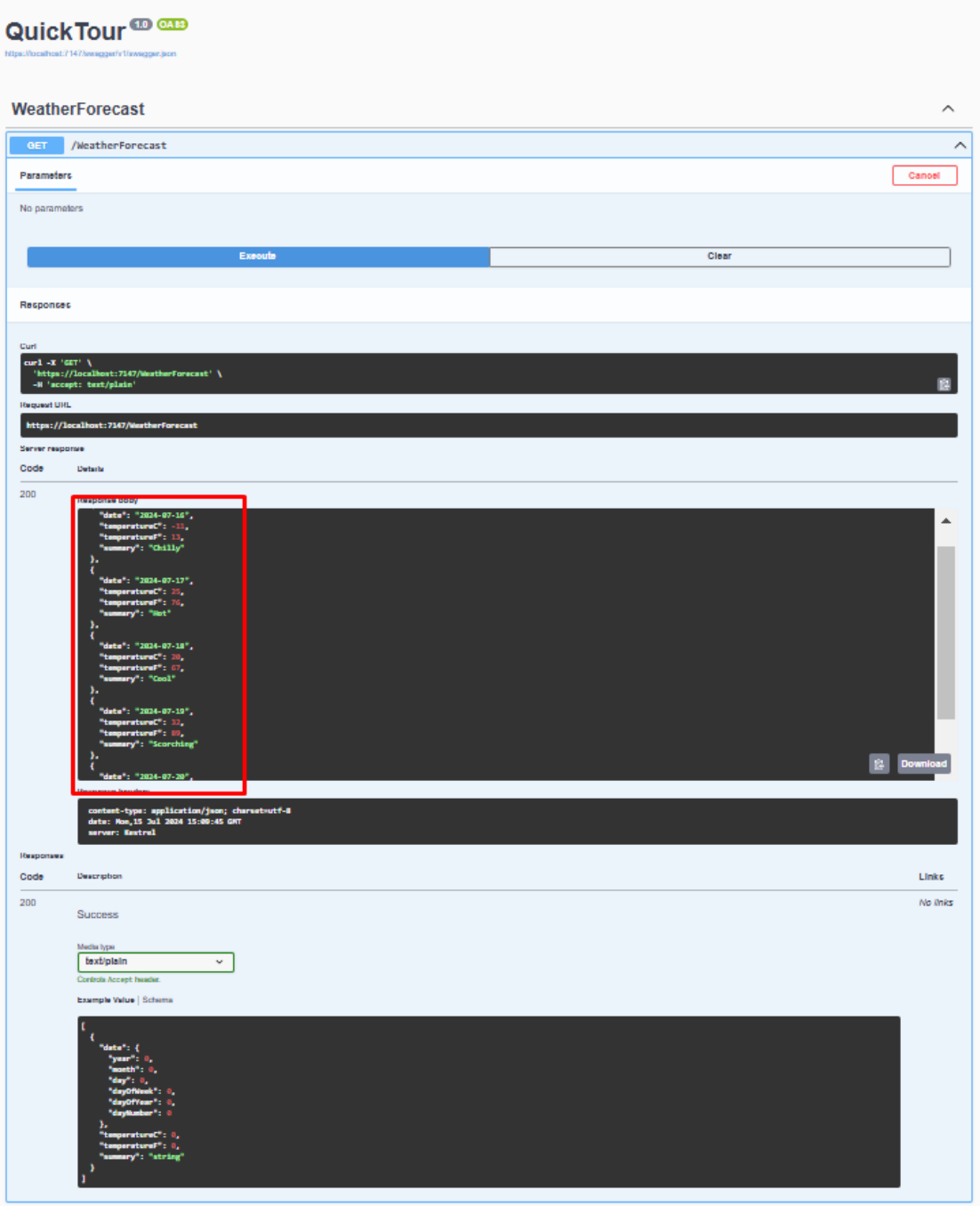
1	There is no starter for this project. Instead, create a new Web Application: We will create one that is very similar to the one which we will use in most of the labs. In Visual Studio, Select Create a new project  Search for "Web Core" and select ASP.NET Core Web API Application  Name the project **QuickTour.** Leave other settings as is:  Select Next Ensure the setting are as specified in the next screenshot and press Create



Visual Studio creates a new MVC API project, based on the default project template,.

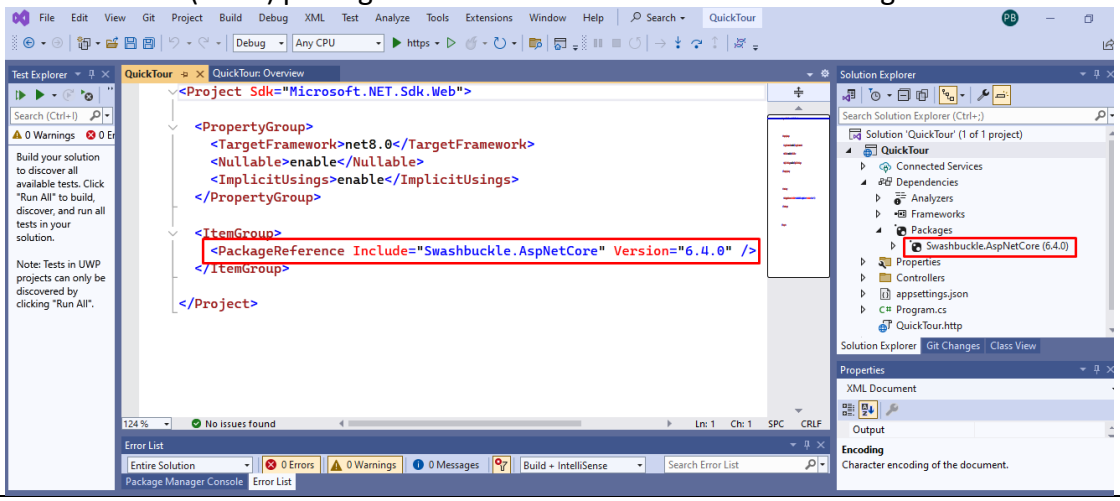


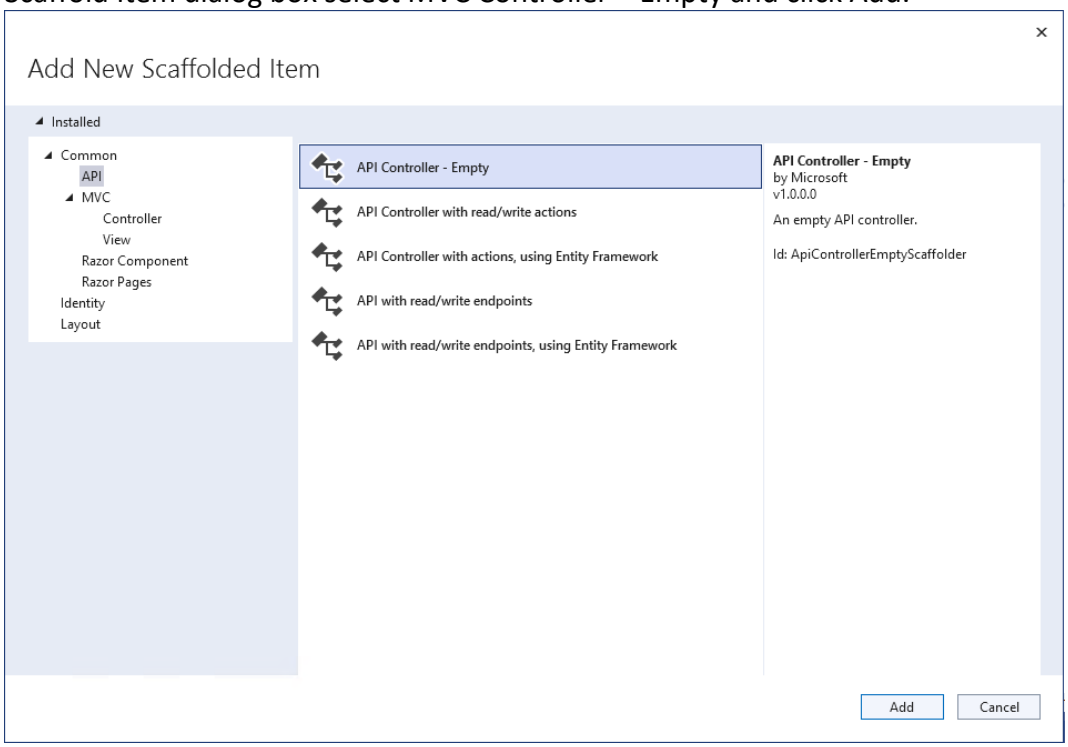
2	To make sure it's a runnable website, press F5. You may be asked to accept a certificate the very first time you run an MVC application in development mode. If so, you should accept the certificate. Then, you will see a Swagger page in a web browser:  Feel free to follow the prompts and invoke the WeatherForecast functionality. You should see something like the following.



The data highlighted in the red box (above) shows some randomly generated data that is supposed to forecast what the weather will be like over the next 5 days.

Close the browser.

3	Expand the Dependencies > Packages folder. Also, right-click the project > Edit Project File. Note that the (meta) packages listed here match those in the Packages folder 
4	Rather than working with the existing "Weather" logic we will learn more about ASP.NET MVC API by adding additional code to the site. To get started we are going to need some data. To flesh it out a bit we will imagine we're building an on-line shop, so let's use that as the topic. Right-click on the QuickTour project in the Solution Explorer window and select Add | New Folder giving it the name Models. Add a C# class called Product.cs. Populate it like this: `public class Product { public int ProductId { get; set; } public string Name { get; set; } }` Note we have added an Id because we would intend to store this in a database eventually. The recommendation is to use <className>Id as it fits in with EntityFramework (discussed later) conventions somewhat better than just 'Id'

5	Right-click on the Controllers folder and select Add | Controller… Then, in the Add New Scaffold Item dialog box select MVC Controller – Empty and click Add.  In the Add New Item dialog select the **API Controller – Empty** option. Name the controller 'ProductsController' and press "Add".

6 You should now see an empty class that is decorated with two attributes `[Route("api/[controller]")]` and `[ApiController]`.

The Route attribute is specifying a template that dictates the part of the URL that directs the request to the controller. The `[controller]` section tells the run-time to replace it with the name of the controller (in this case Products) and would be analogous to `[Route("api/Products")]`. The benefit coming should the developer ever change the controller class name. If this attribute is omitted, then routing is based on method level routing.

The `[ApiController]` attribute can be applied to controller classes to enable some API-specific behaviours such as making attribute routing a mandatory requirement (i.e. use of the Route attribute (see above).

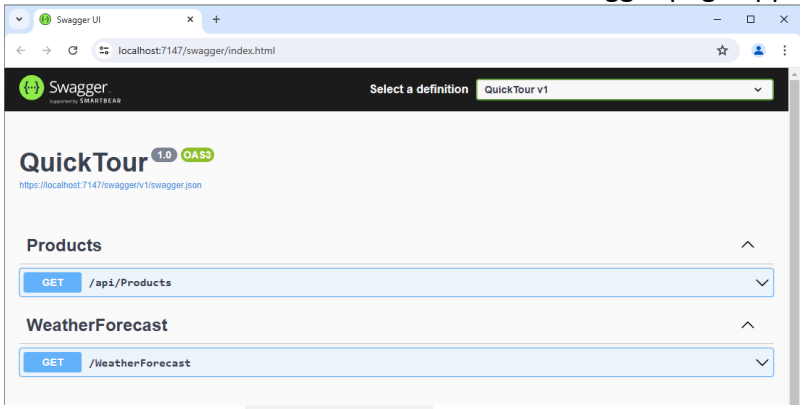
Add a new method to the class called Products that returns an `IEnumerable<Product>`.

Decorate the method with an `HttpGet` attribute. Note this attribute isn't strictly necessary but Swagger uses it to determine how the method is to be used (Get, Post, Put, etc..) and will display an error if the attribute is missing.

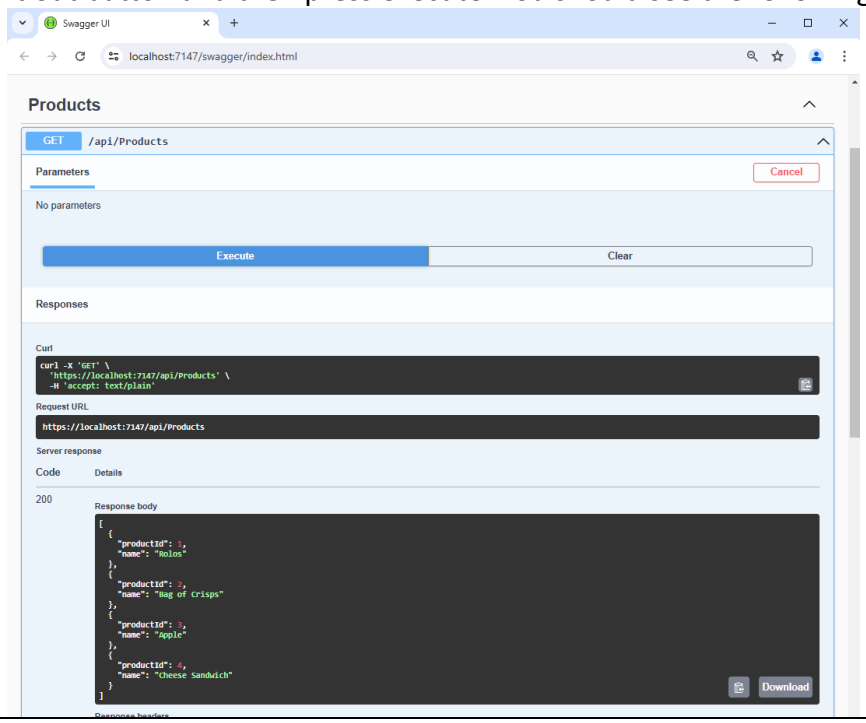
Public methods in a controller are called Actions – this is the `Products()` Action.
Edit the method so it generates a number of Product objects adding them to a List. Then get the method to return the list:

```
[ApiController]
[Route("api/[controller]")]
public class ProductsController : ControllerBase
{
    [HttpGet]
    public IEnumerable<Product> Products()
    {
        List<Product> products = new List<Product>();
        products.Add(new Product { ProductId = 1, Name = "Rolos" });
        products.Add(new Product { ProductId = 2, Name = "Bag of Crisps" });
        products.Add(new Product { ProductId = 3, Name = "Apple" });
        products.Add(new Product { ProductId = 4, Name = "Cheese Sandwich" });
        return products;
    }
}
```

7 Press F5 to launch the service. Ensure the Swagger page appears



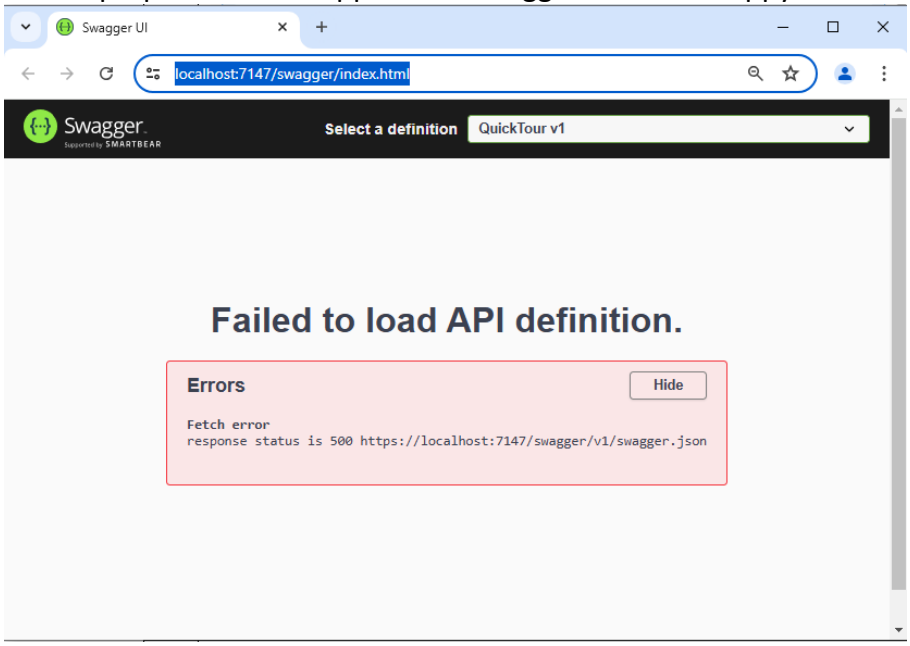
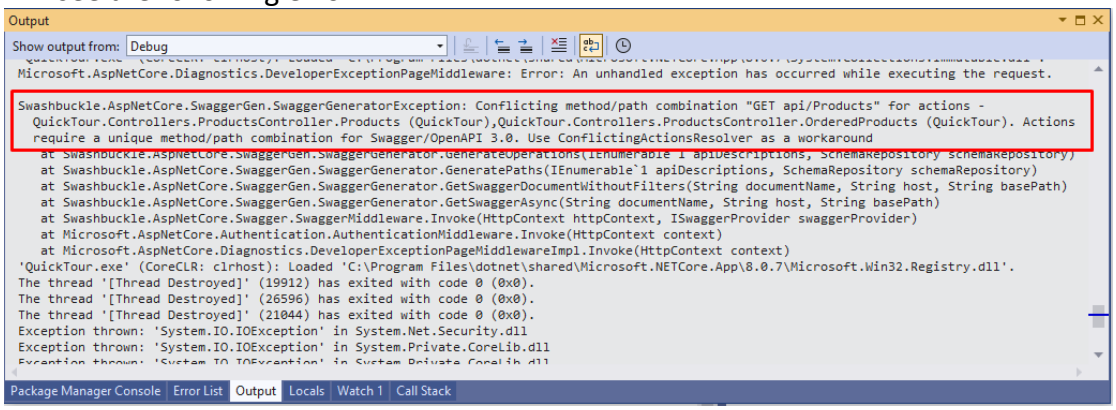
Test drive the Get `/api/Products` option by pressing the drop-down arrow and clicking the Try it out button and then press execute. You should see the following:



8 Let's add a second end-point (Action) to the controller. To keep things brief we'll get it to do the same thing as the Products method but return the list in alphabetical order of product name.

Add the following code to the Products controller:

```
    [HttpGet]
    public IEnumerable<Product> OrderedProducts()
    {
        List<Product> products = new List<Product>();
        products.Add(new Product { ProductId = 1, Name = "Rolos" });
        products.Add(new Product { ProductId = 2, Name = "Bag of Crisps" });
        products.Add(new Product { ProductId = 3, Name = "Apple" });
        products.Add(new Product { ProductId = 4, Name = "Cheese Sandwich" });
        return products.OrderBy(p => p.Name).ToList();
    }
```

9	F5 and prepare to be disappointed. Swagger will be unhappy: 
10	The reason for the error is a little strange. If you dig into Visual Studio's Output window you will see the following error:  It's complaining about a conflicting method/path for `QuickTour.Controllers.ProductsController.Products` and `QuickTour.Controllers.ProductsController.OrderedProducts` And further states `Actions require a unique method/path combination for Swagger`. You'd be forgiven for thinking that the two methods do have unique method/path combinations given their different names. However, it's not just Swagger that's complaining. If you were to call the method from an external client as a real API call, you'd get a similar error. Weirdly, in spite of the different method names, the runtime is upset because the signatures of the two methods are identical (i.e. neither take any parameters) and are therefore deemed to be the same!

11 The workaround is to extend the `HttpGet` attributes to specify an extension to the controller's template (`"api/[Controller]"`):

```
    [HttpGet("ProductsDetail")]
    public IEnumerable<Product> ProductsDetail()
    {
        List<Product> products = new List<Product>();
        products.Add(new Product { ProductId = 1, Name = "Rolos" });
        products.Add(new Product { ProductId = 2, Name = "Bag of Crisps" });
        products.Add(new Product { ProductId = 3, Name = "Apple" });
        products.Add(new Product { ProductId = 4, Name = "Cheese Sandwich" });
        return products;
    }

    [HttpGet("OrderedProducts")]
    public IEnumerable<Product> OrderedProducts()
    {
        List<Product> products = new List<Product>();
        products.Add(new Product { ProductId = 1, Name = "Rolos" });
        products.Add(new Product { ProductId = 2, Name = "Bag of Crisps" });
        products.Add(new Product { ProductId = 3, Name = "Apple" });
        products.Add(new Product { ProductId = 4, Name = "Cheese Sandwich" });
        return products.OrderBy(p => p.Name).ToList();
    }
```

Note, it is perfectly OK to give the template the same value as the Action name. In the above example the two URL's needed to invoke the methods are:

https://localhost:7147/api/Products/ProductsDetail

https://localhost:7147/api/Products/OrderedProducts

It would be perfectly OK to alter the attributes to the following:

```
[HttpGet("Products")]...

[HttpGet("Ordered")]...
```

And then the respective URL's would be:

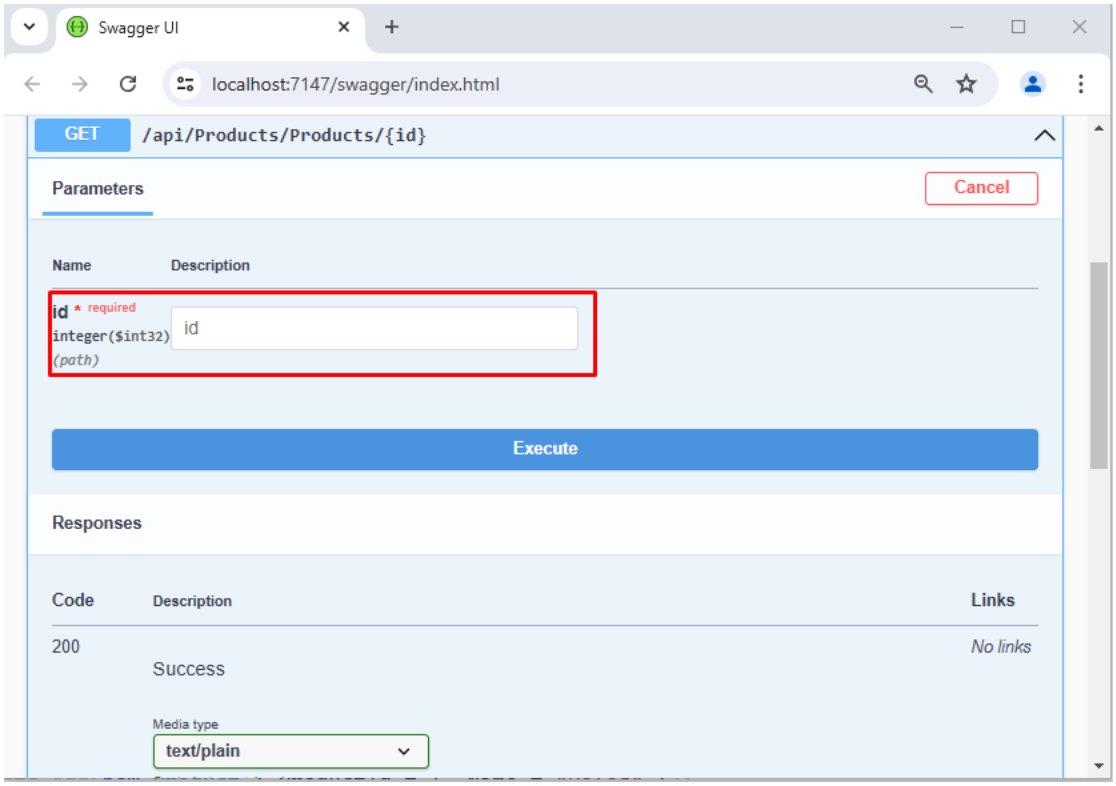
https://localhost:7147/api/Products/Products

https://localhost:7147/api/Products/Ordered

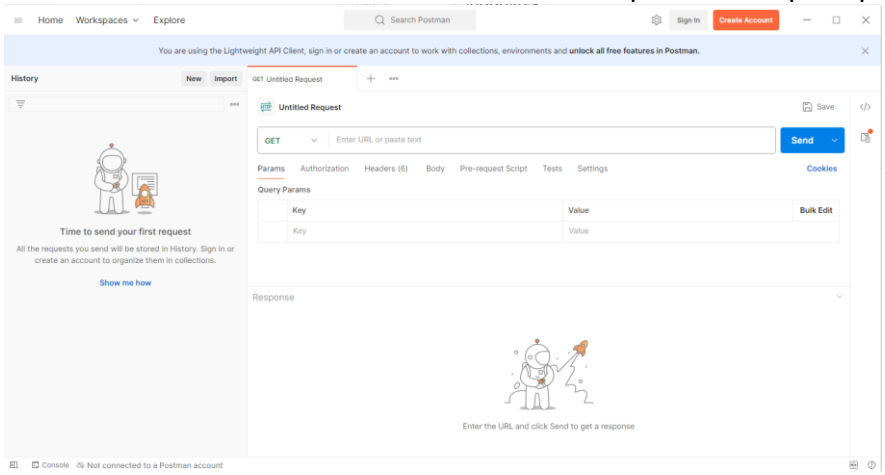
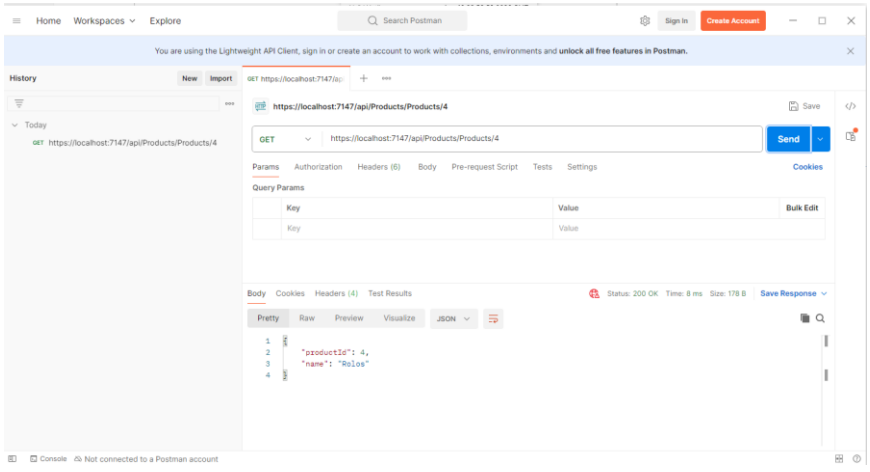
Test drive the app with both of the suggested changes and ensure everything works as expected.

12 Let's now add an additional Action that takes a parameter.

```
    [HttpGet("Products/{id}")]
    public Product ProductsDetail(int id)
    {
        Product p = new Product { ProductId = id, Name = "Rolos" };
        return p;
    }
```

13	Notice we now have two overloaded methods (same name different signature which means the C# compiler will be happy and the new Action's `HttpGet` attribute starts off the same as its sister but is extended to include "`/{id}`" . The Squiggly braces indicate the URL will have a piece of data at its end (e.g. `api/Products/Products/`**`12`**) which will be passed on to the `int id` parameter specified in the method signature.
14	Run the code. When testing in Swagger you will be given the opportunity to enter a value for the id into a Parameters text box:  Obviously, the code, as it stands, will ignore the value and always return Rolos.
15	It is absolutely fine to decorate an Action with more than one route (`HttpGet` attribute]. Try decorating the appropriate Actions with the following additional routes. Think carefully which method should get which attribute and what the corresponding URLs would look like: `[HttpGet("")]` `[HttpGet("{id}")]` `[HttpGet("ProductDetail/{id}")]`
16	What do you think would happen if we removed the controller level `[Route("api/[controller]")]` attribute? Think about it, make a prediction and then launch the app to see if you were right.

17	Add another Action with the same ProductsDetail name that takes the name of a product as a string parameter and returns an associated Product (again fake the search in the same way we did when passing the id). Decorate the new Action with the same `HttpGet` attributes as with the id approach but replace "id" with "name" wherever it occurs.
18	The C# compiler should be happy because whilst there are now three methods that each have the same name it can distinguish between them because of the parameter types (no parameters, int and string). Launch the app and use Swagger to test the new Actions… Unfortunately, the method calls (both the ones that use the new string parameter and also the ones that used to work that used an int parameter) fail with the following message: `Microsoft.AspNetCore.Routing.Matching.AmbiguousMatchException: The request matched multiple endpoints.` Even though we've satisfied the C# compiler the ASP.NET Route selector logic can't distinguish between the two types of parameter, because they both appear to be strings!
19	`The solution to the problem is to spell out the parameter type inside the HttpGet routing template as follows:` ``` [HttpGet("ProductDetail/{id:int}")] [HttpGet("Products/{id:int}")] [HttpGet("{id:int}")] public Product ProductsDetail(int id) { Product p = new Product { ProductId = id, Name = "Rolos" }; return p; } ``` There's no need to do the same for the "name" parameters because the default is to treat them as strings.
20	An alternative to Swagger. Swagger is OK as an an-hoc way of testing your Actions but if you want a set of slightly more permanent tests that save you from having to continually type the same things into the various Swagger text boxes you should consider using a tool like Postman.

21	Launch the app in Visual Studio. Start Postman form the Windows Start menu. You should see a window for an untitled GET request that is prompting for a URL.  Enter the following as the URL: `https://localhost:7147/api/Products/Products/4` Press the blue Send button Note you may receive an "SSL error: unable to verify the first certificate" warning message. It's OK to take the suggested option of disabling SSL verification. Look at the response in the bottom half of the screen and confirm it is what you expect.  To create a new request, you can press the plus "+" button towards the top centre of the screen. You will also be able to create Post, Put and Delete requests by dropping the down arrow that is located to the right of the word GET (and to the left of the test URL.

	Note, if you are prepared to register a set of credentials with Postman (it's free to do this) then you will be able to permanently save your requests (by pressing the Save button to the upper right of the screen). It is definitely worth getting familiar with a tool like Postman it could transform your life!

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If You Have Time

1	Use Postman to create a set of test calls that exercise all the possible URLs that your Quick Tour project supports.
2	Add additional Actions that take multiple parameters
3	Rework the code in Actions that return a single Product so that it picks a matching value from a collection of Products
4	Refactor the code so it contains no duplicate logic

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 05: Dependency Injection, Scope and Configuration

Objective

The goal of this lab is to investigate how Dependency Injection and its configuration is done in ASP.NET applications

Overview

In this exercise you get to do Dependency Injection (DI) and learn how it is configured. You will also see the effect of the different DI scopes.

This exercise will take around 45 minutes.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

Steps:

Dependency Injection and Scope

1 The starter application is the “Quick Tour” that we did previously, with just a bit of extra stuff added (commented out for now, but we will un-comment it later).
Open the ‘Begin’ folder and compile the application. Check that it runs.

2 We left the ProductsController in the Quick Tour app instantiating its own data, which, to be frank, isn't a very clever thing to be doing. We will fix this by creating a new class in the Models folder which represents a fake database. (Of course, we will explore real database connections a little later in the course.) Call the class MockProductsContext. Add this method to the new class:

```
public class MockProductsContext
{
    public IEnumerable<Product> GetProducts()
    {
        return new List<Product>() {
            new Product {  ProductId = 1, Name = "Rolos" },
            new Product {  ProductId = 2, Name = "Bag of Crisps" },
            new Product { ProductId = 3, Name = "Apple" },
        new Product { ProductId = 4, Name = "Cheese Sandwich" },
        new Product { ProductId = 5, Name = "Can of Coke" }
        };
    }
}
```

Modify the ProductsController class to use this new method:

```
public class ProductsController : ControllerBase
{
    IEnumerable<Product> _products = null;
    public ProductsController()
    {
        MockProductsContext mockContext = new MockProductsContext();
        _products = mockContext.GetProducts();
    }
    ...
```

3 At the moment, the ProductsController is making its own MockProductsContext object.
We should always be wary of a class creating service classes itself. Let’s change it to use constructor injection, using the built-in dependency injection framework.
Dependency injection works better if it’s based on interfaces, so add the following interface to the Models folder:

```
public interface IProductsContext
{
    public IEnumerable<Product> GetProducts();
}
```

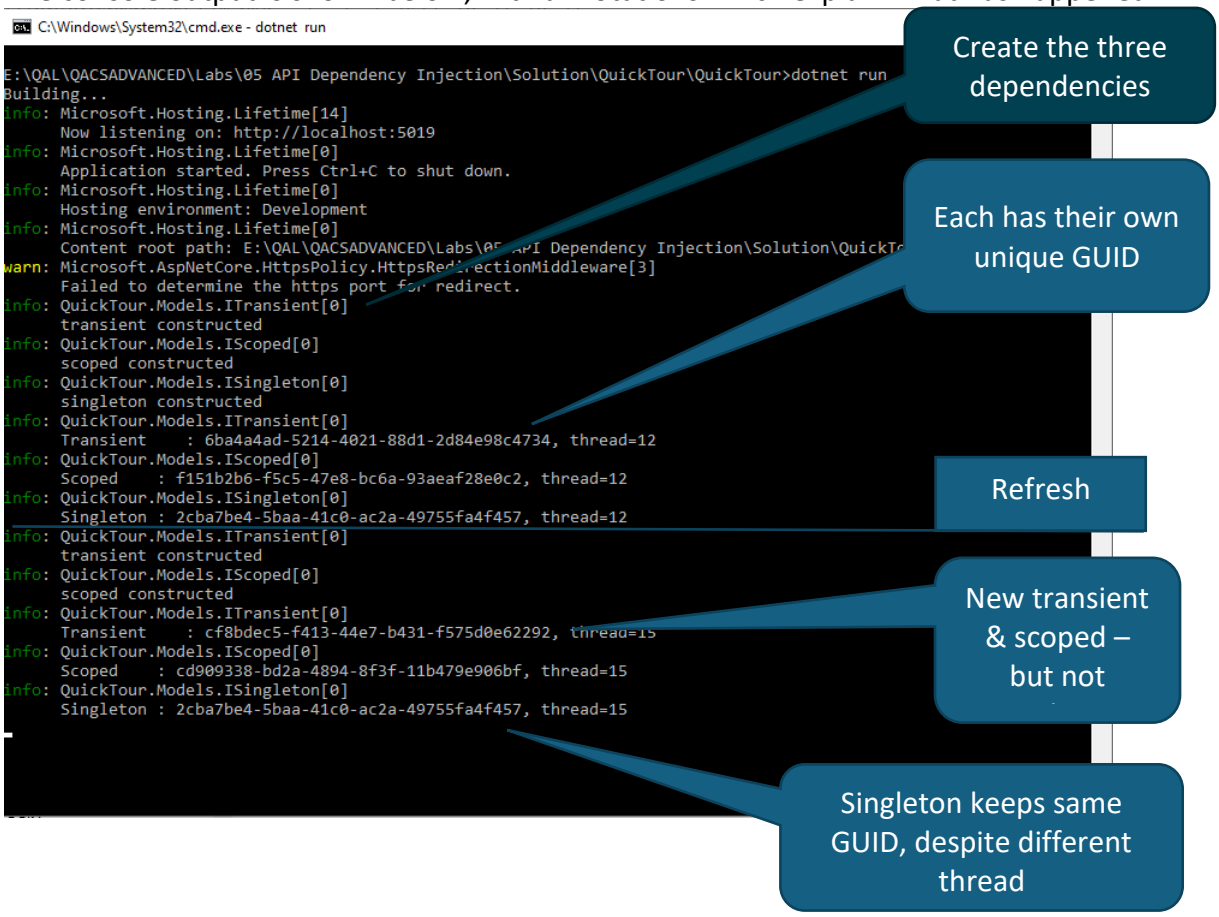
And modify the mock Product context to implement this interface:

```
public class MockProductsContext : IProductsContext
{
    ...
```

4	In the ProductsController, rework the code at the top of the file to read as follows: `public class ProductsController : ControllerBase` `{` `  IProductsContext _context;` `  public ProductsController(IProductsContext context)` `  {` `  _context = context;` `  }` `  ...` You can see the constructor is expecting an object that implements IProductsContext to be passed (injected) to it as a parameter.
5	Modify **all** of the ProductsDetail and OrderedProducts actions to use the injected database context: `...` `public IEnumerable<Product> ProductsDetail()` `{` `  return _context.GetProducts();` `}` `...`
6	In the Program.cs file, add the following line that declares the builder object just before the line that declares the app object. The aim is to identify all the services which can be provided by dependency injection and map the interface that the class requires to the concrete class that we are going to supply. `builder.Services.AddScoped<IProductsContext, MockProductsContext>();` Run the application and check that it still works. Using dependency injection is as easy as that!
7	In the next part of the lab, we are going to investigate the different lifetimes that are available to us when we use dependency injection. Drag the file Dependencies.cs from the Assets folder (in Explorer) onto the Models folder in your project. The contents are 3 classes following this pattern: `public interface ITransient {` `  void WriteGuidToConsole();` `}` `public class TransientDependency ...` Which we will inject with the corresponding scope. Have a look at the TransientDependency – you will see it writes out to the logger each time a new instance is instantiated. Whenever the method WriteGuidToConsole() is called, it will show the unique Guid and the thread on which it is running.

8	In the program.cs file just beneath the Service addition of the IProductsContext, register the class TransientDependency as the desired implementation of the interface ITransient and give it Transient scope. Do the same for Scoped and Singleton – like this: builder.Services.AddTransient<ITransient, TransientDependency>(); builder.Services.AddScoped<IScoped, ScopedDependency>(); builder.Services.AddSingleton<ISingleton, SingletonDependency>();
9	Modify the ProductsController to require these dependencies, and also to add a bit more debug information:

```
        private readonly ITransient _tran;
        private readonly IScoped _scoped;
        private readonly ISingleton _single;
        private readonly ILogger<ProductsController> _logger;
    private IProductsContext _context;


        public ProductsController(ILogger<ProductsController> logger,
                                  IProductsContext context,
                                  ITransient tran,
                                  IScoped scoped,
                                  ISingleton single)
        {
            _logger = logger;
            _context = context;
            _tran = tran;
            _scoped = scoped;
            _single = single;
        }

        [HttpGet("")]
        [HttpGet("Products")]
        [HttpGet("ProductDetails")]
        public IEnumerable<Product> ProductsDetail()
        {
            _logger.LogInformation("In the HttpGet Products Index() method
<=======");

            _tran.WriteGuidToConsole();
            _scoped.WriteGuidToConsole();
            _single.WriteGuidToConsole();

            _logger.LogDebug("About to get the data");

            IEnumerable<Product> products = _context.GetProducts();

            _logger.LogDebug($"Number of Products: {products.Count()}");
            return products();

        }
```

10	Run the application from the console. (A reminder of how to do this: right-click on the project, select “Open folder in file explorer”. Then, in file explorer, click into the address bar and type “cmd”. From the command window, type “dotnet run”.) Open a web browser, go to https://localhost:xxxx (replacing xxxx with the port the app runs on as specified in the command window) . Once the page has been displayed, press the refresh button to display it a second time. The console output is shown below, with annotations which explain what has happened: 
11	Take a closer look at the three dependency classes. Notice that each of them requires a constructor parameter – a logger. Where did the logger come from? When dependency injection is used to create the dependency object (or, indeed, any object), it will check whether that new object has any of its own dependencies and will create those too! Dependency injection is used to create (for example) a ScopedDependency object, and as part of that process it also creates an ILogger<IScoped> that the ScopedDependency needs! This enables a complex series of dependencies to be built up very simply. As you write each class, you need to know what that class depends on, but you don’t need to worry about any dependencies any deeper into the chain, because the dependency injection framework takes care of that for you.

12

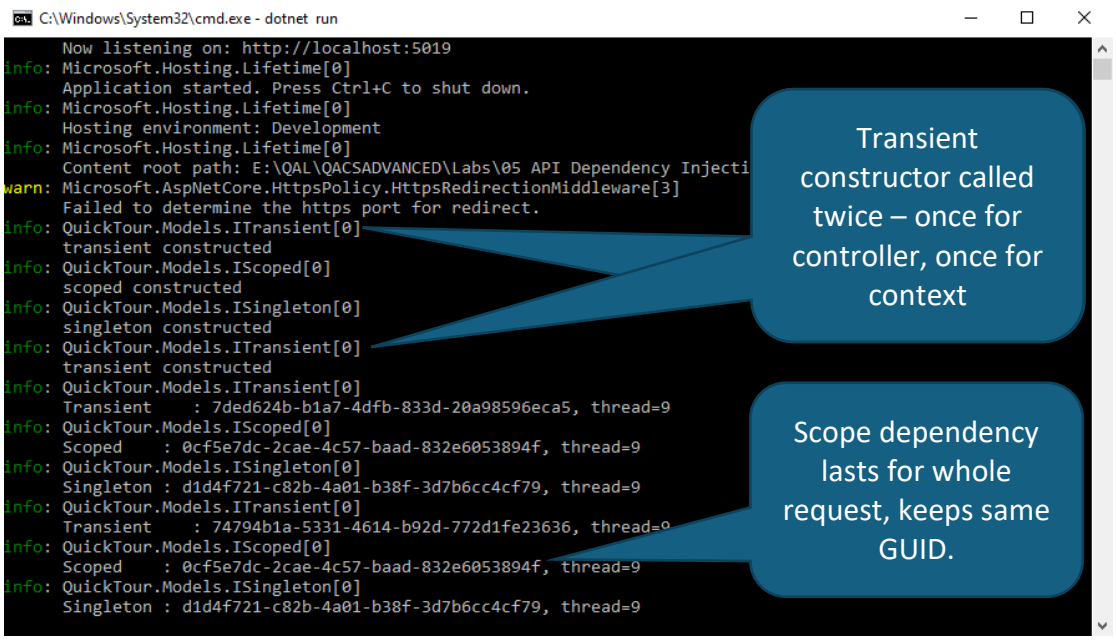
In the screenshot above, the scoped dependency and the transient dependency appear to behave the same way – we get a new instance of the dependency each time we refresh the page.

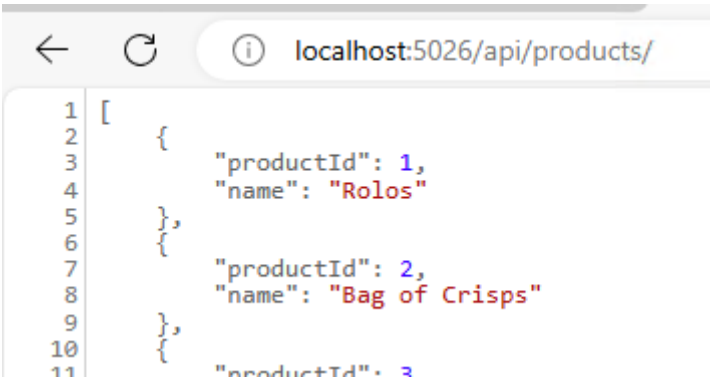
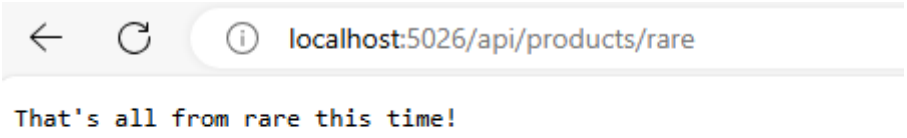
Let's modify our demonstration to show where these two types of lifecycle differ from each other.

Add an instance of each dependency to the MockProductContext class and use constructor injection to get instances of those dependencies. Then, call the WriteGuidToConsole() method on each dependency when creating the data:

```
public class MockProductsContext : IProductsContext
{
    private readonly ITransient _tran;
    private readonly IScoped _scoped;
    private readonly ISingleton _single;

    public MockProductsContext(ITransient tran,
                               IScoped scoped,
                               ISingleton single)
    {
        _tran = tran;
        _scoped = scoped;
        _single = single;
    }

    public IEnumerable<Product> GetProducts()
    {
        _tran.WriteGuidToConsole();
        _scoped.WriteGuidToConsole();
        _single.WriteGuidToConsole();
        ...
```

Since we already use dependency injection to create the MockProductContext, and the dependencies we need are already registered, we don't need to do anything else.

13	Run the application from the console, and once it's running, visit the web site *only once*. The console output now looks like this:  Here, you can see that the scoped dependency is shared between the two classes that use it, whereas the transient dependency is not (and therefore the dependency injection framework needs to create two separate instances of the transient dependency.)
14	Add the following code to the ProductsController. It defines a method called Rare. `[HttpGet("Rare")]` `public string Rare([FromServices]IActionInjection ai)` `{` `ai.WriteGuidToConsole();` `return "That's all from rare this time!";` `}` The idea is that this is a rarely used method, the resource it uses is expensive, so we don't want to create it every time – just when this rare method is called. You will find the interface and implementing class in Models/Depdendencies.cs
15	Register in Program.cs: `builder.Services.AddTransient<IActionInjection, ActionInjectionDependency>();`

16	Run again from the command line. `\QuickTour\QuickTour>dotnet run` Do a few browser refreshes and note that the ActionInjection object is not created.  Now append '/Rare' to the Url and note that the action dependency is now created.  (We've used the LogWarning method here, in contrast to LogInformation in other places, so you can clearly see the difference by the different colour.)

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you have time

Configuring the Pipeline

17	Add a trivial module into the pipeline – copy the folder called Middleware from the Assets folder and add it to the project. Have a look at the code the classes contain. Inject this module into the pipeline by adding it in Program.cs as shown: `app.UseAuthorization();` `app.UseMiddleware<CustomMiddleware1>();` `app.UseMiddleware<CustomMiddleware2>();`

18	Suppress most of the trace information – in appsettings.Development.json `"Logging": { "LogLevel": { "Default": "None", "Microsoft": "None", "QuickTour": "None", "QuickTour.Controllers": "Information", "QuickTour.Middleware": "Debug" }`
19	Start using dotnet run and open a browser at port whatever port the app is running on. Refresh the browser a couple of times. Again, we've used LogWarning() to make the middleware messages stand out. Note that the middleware objects are created once at application startup, and then invoked for every web request. Adding middleware is the process by which a standard MVC application is configured (for example, adding authentication and authorisation modules to the pipeline) so it's definitely worth understanding what we mean when we talk about middleware, although writing your own middleware is not something you will need to do too often. Each middleware component can check details of the request, and either return a response to the web browser, or pass the request on to the next middleware component, modifying either the request or the response as appropriate. Our very basic example simply passes the request along to the next component without altering it in any way.

Configuration – The Options Pattern

20 Drag the folder Configuration from the Assets folder onto your project. This contains a class with 2 configuration options

```
public class FeaturesConfiguration
{
    public bool EnableMyOption1 { get; set; }
    public bool EnableMyOption2 { get; set; }
}
```

20 Add this section to the end of appsettings.json, just above the final }

```
  "Features": {
    "EnableMyOption1": true,
    "EnableMyOption2": false
  }
```

Visual Studio will automatically add the trailing comma to the preceding entry

21 Now bind the json section to the strongly-typed FeaturesConfiguration in Program.cs

```
builder.Services.Configure<FeaturesConfiguration>(builder.Configuration.GetSection("Features"));
```

22 Go to ProductsController.
Modify the constructor:

```
private readonly FeaturesConfiguration _features;
private reaconly ILogger<ProductsController> _ logger;

public ProductsController(..., IOptions<FeaturesConfiguration> features,
ILogger<ProductsController> logger)
{
  ...
    _features = features.Value;
    _logger = logger;
}
```

Note: we are giving the controller logging capabilities via dependency injection. In ASP.NET Core, the logging functionality is built-in and available by default because it is part of the framework's dependency injection (DI) system. The logging services are automatically registered and configured when you create a new ASP.NET Core application so there is no need to add any special instructions to the Program.cs file.

23 Add this line to beginning of the the basic ProductsDetail() method that returns the original list of Products.

```
_logger.LogInformation($"MyOption1 = {_features.EnableMyOption1}, MyOption2 =
{_features.EnableMyOption2}");
```

24 Dotnet run and launch a browser. Note that the appsettings.json settings have been set into a FeaturesConfiguration object:

```
MyOption1 = True, MyOption2 = False
-------------------
```

In appsettings.json, set MyOption2 to be true and save the file (without re-compiling). Refresh the browser and note that the new value has not been read in.
Close and restart the app: it is only read in on app startup.

25	Make these changes to ProductsController `private readonly IConfiguration _config;` `public ProductsController(... IConfiguration config)` `{ .` `.` `.` `_config = config;` `}` And add this line to the ProductsDetail method just after your current features output : `_logger.LogInformation($"MyOption1 = {_config["Features:EnableMyOption1"]}, MyOption2 = {_config["Features:EnableMyOption2"]}");` So now we have a type-safe way of reading configuration data (IOptions) and a type-unsafe way (config[“key”]).
26	Refresh the page and check that the type-unsafe options are the same as the type-safe options.
27	In appsettings.json, set MyOption2 to be false and save the file (without re-compiling). Refresh the browser and note that the new value has been picked up by the new config["key"] approach.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you still have time

Reading environment-specific variants of appsettings.json

28 Add this to appsettings.json, just before the final }

```
"Message": "Hello from appsettings.json"
```

29 Add this to appsettings.Development.json, just before the final }
(Note that you may need to click the arrow next to appsettings.json to see the Development file)

```
"Message": "Hello from appsettings.Development.json"
```

30 By right clicking on the project in Solution explorer, add a new app settings file called appsetting.Staging.json to the project. Copy the contents of appsettings.Development.json to it and alter the "Message" entry to

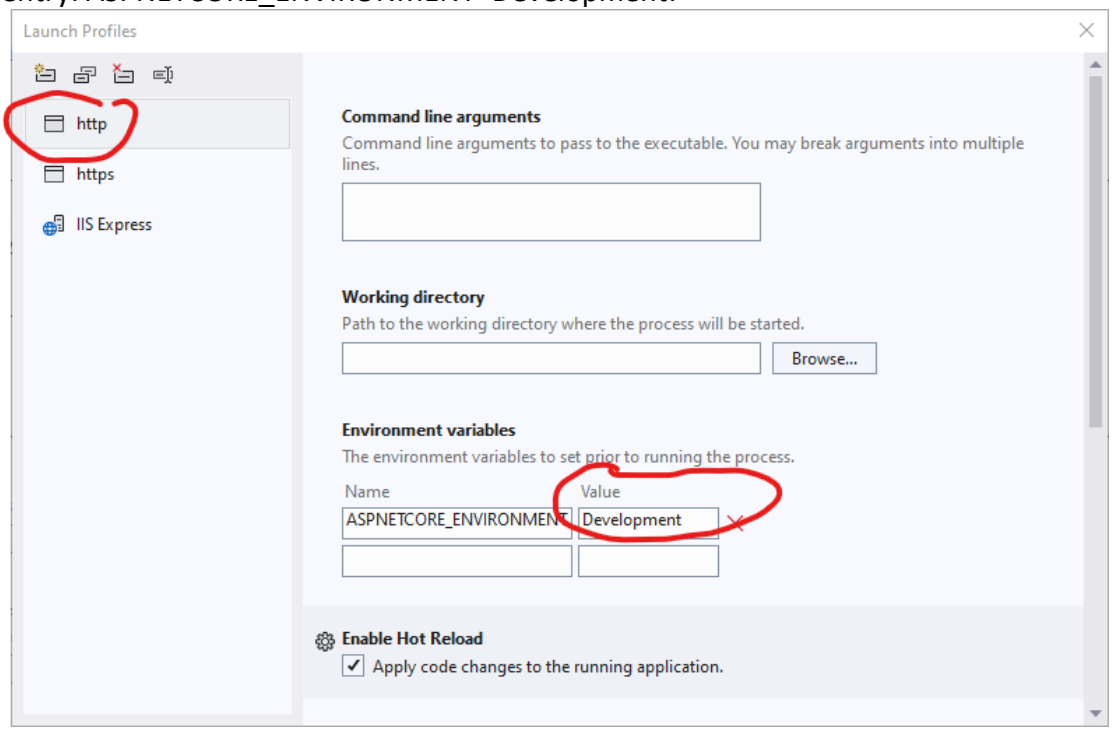
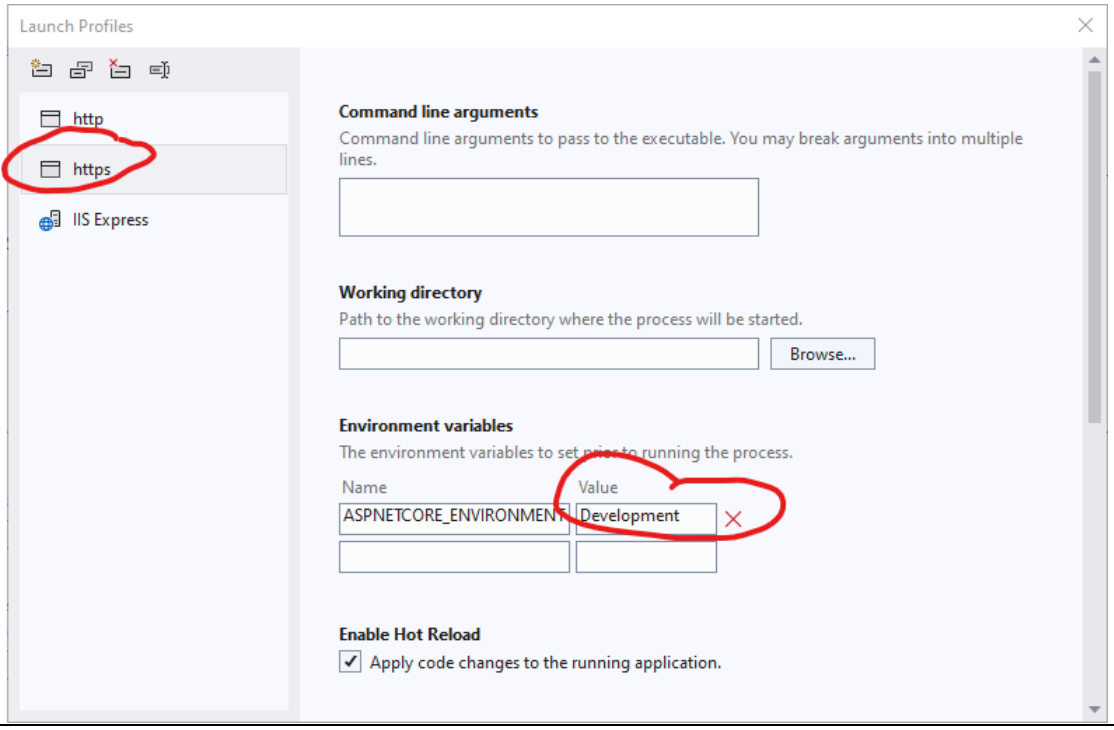
```
"Message": "Hello from appsettings.Staging.json"
```

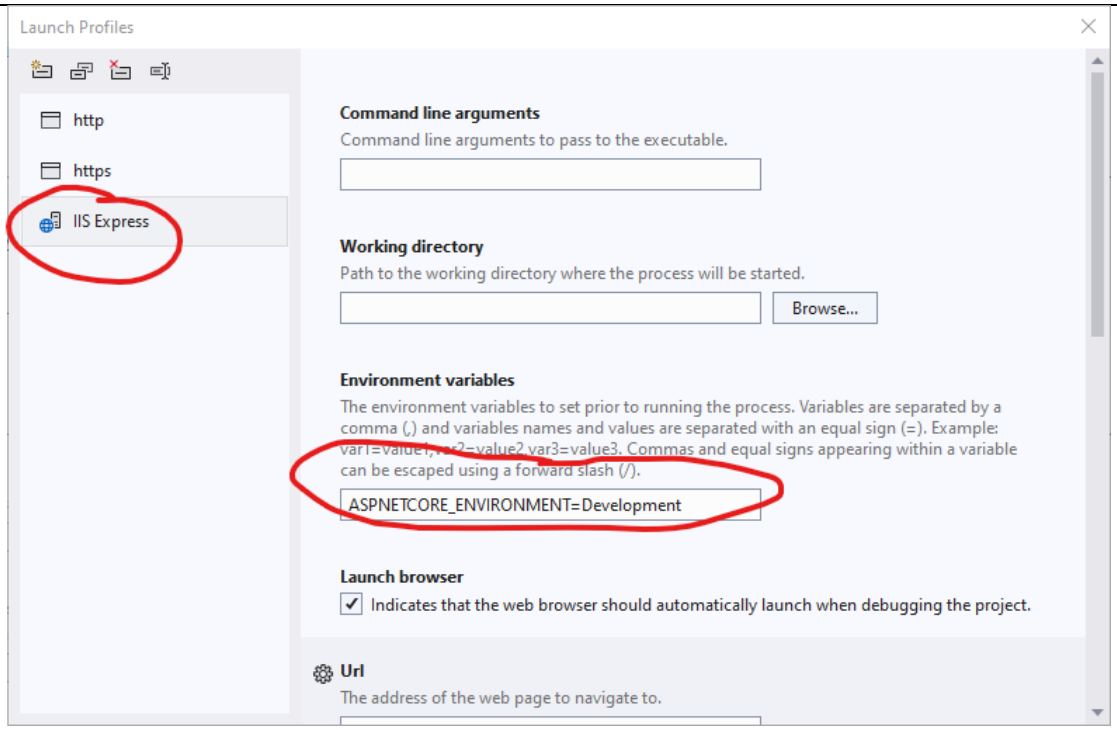
30 Add to Program.cs a line that declares a Microsoft.Extensions.Configuration.ConfigurationManager callled config and make it equal to builder.Configuration:

```
Microsoft.Extensions.Configuration.ConfigurationManager config = builder.Configuration;
```

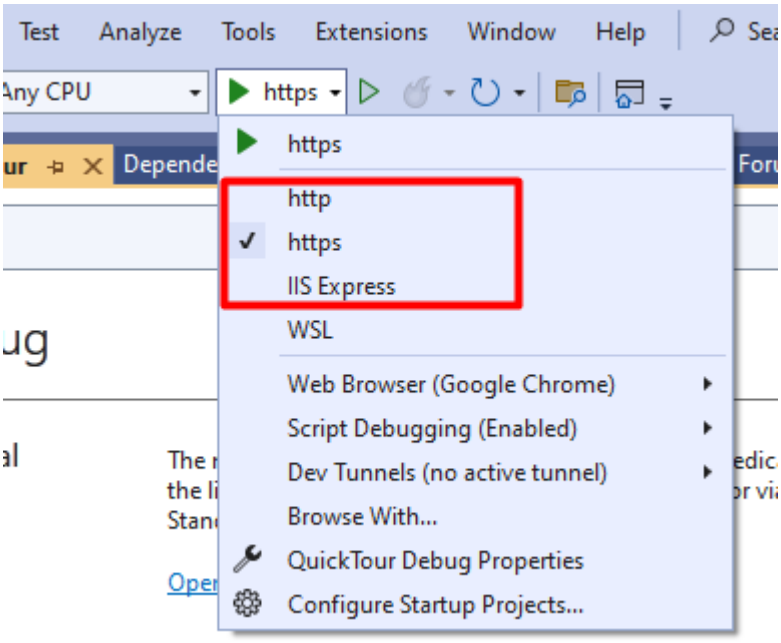
In Program.cs insert the following code just after the app.UseMiddleware lines you added earlier

```
Console.ForegroundColor = ConsoleColor.Magenta;
Console.WriteLine(config["Message"]);
Console.ForegroundColor = ConsoleColor.White;
```

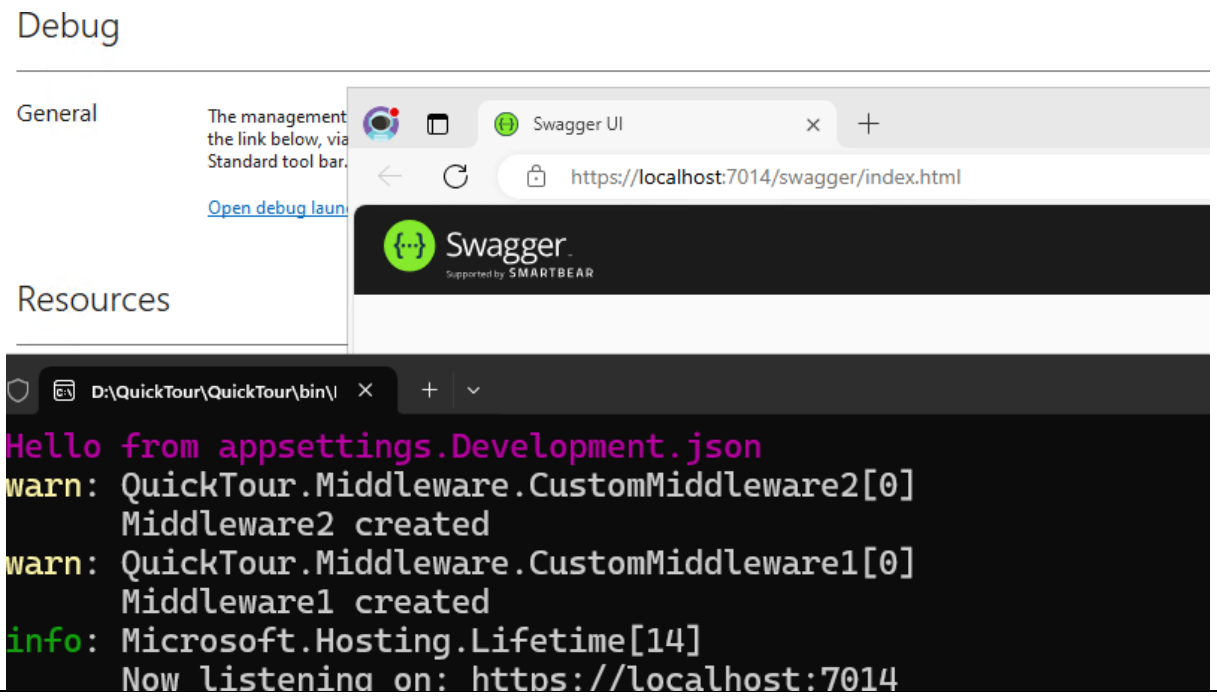
29	Open the Project > Properties and go to the Debug tab and select the "Open debug launch profiles UI" link. Ensure the Environment variables for http, https and IIS Express each have the following entry: ASPNETCORE_ENVIRONMENT=Development:  


Launch Profiles
http
https
IIS Express
Command line arguments
Command line arguments to pass to the executable.
Working directory
Path to the working directory where the process will be started.
Browse...
Environment variables
The environment variables to set prior to running the process. Variables are separated by a comma (,) and variables names and values are separated with an equal sign (=). Example: var1=value1,var2=value2,var3=value3. Commas and equal signs appearing within a variable can be escaped using a forward slash (/).
ASPNETCORE_ENVIRONMENT=Development
Launch browser
Indicates that the web browser should automatically launch when debugging the project.
Url
The address of the web page to navigate to.

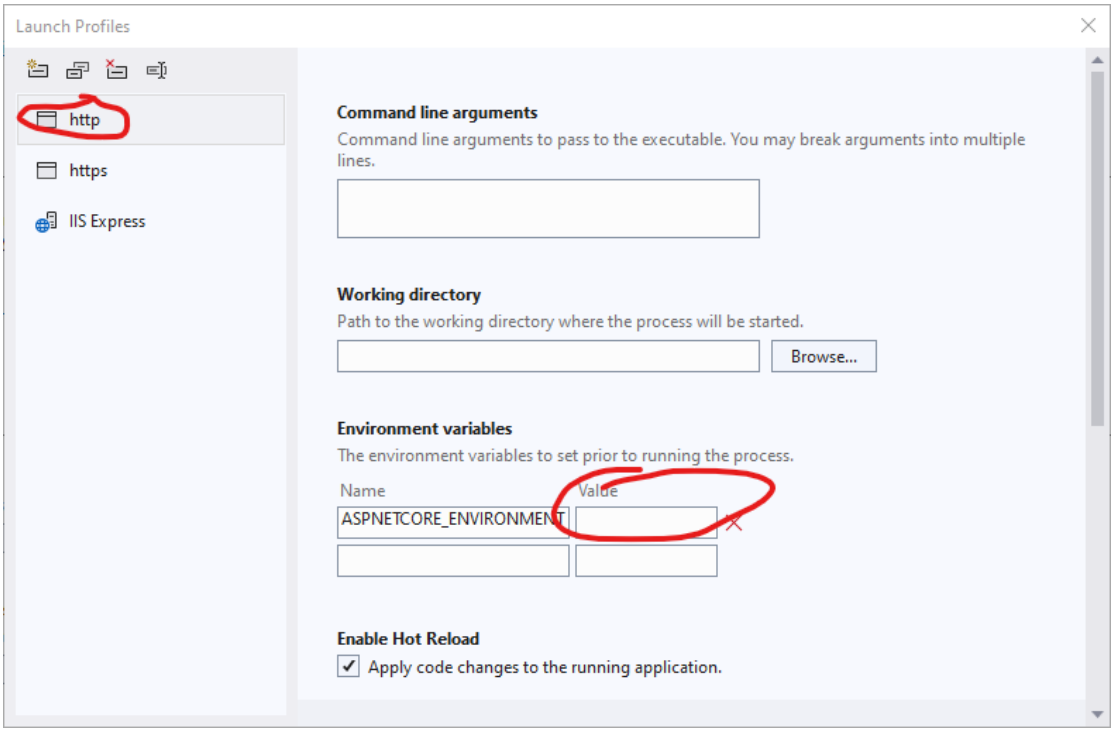
30 Note you can select a number of different ways of communicating with the browser from Visual Studio's drop down start debug menu:

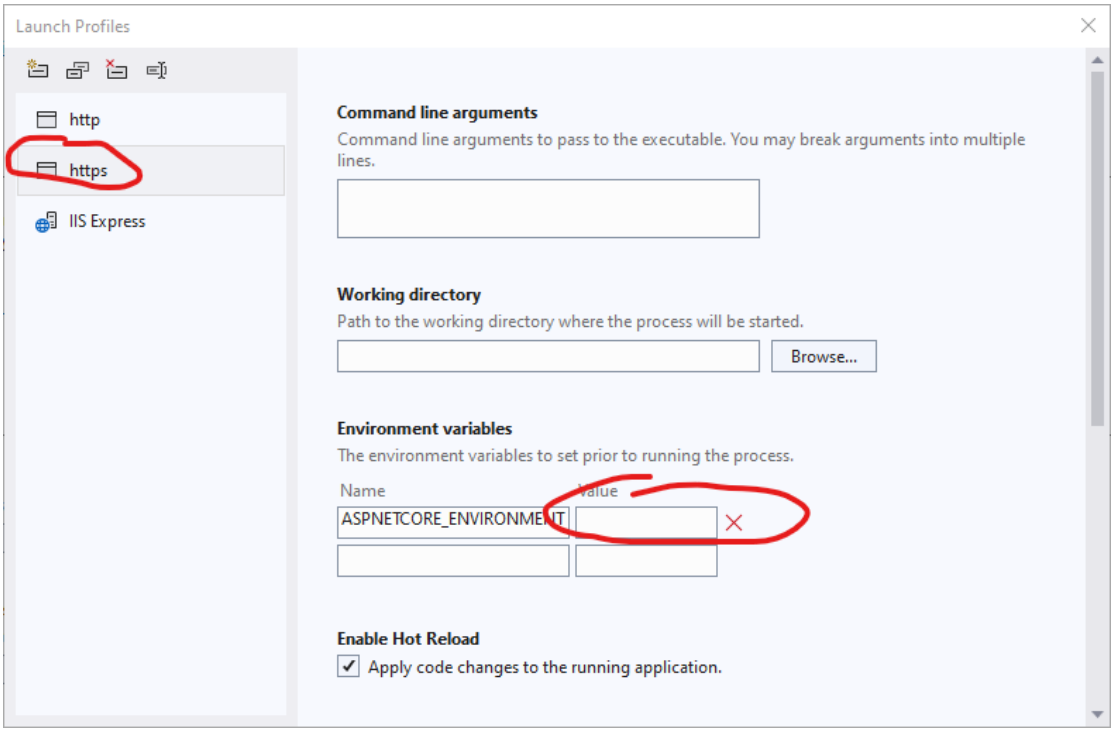


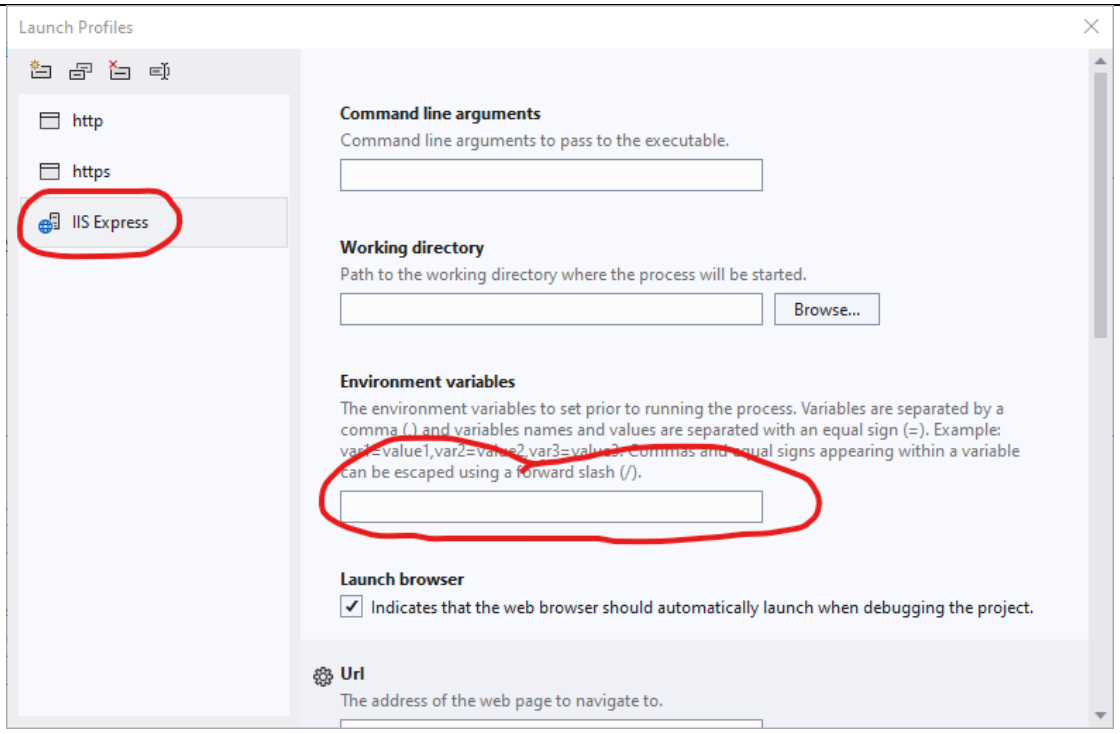
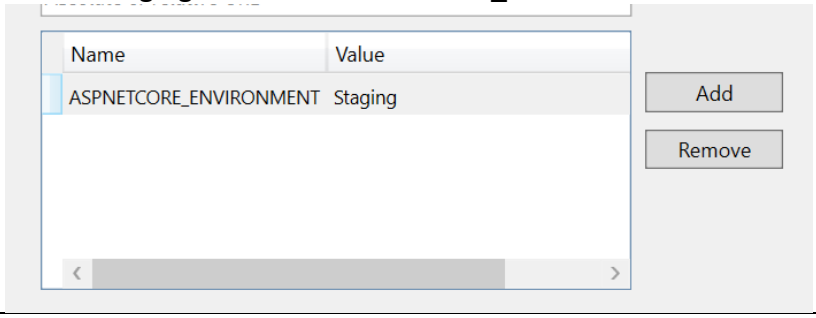
Launch the app in debug mode using any of the three options and note the cyan messagewritten to the console is from appsettings.Development.json i.e. "Hello from appsettings.Development.json"



31	Close the app, reopen the "Open debug launch profile UI" window and delete ‘Development’ for each of the three protocols:





	
32	Run the app in debug mode again. You may need to tweak the URL of the browser to make things work. Note, the console is now showing the message defined in appsetting.json i.e. " Hello from appsettings.json"
33	Edit in 'Staging' into the ASPNETCORE_ENVIRONMENT for all three launch profiles: 
34	Ctrl+F5 and you will see it now reads the Staging file

35	Lastly, just to confirm what has happened. When you set 'Staging' in the environment, it modified the file 'launchsettings.json' (expand under Properties and you'll see it). "profiles": { "http": { "commandName": "Project", "launchBrowser": true, "environmentVariables": { "ASPNETCORE_ENVIRONMENT": "Staging" }, "dotnetRunMessages": true, "applicationUrl": "http://localhost:5126" }, "https": { "commandName": "Project", "launchBrowser": true, "environmentVariables": { "ASPNETCORE_ENVIRONMENT": "Staging" }, "dotnetRunMessages": true, "applicationUrl": "https://localhost:7236;http://localhost:5126" }, "IIS Express": { "commandName": "IISExpress", "launchBrowser": true, "environmentVariables": { "ASPNETCORE_ENVIRONMENT": "Staging" } } }... Depending on the chosen launch protocol, the project that gets run is the first one in the list with "commandName": "Project",

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 06a: Using the Entity Framework

Part A – Code First (OPTIONAL)

Objective

To become acquainted with the Microsoft Entity Framework and make use of its Code First capabilities.

Overview

Entity Framework is an essential part of most .NET /CORE applications and is certainly used extensively in this course. We have this (optional) exercise to refresh/familiarise you with Entity Framework.

This exercise will take around 30 minutes.

GITHUB
Before starting on the lab please think seriously about using GitHub as a repository for the code.

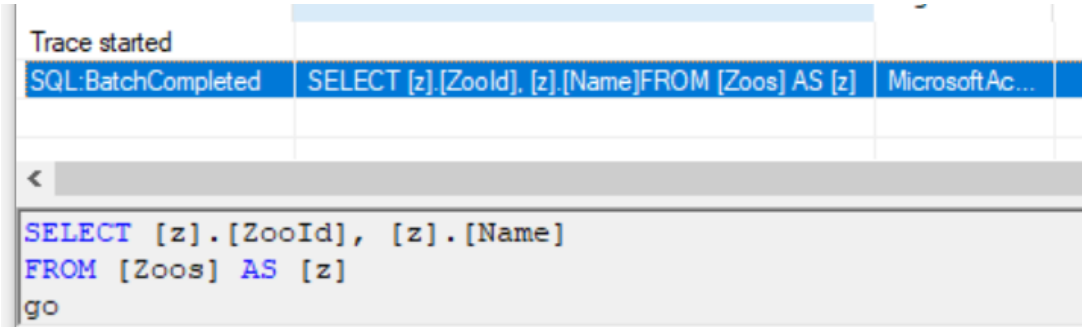
Steps

The 'Begin' Solution

1	Open the 'Begin' solution in Visual Studio and compile (Shift Ctrl+B). Have a look at the code and note: • Program/Main(): Currently the program does not touch a database • DataClasses: We have placed the data classes all in the 1 file. This is purely so you can see all the components. Operationally stick to 1 class in 1 file In order to focus on only the Entity Framework elements, the exercise is presented in a Console Application, but we will use Dependency Injection. There is nothing in the 'Begin' that wouldn't have been there even if you had no intention of storing this in a database. There are quite a few commented-out items Run it (Ctrl-F5) – you should get this: `Name = London, number of animals = 3` `...Elephant  Dumbo` `...Elephant  Heffalumps` `...Lion  Clarence` `Name = Edinburgh, number of animals = 2` `...Panda  Sweetie` `...Panda  Sunshine` We now proceed to add what you need to implement Entity Framework, starting with the code (ie Code First). Later, we will do this from an existing database (aka CodeFirstFromDatabase)
2	In Visual Studio, select View/Task List. This will show a window where you can see all the To Do comments that we've added to the code. Uncomment TODO 1, launch the app and confirm that the backpointer (animal to zoo) is null so you get a null reference exception. Re-instate the comment-out

NuGet	
3	Read TODO 2 and Nuget the packages listed.
4	We will need a context to describe which tables we wish to have in the database. Go to TODO 3 and uncomment the zoocontext class (but OnConfiguring still commented out. You will need to add a using clause for Microsoft.EntityFrameworkCore to the top of the file listing.
5	*Everything* in EF is a property – we've done this already. However, because we are going to store Zoo and Animal objects in a relational database, they must have an Id. Go to TODO 4 and uncomment these.
6	Comment out the foreach loop in Program/Main() and store it temporarily in Notepad
7	Delete the entire contents of Program/Main() and replace with `static void Main(string[] args)` `{` `  ConfigureServices();` `  Configure();` `}` Hopefully these names should look familiar to you... Dependency Injection!
8	Right-click ConfigureServices() > Quick Actions and refactoring > Generate Method. Repeat for Configure()
9	Paste your commented-out foreach loop (in Notepad) into Configure(), in place of the "throw new NotImplementedException" line. For now leave it commented out
10	Add in the following code – this is the Console equivalent of what ASPNET Core largely does for you : `class Program` `{` `  public static ServiceCollection services;` `  public static ServiceProvider serviceProvider;` `  static void Main(string[] args)` `  {` `  ConfigureServices();` `  Configure();` `  }` `  private static void ConfigureServices()` `  {` `  services = new ServiceCollection();` `  string conn =` `@"Server=.\SqlExpress;Encrypt=False;Database=EFRefresh;Trusted_Connection=true;` `MultipleActiveResultSets=True";` `  services.AddDbContext<ZooContext>(options =>` `options.UseSqlServer(conn));` `  serviceProvider = services.BuildServiceProvider();` `  }` NB – in the above we have had to split the connection string across 2 lines to fit into the Word document. The Connection string **must** be all on 1 line, not just in this lab but in any other labs that follow. **ALSO: If you are using the developer version of SQL Server then replace the `.\SQLExpress` in the connection string with `(local)`.**

11	In Configure() we use the injected ZooContext. Add this line: `private static void Configure()` `{` `    ZooContext ctx = serviceProvider.GetService<ZooContext>();` `    //foreach (Zoo zoo in zoos)` `    //{` `    //  Console.WriteLine($"\nName = {zoo.Name}, number of animals = {zoo.Animals.Count()}");` `    //    foreach (Animal animal in zoo.Animals)` `    //    {` `    //        Console.WriteLine($"...{animal.Type,-10}{animal.Name}");` `    //    // TODO 1 Console.WriteLine($"......in zoo {animal.Zoo.Name}");` `    //    }` `    //}` `}`
12	Uncomment the foreach loop and make this 1 change: `foreach (Zoo zoo in ctx.Zoos)`
13	If we ran it now, it would fail because there is no database (if you're familiar with the older Entity Framework 6, this behaves differently – it would create the database automatically). In a Console App, the way that our database server is configured means that we have the permissions to be able to drop and create databases and hence seed some data. Note a web app does *not* typically have these permissions Add this code `ZooContext ctx = serviceProvider.GetService<ZooContext>();` `ctx?.Database.EnsureDeleted();` `ctx?.Database.EnsureCreated();` `AddSampleData(ctx);` `foreach (Zoo zoo in ctx.Zoos)` Uncomment the provided code for AddSampleData() (TO DO 5)
11	Ctrl+F5 to run it and you should get the same output as before. Now comment out the three highlighted lines that you have just added in (highlighted in yellow above) – the database is present and populated so we should get the same result when we run it? Try it and see. Can you explain why it worked with a new database but not an existing one? (Hint – Fix Up)

12	Let see what SQL commands EntityFramework is invoking. In the Assets folder is the Express Profiler. There is a .msi file but you can just run the .exe Make sure the Server is set to the appropriate server (`.\SQLExpress` or `(local)`). Press the green arrow to start a new trace and run the Console App (with the 3 lines commented out) The trace should show  I.e. only the Zoos have been requested.
13	Solve the problem by using Eager Loading `foreach (Zoo zoo in ctx.Zoos.Include(z=>z.Animals))`
14	Note we still have the 'backpointer' line `Console.WriteLine($".....in zoo {animal.Zoo.Name}");` Which previously caused a NullReferenceException. Confirm this now works – ie EntityFramework populates it for free.
15	Undo your Eager Loading solution. Solve the problem by Lazy Loading : Uncomment TODO 6 And use NuGet to import Microsoft.EntityFrameworkCore.Proxies Finally, make this change in the Zoo class `public virtual ICollection<Animal> Animals { get; set; } = new List<Animal>();` Run it - it should work. Use the profiler to see the 3 SQL statements
16	In OnConfiguration(), comment out `optionsBuilder.UseLazyLoadingProxies();`
17	Explicit Loading is not so easy to remember. Implement it: `ctx.Entry(zoo).Collection(z=>z.Animals).Load();` `Console.WriteLine($"\nName...` `foreach (Animal animal in zoo.Animals)` Check it works
Migration	

18	Make this change to the Animal class `public string Name { get; set; }` `public double Weight { get;set;}` `public virtual Zoo Zoo { get;set;}` Ctrl+F5 and confirm you get an exception: `Name = London, number of animals = 0` `Unhandled Exception: System.Data.SqlClient.SqlException: Invalid column name 'Weight'.` `at System.Data.SqlClient.SqlConnection.OnError(SqlException exception, Boolean breakConnect` Comment out this new line.
19	We will use 'Migrations" to resolve this. Since Migrations does not use dependency injection, we need to tell it how to configure our connection. Uncomment the ZooContextFactory at the bottom of the ZooContext.cs file. Since this class implements the interface IDesignTimeDbContextFactory<ZooContext>, Migrations will automatically use it to create the context. Watch out for the server name in the connection string (`.\SQLExpress` or `(local)`).
20	Now, select Tools/Nuget Package Manager/Package Manager Console Into the new console window that appears, type the following and press enter: add-migration Initial A class gets created (and opened) in the new Migrations folder, called Initial. It has a method called "Up", which creates the database (without the Weight property), but we don't need that to happen – our database already exists. Modify the method so that it doesn't do anything: `protected override void Up(MigrationBuilder migrationBuilder)` `{` `return;` `migrationBuilder.CreateTable(.....` Now, back in the package manager console, type and run: update-database And then, remove the "return" from the "Up" method. (This method won't run again, since entity framework remembers that this migration has already been run – unless we drop and create the database.)

21	Un-comment the Weight property. Then, type the following two commands in the package manager console to add it to the database: add-migration AddWeight update-database The new column has now been added to the Animals table. Check this is SSMS, and also press F5 and check your program now runs again.
22	All the animals have weights which have defaulted to 0. We could now easily modify our program to include weights for each animal and display those weights. If you have time, try to do this!

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 06b: Using the Entity Framework

Part B – Code First from Database

Objective

To learn how to create projects that use the Entity Framework to operate in a Code First from Database manner.

Overview

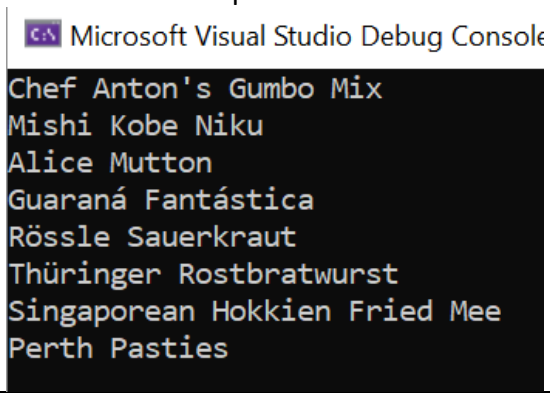
In the previous (optional) lab you did Code First – i.e. start with the code and construct the database from it. In this lab, we do it the other way around – start with the Database and build the code from the database schema.

This exercise will take around 40 minutes.

GITHUB
Before starting on the lab please think seriously about using GitHub as a repository for the code.

Steps:

1	Start a new Core Console App called EFFromDatabase and add the following NuGet packages: Microsoft.EntityFrameworkCore.SqlServer Microsoft.EntityFrameworkCore.Tools Microsoft.EntityFrameworkCore.Design Bricelam.EntityFrameworkCore.Pluralizer (without the last one, the scaffolder will produce plural-named classes eg Customer**S**)
2	Ensure you have the Northwind database installed in .\SqlExpress or (local). If not, there is a SQL script for installing is in the Assets folder
3	Open a command window at the project folder (as we've done in previous labs) and enter this (it must all be on 1 line so drop it into Notepad first and check no new lines and regular quotes – not "xx" type of quotes). `dotnet ef dbcontext scaffold "Server=.\SqlExpress;Encrypt=False;Database=Northwind;Trusted_Connection=True" Microsoft.EntityFrameworkCore.SqlServer -o Models --context NorthwindContext` **NOTE: Depending on the version of SQL Server you are using you may need to replace** `.\SQLExpress` with `(local)`. This should produce all classes into a folder named 'Models' **NOTE:** If you get an error message that says "dotnet : Could not execute because the specified command or file was not found". Then, you may need to run the following to install the relevant tool: `dotnet tool install --global dotnet-ef`
4	Have a look at the Customer class and note: It's a partial class There are no fields – it is all properties Collections are virtual
5	Enter this into Main() and run it `using (NorthwindContext ctx = new NorthwindContext())` `{` `  foreach (Customer c in ctx.Customers` `  .Include(c => c.Orders)` `  .ThenInclude(o => o.OrderDetails)` `  .ThenInclude(od => od.Product))` `  {` `  Console.WriteLine(c.ContactName);` `  foreach (Order o in c.Orders)` `  {` `  Console.WriteLine("..." + o.OrderId);` `  foreach (OrderDetail od in o.OrderDetails)` `  {` `  Console.WriteLine("......" + od.Product.ProductName);` `  }` `  }` `  }` `}` You should get lots of Order and Order Details

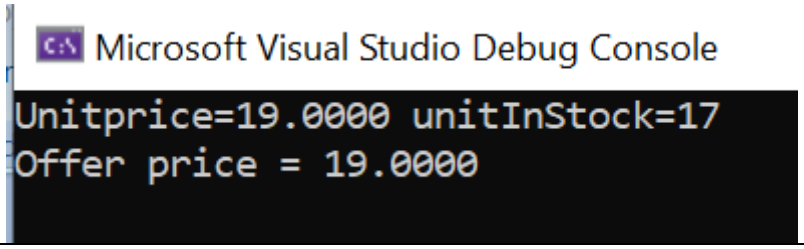
Query Filters	
6	Comment-out all the above code in Main() and add in this code `using (NorthwindContext ctx = new NorthwindContext())` `{` `  var discontinued = ctx.Products.Where(p => p.Discontinued).ToList();` `  discontinued.ForEach(d => Console.WriteLine(d.ProductName));` `}` Run it – it will output a list of all discontinued products: 
7	But suppose you *never* wanted to see discontinued products in any of your queries. Right now, you'd have to put in a Where statement into every query. EFCore has a QueryFilter feature where you can do this globally. Go to the Northwind context class and search for <Product> (include the angle brackets in the search) When you reach this line `modelBuilder.Entity<Product>(entity =>` `{` Somewhere in this section add a global query filter: `entity.HasQueryFilter(e=>!e.Discontinued);`
8	Run again and this time your query won't even see discontinued products.
9	If, in particular queries, you really did want to see the discontinued products, you can override this (in Program/Main()) : `ctx.Products.Where(p => p.Discontinued).IgnoreQueryFilters().ToList();` Do this and confirm you again see the discontinued products.
10	Remove the Query Filter you just added to NorthwindContext and comment-out all code in Main()

Adding own functions to database classes

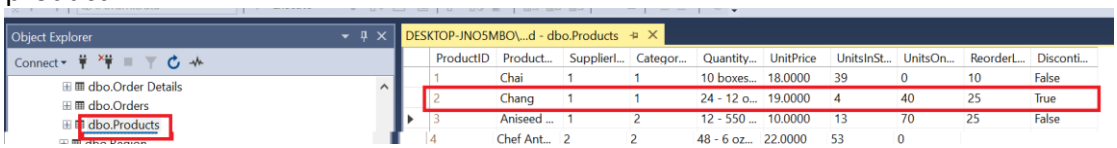
11 Suppose that the company wanted to sell off discontinued lines at half price.
Comment out existing code in Main() and add this:

```
using (NorthwindContext ctx = new NorthwindContext())
{
    Product chang = ctx.Products
                           .Where(p => p.ProductName == "Chang").Single();
    Console.WriteLine(
       $"Unitprice={chang.UnitPrice } unitInStock={chang.UnitsInStock}");

    decimal? offerPrice = chang.UnitPrice;
    if (chang.UnitsInStock < 5 && chang.Discontinued)
    {
        offerPrice /= 2;
    }
    Console.WriteLine($"Offer price = {offerPrice}");
}
```

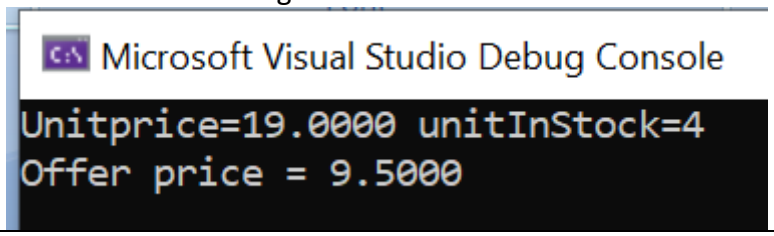
Run this
The offer price is 19 because this produce does not meet the UnitsInStock<5 and Discontinued conditions.



12 Open up the Products table in SSMS by right-clicking and “Edit top 200 rows”. Find the product



Change the Units in stock to 4 and set the Discontinued status to True to show the above code is working



13	It would be good to move this code into the Product class – that's where it really belongs. Open the Product class and add `public decimal? OfferPrice =>` `  (UnitsInStock < 5 && Discontinued) ? UnitPrice /= 2 : UnitPrice;` Have this as your code in Main() `using (NorthwindContext ctx = new NorthwindContext())` `{` `  Product chang = ctx.Products` `  .Where(p => p.ProductName == "Chang").Single();` `  Console.WriteLine(` `  $"Unitprice={chang.UnitPrice } unitInStock={chang.UnitsInStock}");` `  Console.WriteLine($"Offer price = {chang.OfferPrice}");` `}` Confirm it still works.
14	Now imagine that we want to delete the Discontinued column completely from the database. If we did this, we would need to re-generate our classes (imagine there might be other subtle changes we didn't necessarily know about). Doing this would lose the OfferPrice code we've just added to the Product class as this is going to get blown away.
15	To solve the first one, add a new folder called Logic alongside Models. Hold down the Ctrl key and drag Product into Logic (ie copy it)
16	Delete OfferPrice from Models/Product and delete everything except OfferPrice from Logic/Product
17	Suppose we had an additional constraint that ProductName must be shorter than 50 characters. We can accommodate this too. Make your Logic/Product file look like this: `using Microsoft.AspNetCore.Mvc;` `using System;` `using System.Collections.Generic;` `using System.ComponentModel.DataAnnotations;` `namespace EFFromDatabase.Models` `{` `  [ModelMetadataType(typeof(Product_Buddy))]` `  public partial class Product` `  {` `  public decimal? OfferPrice =>` `  (UnitsInStock < 5 && Discontinued) ? UnitPrice /= 2 : UnitPrice;` `  }` `  public class Product_Buddy` `  {` `  [MaxLength(50)]` `  public string ProductName { get; set; }` `  }` `}` If you Ctrl+dot ModelMetadataType it will suggest you install Microsoft.AspNetCore.Mvc.Core. Install this then resolve namespaces. Ie this extra constraint is available to the MVC validation system. Run and make sure all is still working

18	Now, in SSMS, right-click the Products table > Design and delete the Discontinued column. Save the table
19	Run the app again and you will get Microsoft Visual Studio Debug Console `Unhandled Exception: System.Data.SqlClient.SqlException: Invalid column name 'Discontinued'.` `at System.Data.SqlClient.SqlConnection.OnError(SqlException exception, Boolean breakConnection,` `tion)` Imagine it wasn't just the one change and that now we need to do a complete re-scaffolding
20	Open a command window at the project directory and enter `dotnet ef dbcontext scaffold "Server=.\SqlExpress;Database=Northwind;Trusted_Connection=True;Encrypt=False" Microsoft.EntityFrameworkCore.SqlServer -o Models --context NorthwindContext --force` `Watch out for .\SQLExpress vs (local)` Check that the 'Discontinued' property has gone from the Product class
21	If you now compile, you can fix the 2 'Discontinued' issues: `public decimal? OfferPrice => (UnitsInStock < 5) ? UnitPrice /= 2 : UnitPrice;` Run and you're back in business!

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 07a: Introduction to the Estate Agent Microservices Project

The next set of labs are based around the creation of a set of microservices for a chain of estate agencies. We don't have the time to create the entire front and back ends but to set the scene here's an overview of the kind of things the finished site would be capable of.

The development revolves around an Estate Agent Management System with the following Features:

Feature: Manage Buyer

Scenario: Register Buyer
Given the new buyer with the given first name and surname does not exist
When a create buyer request is received with the given first name and surname
Then a new buyer record is created with a buyer ID

Feature: Manage Seller

Scenario: Register Seller
Given a seller with the given first name and surname does not exist
When a create seller request is received with the given first name and surname
Then a new seller record is created with a seller ID

Feature: Manage Property

Scenario: Add Property
Given a seller exists for the new property
When a create property request for the given seller is received
Then the property is added to the catalogue
Then the property status is set to FORSALE
NOTE: A property can have the following status: FORSALE, SOLD, WITHDRAWN

Scenario: Find properties
When a Find properties request is received
Then a list of properties with the corresponding criteria is shown

Scenario: Withdraw Property that is FORSALE
Given The required Property exists
Given The required Property is FORSALE
When a Withdrawn property request is received
Then property status is changed to WITHDRAWN

Scenario: Resubmit Property that has been WITHDRAWN
Given The required Property exists
Given The required Property has been WITHDRAWN
When a Resubmit property request is received
Then property status is changed to FORSALE

Scenario: Amend property details
Given The required Property exists
Given The required Property is FORSALE

When an Amend property request is received
Then property details are updated

Feature: Manage Bookings

Scenario: Make booking with Slot available
Given no active booking exists for the desired time slot for the property
Given the property status is FORSALE
Given the buyer is registered
When a viewing is requested
Then a booking is created for the buyer for the property at the given time slot
Note: Viewing slot is every hour on the hour between 8am to 5pm every day including weekends and holidays

Scenario: Make Booking - Time Slot not available
Given a booking already exists for the required timeslot for the given property
When a viewing is requested is made for that time slot
Then an error is shown to the user

Scenario: Cancel Booking
Given a booking exists
When a cancel booking request is made
Then the booking is removed

Minimal Viable Product

Manage Seller

- Register a new seller
- Display all sellers

Manage Properties

- Add properties
- Display all properties
- Find and display properties with given search criteria on price, bedrooms, bathroom and garden
- Withdraw a property
    - Cascade delete any associated bookings
- Resubmit a property

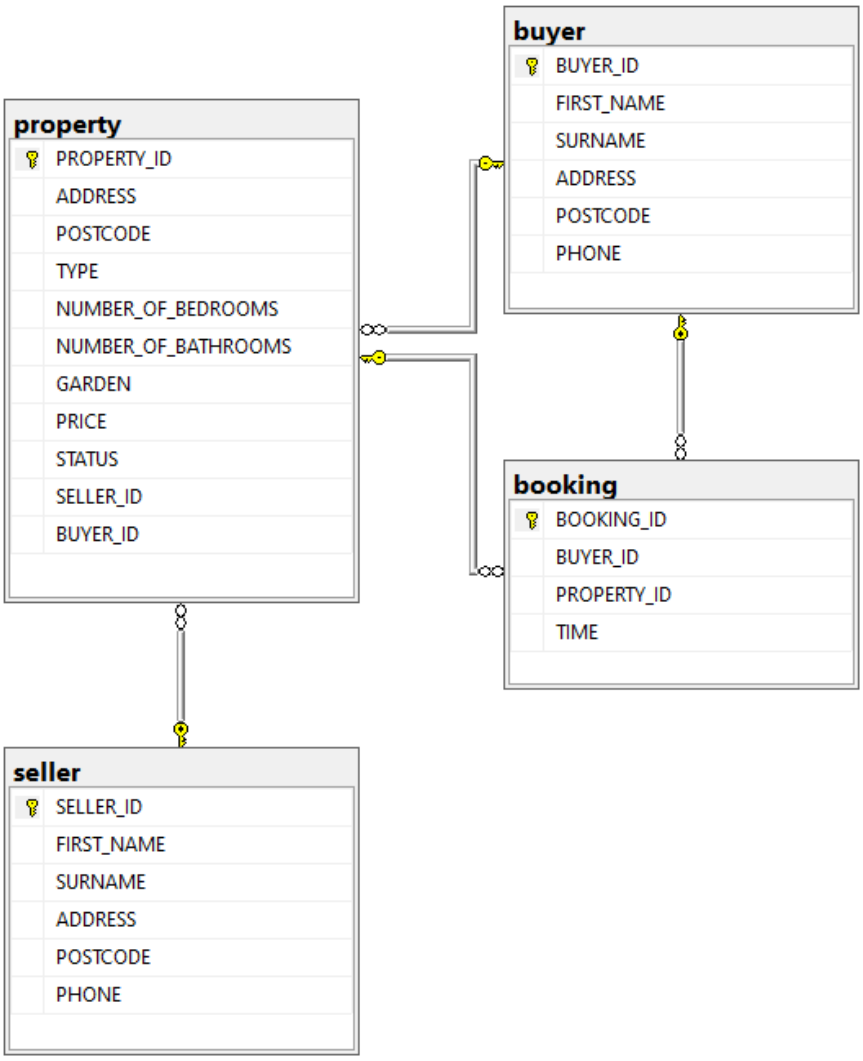
Manage Buyer

- Register new buyer
- Display all buyers

Manage Bookings

- Add bookings
    - Ensure the proposed date and time are available
    - Don't allow bookings for houses that are SOLD
- Display all bookings for a property

Database Schema



Lab 07b: Creating an ASP.NET **MVC** API Microservice

Objective

Your goal is to create a microservice for "buyer" information. The microservice should be support full CRUD capabilities.

Overview

The Estate Agent application needs to keep track of potential property buyers. In this lab you will create a Visual Studio solution that hosts a Buyers microservice that is built using Visual Studio's ASP.NET API template. The microservice should allow a consumer of the service to:

- Retrieve a list of all buyers.
- Retrieve a buyer by their id.
- Retrieve a buyer by their name.

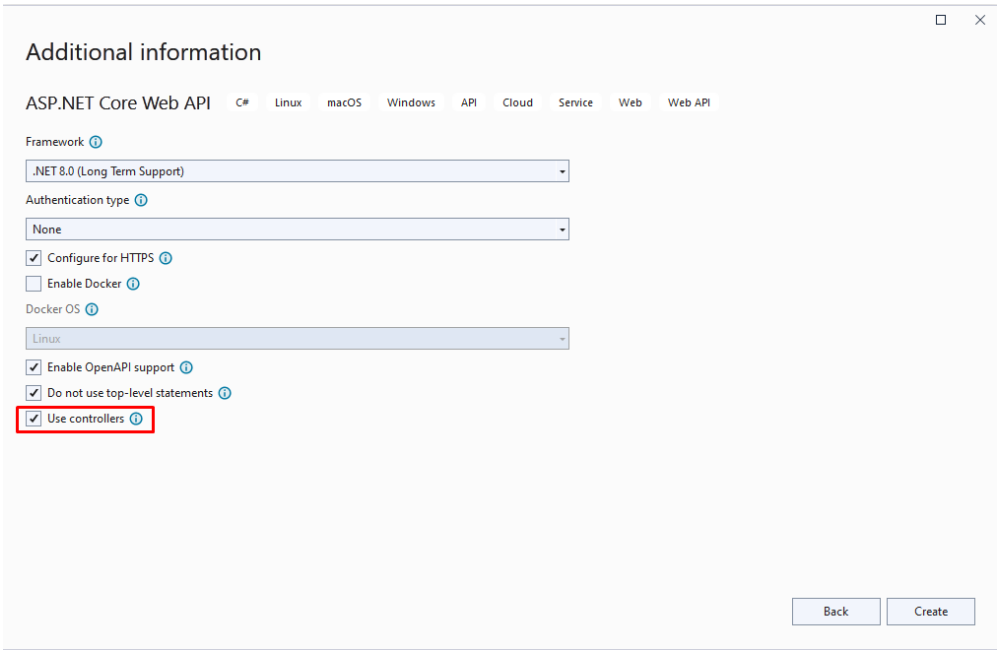
- Add new buyers.
- Delete existing buyers.
- Update existing buyers.

GITHUB
Before starting on the lab please think seriously about using GitHub as a repository for the code.

DATABASE SETUP

Before you can start on the Web application development you may be thinking you will need to create the EstateAgent database in SQL Server. You don't need to worry about this because there are some steps below that will test to see if the database exists and create and populate it with data if it doesn't.

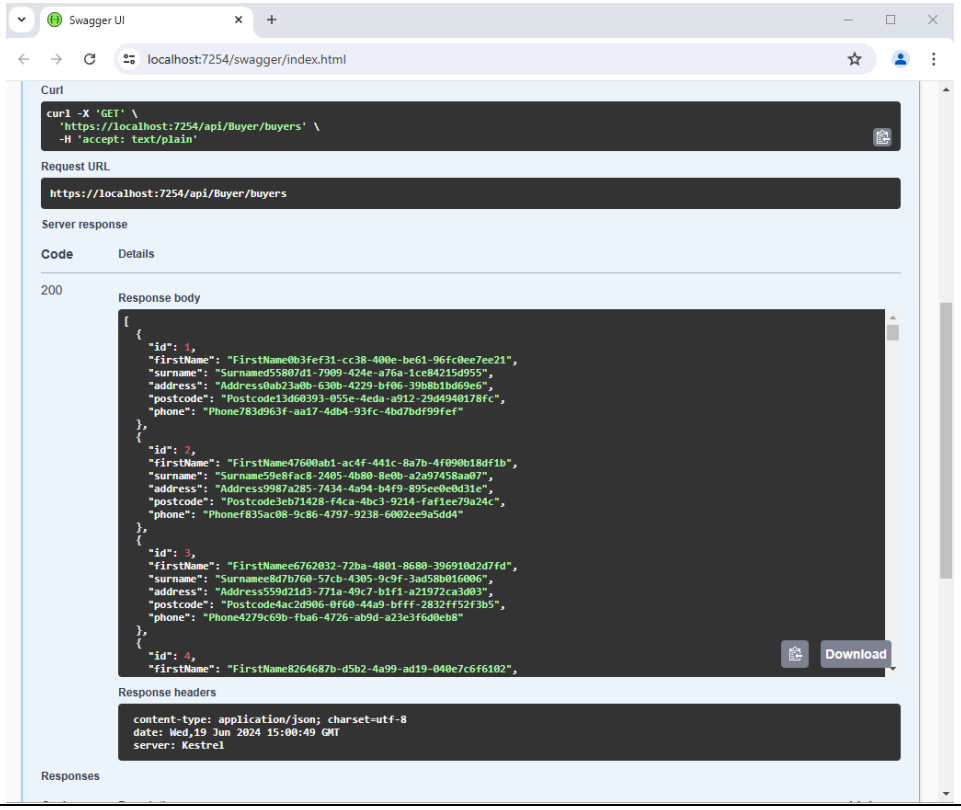
STEPS

1	Use Visual Studio to create a new ASP.NET Core Web API project called "Buyer Service". Call the solution that hosts the project "EstateAgentBackEnd". Ensure the project uses an up-to-date version of .NET (e.g. 8.0). Don't worry about authentication or enabling Docker but do ensure the "Use controllers" box is checked. 
2	Delete any preexisting controllers and/or classes based around the weather.
3	Use NuGet package manager to add references to: a. Microsoft.EntityFrameworkCore b. Microsoft.EntityFrameworkCore.SqlServer c. Newtonsoft.Json
Sorting out the database access logic:	
4	Add a folder called Models to the project.
5	Add a class called Buyer to the Models folder.

6	Replace the code in the Buyer.cs file with the following: `using System.ComponentModel.DataAnnotations;` `using System.ComponentModel.DataAnnotations.Schema;` `namespace BuyerService.Models` `{` `  [Table("buyer")]` `  public class Buyer` `  {` `  [Column("BUYER_ID")]` `  [Key]` `  public int Id { get; set; }` `  [Column("FIRST_NAME")]` `  public string? FirstName { get; set; }` `  [Column("SURNAME")]` `  public string? Surname { get; set; }` `  [Column("ADDRESS")]` `  public string? Address { get; set; }` `  [Column("POSTCODE")]` `  public string? Postcode { get; set; }` `  [Column("PHONE")]` `  public string? Phone { get; set; }` `  }` `}`
7	Add folder called Infrastructure to the project.
8	Add a class called BuyerContext to the Infrastructure folder.
9	Replace the code in the BuyerContext.cs file with the following: `using BuyerService.Models;` `using Microsoft.EntityFrameworkCore;` `namespace BuyerService.Infrastructure` `{` `  public class BuyerContext : DbContext` `  {` `  public BuyerContext(DbContextOptions<BuyerContext> options) :` `  base(options)` `  {` `  }` `  public DbSet<Buyer> Buyers { get; set; }` `  }` `}`
10	Add an empty Controller called BuyerController to the Controllers folder.
11	Add using System.Net to the list of existing using statements.
12	Add a Route attribute to the BuyerController class with a value of "api/[controller]".
13	Add a private readonly variable of type BuyerContext called _buyerContext to the top of the class.
14	Add a constructor to the class that takes a BuyerContext parameter BuyerContext called context.

15	Add a line of code to the constructor that sets _buyerContext to the context parameter but only if the context is not null. Throw an ArgumentNullException if it is.
16	Delete the Index method.
17	Add a new public method to the BuyerController class called GetBuyers giving it a return type of async Task<IActionResult>.
18	Decorate the method with the following attributes: a. `HttpGet` b. `Route` with a value of "buyers" c. `ProducesResponseType` with a type of `IEnumerable<Buyer>` and a statusCode of `HttpStatusCode.OK`.
19	Add a line of code to the method that awaits a call to _buyerContext.Buyers.ToListAsync() placing the returned value into a nullable List<Buyer> variable called buyers.
20	Return the buyers collection from the method wrapped in an OKObjectResult.
21	Your code should look something like the following: `[Route("api/[controller]")]` `public class BuyerController : Controller` `{` `  private readonly BuyerContext _buyerContext;` `  public BuyerController(BuyerContext context)` `  {` `  _buyerContext = context ?? throw new` `  ArgumentNullException(nameof(context));` `  }` `  [HttpGet]` `  [Route("buyers")]` `  [ProducesResponseType(typeof(IEnumerable<Buyer>),` `  (int)HttpStatusCode.OK)]` `  {` `  List<Buyer>? buyers = await _buyerContext.Buyers.ToListAsync();` `  return Ok(buyers);` `  }` `}`
22	Open up the appsettings.json file.

23	Add the following connection string details to the top of the file just below the first opening curly brace. **NOTE: The connection string assumes you have a local version of SQL Server installed that is up and running and, depending on the type of SQL Server engine installed you may need to use ".\\SQLExpress" as the Server name rather than "(local)"**: `"ConnectionStrings": {` `  "sqlestateagentdata":` `"Server=(local);Database=estateagent;Trusted_Connection=Yes;MultipleActiveResultSets=true;Encrypt=False;TrustServerCertificate=True"` `},`
24	Open up the Program.cs file.
25	Add the following code just beneath the builder.Services.AddControllers line: `builder.Services.AddDbContext<BuyerContext>(options =>` `  options.UseSqlServer(` `  builder.Configuration.GetConnectionString("sqlestateagentdata")));`
26	That's all the database access logic in place along with a method that should return the content of the buyers table. Unfortunately, neither the estateagent database nor the buyers table exist so we will need to create some code that checks for this and creates and seeds them if necessary.
27	Add a NuGet reference to AutoFixture. This library is usually used in the generation of test data inside unit test projects but we're going to use it to generate some random data to populate the buyers table.
28	Add a **static** class called BuyerSeeder to the Infrastructure folder
29	Add the following code to the class: `public static void Seed(this BuyerContext buyerContext)` `{` `  if (!buyerContext.Buyers.Any())` `  {` `  Fixture fixture = new Fixture();` `  fixture.Customize<Buyer>(buyer => buyer.Without(p => p.Id));` `  //--- The next two lines add 100 rows to your database` `  List<Buyer> products = fixture.CreateMany<Buyer>(100).ToList();` `  buyerContext.AddRange(products);` `  buyerContext.SaveChanges();` `  }` `}`

30	Return to the Program.cs file and add the following inside the if (App.Environment.IsDevelopment()) test. `if (app.Environment.IsDevelopment())` `{` `  using (var scope = app.Services.CreateScope())` `  {` `  var buyerContext =` `  scope.ServiceProvider.GetRequiredService<BuyerContext>();` `  buyerContext.Database.EnsureCreated();` `  buyerContext.Seed();` `  }` `  app.UseSwagger();` `  app.UseSwaggerUI();` `}`
31	Launch the app and wait for the Swagger page to open in a browser. Then Test drive the call to the "/api/Buyer/buyers" endpoint and ensure it returns some data that looks something like the following: 

Adding New Buyers

32	Return to the BuyerController and create a new method with a return type of async Task<IActionResult> called InsertBuyer that takes a Buyer called buyer as a parameter.

33	Decorate the method with the following attributes (the Route and ProducesResponseType are exactly the same as those used on the GetBuyers method): a. `HttpPost` b. `Route` with a value of "buyers" c. `ProducesResponseType` with a type of `IEnumerable<Buyer>` and a statusCode of `HttpStatusCode.OK`.
34	**NOTE: Whilst the methods have different names (GetBuyers and InsertBuyer) their Web API endpoints are identical (/api/Buyer/buyers). The difference is in the HTTP request types (Get and Post).**
35	We really ought to validate the properties of the buyer parameter to make sure they meet any business constraints. However, given you should already have a good idea as to how to go about doing this we'll give it a miss and focus on the "microservice" elements of the tasks in hand.
36	Add code to the InsertBuyer method that calls the Add method of the Buyers collection associated with the _buyerContext passing it the buyer object.
37	Invoke the _buyerContext object's SaveChanges method.
	If the insert is successful, the entity framework should have updated the buyer object's Id property with the value automatically generated by the database. Consequently, we will return the updated buyer object wrapped in an OKObjectResult.
38	Launch the app and test drive the new insert method by using the Swagger interface.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you have time:

39	Try to create methods that allow Buyers to be removed from the database and have their data updated making use of the HttpDelete and HttpPut attributes. Make sure to keep the Route signatures the same as those used for GetUsers and InsertUser. Note: a. To delete a Buyer, you will need to ensure they exist in the database by making use of the _buyerContext.Buyers.SingleOrDefaultAsync method. If the lookup is successful you need to pass the object reference to the _buyerContext.Buyers.Remove method.

	b. To update a Buyer, note there is no Update method. Instead, you will have to make use of the use of the _buyerContext.Buyers.SingleOrDefaultAsync method to retrieve the appropriate Buyer object (let's call it "b") from the database. Then you need to set this object's properties to those of the passed in Buyer parameter. Finally, you need to invoke SaveChanges.
40	If you manage to do all of the above, then add two final methods to the Controller class that retrieve a single Buyer object based on a passed in Id or buyer name.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 08: Creating an ASP.NET **Minimal** API Microservice

Objective

Your goal is to return to the Estate Agent application and create a microservice for "seller" information.

Overview

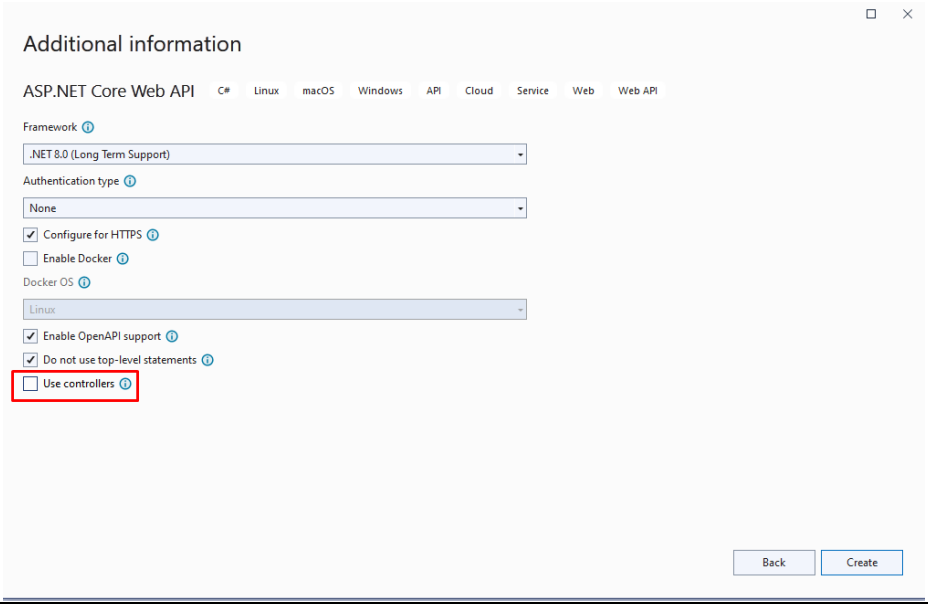
The Estate Agent application you worked on in the previous lab needs to keep track of property sellers as well as potential buyers. In this lab you will add a Sellers microservice that is built using Visual Studio's ASP.NET **Minimal** API template. The microservice should allow a consumer of the service to:

- Retrieve a list of all sellers.
- Retrieve a seller by their id.
- Retrieve a seller by their name.
- Add new sellers.
- Delete existing sellers.
- Update existing sellers.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

STEPS

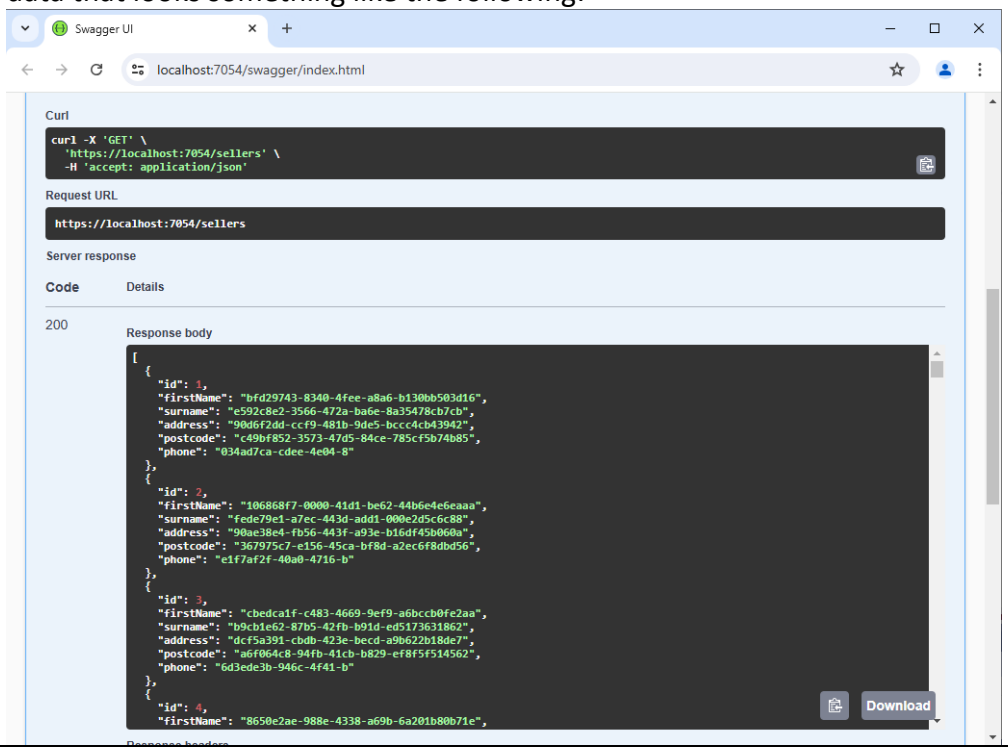
1	Use Visual Studio to add a new ASP.NET Core Web API project called "Seller Service" to the "EstateAgentBackEnd" solution. Ensure the project uses an up-to-date version of .NET (e.g. 8.0). Don't worry about authentication or enabling Docker but do ensure the "Use controllers" box is **unchecked**. 
2	Delete any preexisting code and/or classes based around the weather including the summaries array and app.MapGet function in Program.cs.
3	Use NuGet package manager to add references to: a. Microsoft.EntityFrameworkCore b. Microsoft.EntityFrameworkCore.SqlServer c. Newtonsoft.Json

Sorting out the database access logic:

4	Add a folder called Models to the project.
5	Add a class called Seller to the Models folder.
6	Replace the code in the Seller.cs file with the following: `using System.ComponentModel.DataAnnotations.Schema;` `using System.ComponentModel.DataAnnotations;` `namespace SellerService.Models` `{` `  [Table("seller")]` `  public class Seller` `  {` `    public Seller()` `    {` `      //Properties = null;` `    }` `    [Column("SELLER_ID")]` `    [Key]` `    public int Id { get; set; }` `    [Required]` `    [StringLength(255)]` `    [Column("FIRST_NAME")]` `    public string FirstName { get; set; }` `    [Required]` `    [StringLength(255)]` `    [Column("SURNAME")]` `    public string Surname { get; set; }` `    [Required]` `    [StringLength(255)]` `    [Column("ADDRESS")]` `    public string Address { get; set; }` `    [Required]` `    [StringLength(255)]` `    [Column("POSTCODE")]` `    public string Postcode { get; set; }` `    [Required]` `    [StringLength(20)]` `    [Column("PHONE")]` `    public string Phone { get; set; }` `    public object Clone()` `    {` `      return new Seller` `      {` `        Id = this.Id,` `        FirstName = this.FirstName,` `        Surname = this.Surname,` `        Address = this.Address,` `        Postcode = this.Postcode,` `        Phone = this.Phone` `      };` `    }` `    public bool Equals(Seller? other)` `    {` `      return Id == other.Id;` `    }` `  }` `}`
7	Add a folder called Infrastructure to the project.
8	Add a class called SellerContext to the Infrastructure folder.

9	Replace the code in the SellerContext.cs file with the following: `using Microsoft.EntityFrameworkCore;` `using SellerService.Models;` `namespace SellerService.Infrastructure` `{` `  public class SellerContext : DbContext` `  {` `  public SellerContext(DbContextOptions<SellerContext> options) :` `  base(options)` `  {` `  }` `  public DbSet<Seller> Sellers { get; set; }` `  }` `}`
10	Open up the appsettings.json file.
11	Add the following connection string details to the top of the file just below the first opening curly brace. **NOTE: The connection string assumes you have a local version of SQL Server installed that is up and running and, depending on the type of SQL Server engine installed you may need to use ".\SQLExpress" as the Server name rather than "(local)"**: `"ConnectionStrings": {` `  "sqlestateagentdata":` `"Server=(local);Database=estateagent;Trusted_Connection=Yes;MultipleActiv` `eResultSets=true;Encrypt=False;TrustServerCertificate=True"` `},`
12	Open up the Program.cs file.
13	Add the following code just beneath the "//Add services to the container" comment: `builder.Services.AddDbContext<SellerContext>(options =>` `  options.UseSqlServer(` `  builder.Configuration.GetConnectionString("sqlestateagentdata")));`
14	Add a NuGet reference to AutoFixture. This library is usually used in the generation of test data inside unit test projects but we're going to use it to generate some random data to populate the sellers table.
15	Add a **static** class called SellerSeeder to the Infrastructure folder
16	Add the following code to the class: `public static void Seed(this SellerContext sellerContext)` `{` `  if (!sellerContext.Sellers.Any())` `  {` `  Fixture fixture = new Fixture();` `  fixture.Customize<Seller>(seller => seller.Without(p => p.Id));` `  //--- The next two lines add 100 rows to your database` `  List<Seller> sellers = fixture.CreateMany<Seller>(100).ToList();` `  sellerContext.AddRange(sellers);` `  sellerContext.SaveChanges();` `  }` `}`

17	Return to the Program.cs file and add the following inside the if (App.Environment.IsDevelopment()) test. `if (app.Environment.IsDevelopment())` `{` `  using (var scope = app.Services.CreateScope())` `  {` `  var sellerContext =` `  scope.ServiceProvider.GetRequiredService<SellerContext>();` `  sellerContext.Database.EnsureCreated();` `  sellerContext.Seed();` `  }` `  app.UseSwagger();` `  app.UseSwaggerUI();` `}`
18	That's all the database access logic in place. All we need now are some Http endpoints.
19	Given that this time we are creating a minimal microservice there is no need to add any Controllers. Instead, we are going to add our endpoints directly to the Program.cs file in the form of lambda expressions.
20	At the foot of the Program.cs file just before the "app.Run()" line add the following code: `app.MapGet("/sellers", async (SellerContext db) =>` `  await db.Sellers.ToListAsync());`
21	The code creates an anonymous function that specifies an Http endpoint ("/sellers") that uses the SellerContext to asynchronously implicitly return all the sellers in the database's sellers table.
22	Before running the program you will need to delete the database from SQL Server otherwise the code in SellerSeeder will trigger an SQLException. You can do this inside SQL Server Management Studio (SSMS) byt right-clicking on the estateagent database and selecting Delete. Make sure the Close existing connections box is checked and press OK.
23	Make sure the SellerService project has been configured to be the Start-up project and launch the app. Wait for the Swagger page to open in a browser. Then Test drive the call to the "/sellers" end-point and ensure it returns some

	data that looks something like the following: 

Adding New Sellers

24	Return to the Program.cs and create a new anonymous method that calls the app object's MapPost method passing it "/sellers" as the pattern parameter and async (Seller seller, SellerContext db) => as the signature of the lambda delegate.
25	Add the following code as the delegate logic: `db.Sellers.Add(seller);` `  await db.SaveChangesAsync();` `  return Results.Created($"/sellers/{seller.Id}", seller);` A 201 status code is generated by the Results.Created method when a seller is created. In this code path, the Seller object is provided in the response body along with the URI at which the content will have been created.
26	**NOTE: Whilst the two methods have the same endpoints (sellers). Like before, with Buyers, the difference is in the HTTP request types (MapGet and MapPost).**
27	We really ought to validate the properties of the seller object to make sure they meet any business constraints. However, we didn't do it for the Buyer functionality so we're not going to do it here! The rest of the functionality is pretty much the same as it was for the BuyerService's InsertBuyer method and so, needs no explanation
28	Launch the app and test drive the new insert method by using the Swagger interface.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you have time:

29	Try to create additional methods that allow Sellers to be removed from the database and have their data updated making use of the app.MapDelete and app.MapPut methods. Make sure to keep the Route signatures the same as those used for MapGet and MapPost. Note: a. To delete a Seller, you will need to ensure they exist in the database by making use of the SellerContext's .Sellers.FindAsync method. If the lookup is successful you need to pass the object reference to the SellerContext's Sellers.Remove method. b. To update a Seller, note there is no Update method. Instead, you will have to make use of the use of the SellerContext's Sellers. FindAsync method to retrieve the appropriate Seller object (let's call it "s") from the database. Then you need to set this object's properties to those of the passed in Seller parameter. Finally, you need to invoke SaveChanges.
30	If you manage to do all of the above, then add two final methods to the Controller class that retrieve a single Single object based on a passed in Id or seller name.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 09: Estate Agent Microservice – One Database per Microservice

Objective

Your goal is to edit the microservices so that they each use their own single table database. You will also need to worry about referential integrity between the databases.

Overview

In the current setup all the microservices use the same database which is configured to "cascade delete" any dependencies. In our case this means when a property is removed from the properties table the database ensures any associated bookings for that property are automatically deleted from the "bookings" table. In the "new world" of microservices we are encouraged to develop services that each use their own database such that the databases only host a minimal number of tables (typically just one). This means we, as developers, need to worry about the referential integrity of our data rather than letting the databases do it for us.

Note: There are many other dependencies which the original database could (and would) have managed automatically. For the purposes of brevity, we won't be managing all of these issues in this lab (that's something you could consider doing later if and when you have time). However, we will deal with the "bookings for deleted properties" issue mentioned above and we will also create code that ensures a booking can't be made for a non-existent property or buyer.

Important note: Splitting a relational database up in the way the lab does is often not a good idea. What if the deletion of a property is successful but, for some reason, the deletion of associated bookings fails? For the purpose of this and other following labs we are going to ignore these concerns. The point of the labs is to understand how to create and containerize microservices and to deal "conceptually" with some of the issues that raises.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

STEPS

Reconfigure code so each service uses its own single table database.

1	Locate the SQL script called "EstateAgentFourSeparateDatabasesScript.sql" in the Assets folder. Open and run it inside SQL Server Management Studio (SSMS). The script generates four individual databases called EABuyer, EASeller, EAProperty and EABooking. Each database contains a single table whose name is directly related to the name of the database it resides in. Each table contains a small amount of test data.
2	Open the starter project. You will notice we've added two more projects to the solution (BookingService and PropertyService). Both are fully functioning and currently make use of the same single EstateAgent database that the (unchanged) Buyer and Seller services are using. Also note all four services offer only basic CRUD capabilities. No validation is done on any of the submitted data. We've done this for the sake of simplicity. There

	would be a world of pain to go through to get the code up to scratch for a real-world deployment 😉.
3	Open the BookingService project's appsettings.json file and change the name of the database (located in the connection string) to EABooking: `"ConnectionStrings": { "sqlestateagentdata": "Server=(local);Database=EABooking;Trusted_Connection=Yes;MultipleActiveResultSets=true;Encrypt=False;TrustServerCertificate=True" }`
4	Repeat step 3 for each of the other projects changing the database names to EABuyer, EAProperty or EASeller accordingly.

Manage the deletion of properties that have associated bookings.

5	If a property has been successfully removed from the EAProperty database, we need to get the `BookingService` to remove any associated bookings that have been made by any potential buyers. We'll do this by making a call to a BookingService endpoint (that we've yet to write) that takes a `propertyId` as a parameter. But first we will tackle the code that needs to be added to the PropertyService:
6	Locate the `MapDelete` function in the PropertyService project's program.cs file.
7	Add the following code between the line that calls `db.SaveChanges()` and the return statement (**Note: the highlighted port number will probably be different for your app. You can find the number by looking at the BookingService project's launchSettings.json file located in the Properties folder.**): `var http = new HttpClient(); string url = $"http://localhost:5225/bookingsByPropertyId/{id}"; HttpResponseMessage response = await http.DeleteAsync(url);`
8	Change the return statement to test the result of the API call to see if it was successful (`response.IsSuccessStatusCode`). If it is then return `Results.NoContent()` but if not return `Results.NotFound()`.
9	Locate the `MapDelete` function in the BookingService project's program.cs file and add a new `MapDelete` function beneath it with a pattern parameter of `bookingsByPropertyId`. Use the same lambda expression for the second (delegate) parameter as the other `DeleteMap` function.
10	Add code to the new function that returns all the bookings (as a `List`) where the `PropertyId` of each booking matches the passed in `id` parameter. Make this call an awaited task. Your code may look like the following: `app.MapDelete("/bookingsByPropertyId/{id}", async (int id, BookingContext db) => { List<Booking> bookings = await db.Bookings.Where(b => b.PropertyId == id).ToListAsync();`

11	Add code that tests to ensure a collection was returned and the collection is not empty. If not return `Results.NotFound()`. If some bookings have been found iterate around the collection and call the `db.Bookings.Remove()` method for each of them.
12	After the loop completes call `db.SaveChangesAsync()` to force the changes to the database and return `Results.NoContent()`.
13	Test the application by starting the app (F5). Notice the solution has been configured to start all four projects.
14	Use Swagger (or Postman or SSMS) to add a new property to the EAProperty database. Look at the response to ensure this has been successful and make a note of the newly generated `propertyId`. Then (again using Swagger, Postman or SSMS) add 3 new bookings for the property.
15	Finally Use Swagger (or Postman) to trigger the PropertyService's Delete function to delete the property. Ensure that both the property and its corresponding bookings have been removed from both databases. You may wish to set some breakpoints within the relevant functions and use the debugger to step through the code to follow the action.

Ensuring a booking can't be made for a non-existent property or buyer.

16	Return to the program.cs file in the BookingService project.
17	Locate the MapPost function.
18	Before we can add a new booking, we need to ensure that passed in booking's propertyId and buyerId are set to values that exist in their corresponding databases. We'll achieve this by making API calls to the "Get by Id" functions supported by both of the services and ensuring we get valid Property and Buyer objects back. Add the following to the top of the function just above the `db.Bookings.Add(booking)` line (make sure you replace the highlighted port number with the one associated with your PropertyService API (You can find the number by looking at the PropertyService project's launchSettings.json file located in the Properties folder): `var http = new HttpClient();` `//Check to see if PropertyId is valid` `string url = $"https://localhost:7139/properties/{booking.PropertyId}";` `HttpResponseMessage response = await http.GetAsync(url);` `string responseJson = response.Content.ReadAsStringAsync().Result;` `dynamic responseData = JsonConvert.DeserializeObject(responseJson);` `if (responseData == null || responseData["id"] != booking.PropertyId)` `return Results.NotFound();`

19	Add similar code that tests to see if the passed in booking object's buyerId is also valid. **Note, that because we created the BuyerService using a Controller class the endpoint URL will be a little bit different**.
20	Run and test the functionality to ensure bookings are only added to the Bookingservice's database when both the PropertyId and BuyerId exist as entries in their respective datbases.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you have time:

21	Try and add further code to the projects so as to further maintain relational integrity. Scenarios to consider include: • Deleting any associated properties when a seller is removed from the EASeller database. • Deleting any associated bookings when a buyer is removed from the EABuyer database. You may also want to consider setting any related BuyerId's to null in the EAProperty database. • Not allowing a property to be added if the sellerId is not in the EASeller database and. If specified, the BuyerId is not in the EABuyer database. **Note, the model solution does not implement any of these potential enhancements.**

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 10a: Docker MINI Lab 1 - Register for Docker

Note: In order to use Docker you must have downloaded and installed Docker Desktop onto your computer (If using a QA provided machine this will already have been done).

In this mini lab, we will register for Docker and then exercise the commands outlined previously.

First, register an account with Docker at https://hub.docker.com

Once created, open Windows PowerShell, authenticate the Docker CLI to Dockerhub with the login command.

```
docker login
```

Next, let's download a hello world image.

```
docker search hello-world
```

The search command returns a table of images relevant to the search term with their description and whether they are an official image.

NAME	DESCRIPTION	STARS	OFFICIAL
hello-world	Hello World! (an example of minimal Dockeriz...	2298	[OK]
atlassian/hello-world	0		
rancher/hello-world	This container image is no longer maintained...	6	
hellobello/hello-world	0		
hellojinl/hello-world	0		
tutum/hello-world	Image to test docker deployments. Has Apache...	90	
infrastructureascode/hello-world	A tiny "Hello World" web server with a healt...	1	
uniplaces/hello-world	0		
prajwalendra/hello-world	0		
...	...	...	...

We see a hello-world image on line 1. Use the `docker pull` command to download the image.

```
docker pull hello-world
```

See what docker images exist by using the `docker images` command:

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
hello-world	latest	d2c94e258dcb	15 months ago	13.3kB

Rename the hello-world image so that it is prefixed with your *Docker hub* name

Replace <your_docker_username> with your Docker username and run the following command:

```
docker tag hello-world <your_docker_username>/hello-world
```

Now, when we run `docker images`, we can see two images. We have created a new image with a different name.

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
hello-world	latest	d2c94e258dcb	15 months ago	13.3kB
<your_docker_username>/hello-world	latest	d2c94e258dcb	15 months ago	13.3kB

Now we can push the newly tagged image to our repository by tagging it in the format [USERNAME]/[IMAGE]:[TAG].

```
docker push <your_docker_username>/hello-world
```

Navigate to Dockerhub, and you should see a new repository.

Now that the image has been uploaded, we can delete the images we have locally and free up space.

Delete the *hello-world* image

```
docker rmi hello-world
```

The output displays the different layers being deleted. The last two lines:

Deleted: sha256:dbf7b16cf5d32dfec3058391a92361a09745421deb2491545964f8ba99b37fc2

Deleted: sha256:a2ae92ffcd29f7ededa0320f4a4fd709a723beae9a4e681696874932db7aee2c

Repeat for the renamed image

```
docker rmi <your_docker_username>/hello-world
```

Now, when we run `docker images` we should see an empty table.

Lab 10b: Docker MINI LAB 2 – Run and Test a Container

In this mini lab we will go through the process of setting up a SQL Server instance inside a container.

Checklist:

- Spin up a container using the official Microsoft SQL-Server image.
- Map port the machine's port 1433 to the container port 1433
- Retrieve the initial administrator password from the container

Download the container

It is important to remember to map the container port to the machine's port. In this case, SQL-Server is configured to port 1433. So, we use the -p flag map the ports to each other. And the -e flag to set a default password.

```
# -d for detached mode so we can still use the terminal
# -p maps the machine's port 1433 to the container's port 1533
# -e sets up environment variables
# --name names the container so that we are not using a random name
docker run -e "ACCEPT_EULA=Y" -e "MSSQL_SA_PASSWORD=<Your_Strong_Password>" -d -p 1533:1433
--name sql_server_container mcr.microsoft.com/mssql/server:2022-latest
```

Replace <Your_Strong_Password> with a strong password of your own. **For the purpose of the course it is suggested you use "PaSSw0rdPaSSw0rd".**

Now we can check if the container has started properly:

```
docker ps
```

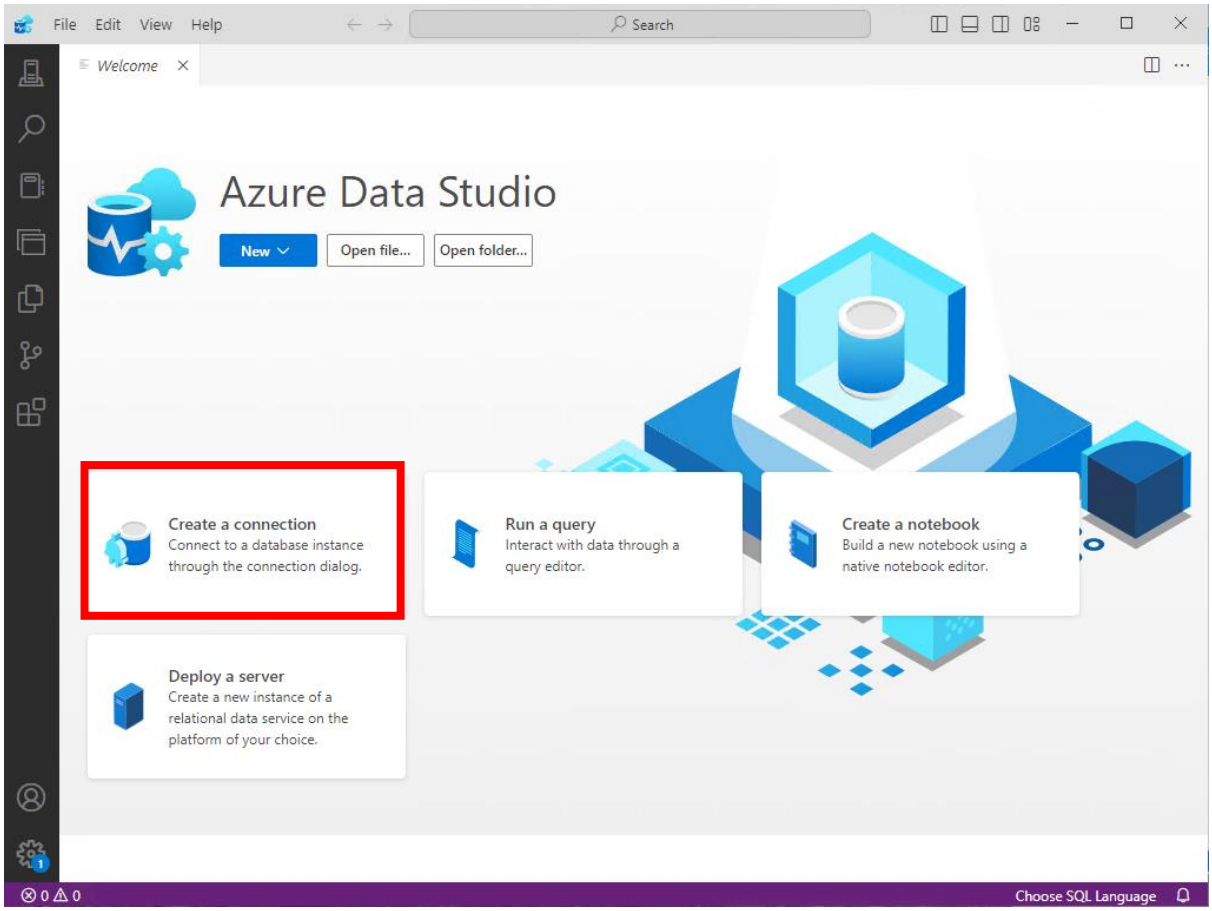
You should see a similar output to the following:

```
CONTAINER ID:    4017a9ca9621
IMAGE:           mcr.microsoft.com/mssql/server:2022-latest
COMMAND:         "/opt/mssql/bin/perm…"
CREATED:         3 minutes ago
STATUS:          Up 3 minutes
PORTS:           0.0.0.0:1533->1433/tcp
NAMES:           sql_server_container
```

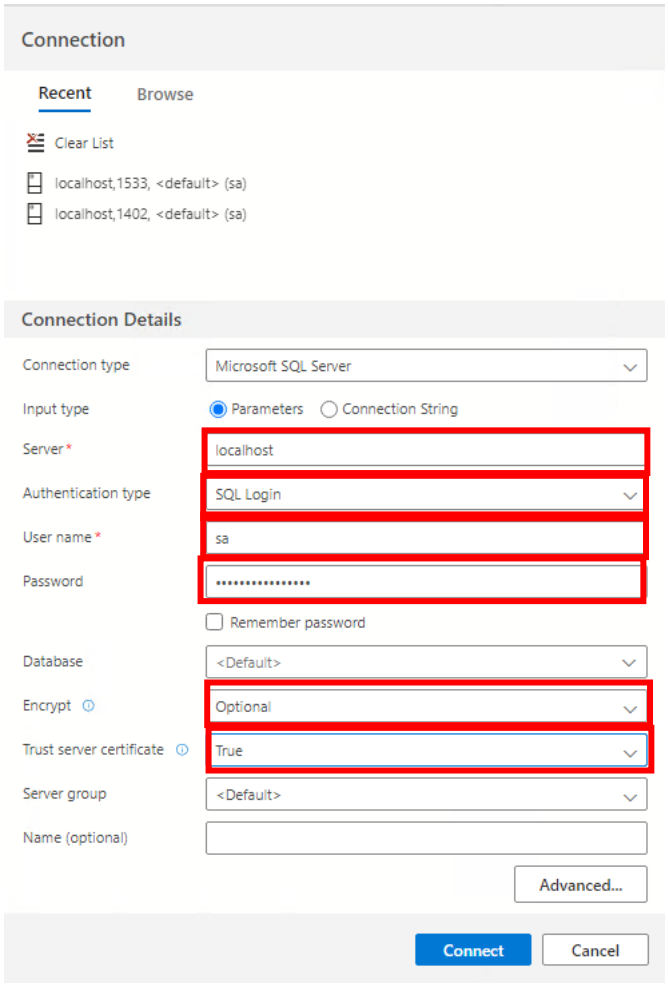
connect to SQL Server Linux containers

Next, we need to connect and log in to the SQL Server instance

Open Azure Data Studio and click the connect button:



Fill in the connection window with the following (use the secure password you specified when setting up the container):



Click the Advanced… button.

Scroll down and enter 1533 for the Port.

Press OK and then press Connect.

If all is well, you will have successfully made a connection to the server.

Close the Azure Data Studio window.

Tear down

To stop and delete the container:

```
# Stop the container
docker stop sql_server_container
# Deletes the container
docker rm sql_server_container
```

Lab 10c: Docker MINI LAB 3 – Creating and using a Docker File

1. Create a Minimal C# Application

First, create a new C# Console Application. There's no need to fire up Visual Studio, instead, run the following instructions in PowerShell:

```
dotnet new web -n HelloWorldAspNet -f net8.0
cd HelloWorldAspNet
```

generates a simple ASP.NET Core web application with a `Program.cs` file that hosts a minimal web server.

Edit the `Program.cs` file by typing:

```
Notepad Program.cs
```

Replace the code with the following which is essentially the same but ensures the Kestrel server is configured to listen on port 80:

```
var builder = WebApplication.CreateBuilder(args);

// Explicitly set Kestrel to listen on port 80
builder.WebHost.ConfigureKestrel(serverOptions =>
{
    serverOptions.ListenAnyIP(80); // Listen on port 80 for any IP address
});

var app = builder.Build();

app.MapGet("/", () => "Hello, World from ASP.NET Core 8.0!");

app.Run();
```

2. Create a Dockerfile

Next, create a Dockerfile in the same directory as your Program.cs file by typing:

```
New-Item Dockerfile
```

Edit the `Dockerfile` file by typing:

```
Notepad Dockerfile
```

Copy code the following code into the file

```
# Use the official .NET SDK image for building the application
FROM mcr.microsoft.com/dotnet/sdk:8.0 AS build
WORKDIR /src

# Copy the project files into the container
COPY . .

# Restore dependencies
RUN dotnet restore

# Publish the application
```

```
RUN dotnet publish -c Release -o /app

# Use the official .NET runtime image for running the application
FROM mcr.microsoft.com/dotnet/aspnet:8.0 AS runtime
WORKDIR /app

# Copy the published output from the build stage
COPY --from=build /app .

# Set the entry point to run the application
ENTRYPOINT ["dotnet", "HelloWorldAspNet.dll"]

# Expose port 80
EXPOSE 80
```

3. Build the Docker Image

Build the Docker image using the following command:

```
docker build -t helloworldaspnet .
```

4. Run the Docker Container

Run the Docker container using the following command:

```
docker run --rm -p 8080:80 helloworldaspnet
```

Browse to localhost:8080. This will output something like:

```
Hello, World from ASP.NET Core 8.0!
```

Summary

With this small amount of code, you have demonstrated how to deploy a basic C# application to a Docker container. The essential components are:

1. A basic C# console application (Program.cs).
2. A Dockerfile to define how the application is built and run in a Docker container.

Lab 10d: Estate Agent Microservice – Containerising the Services Using Docker

Objective

Your goal is to reengineer the Estate Agent services so that they each run in their own Docker container and in addition, each service should make use of a dedicated SQL server service that hosted in their own Docker containers.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

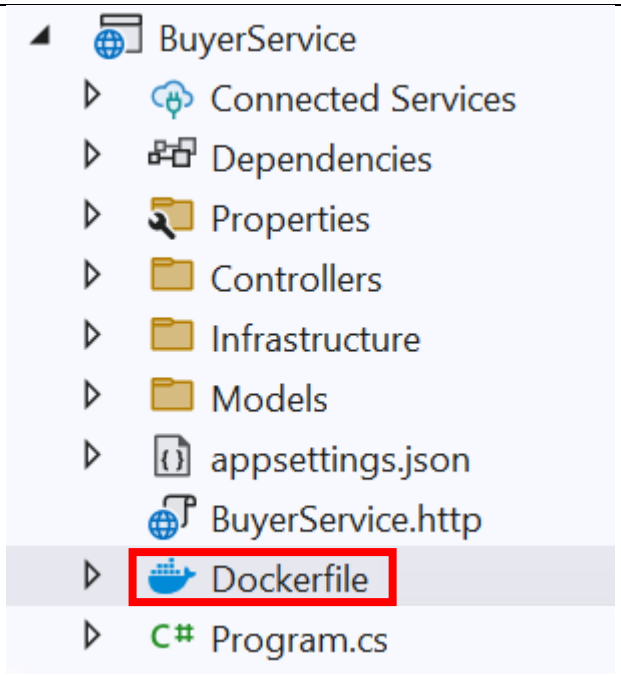
STEPS

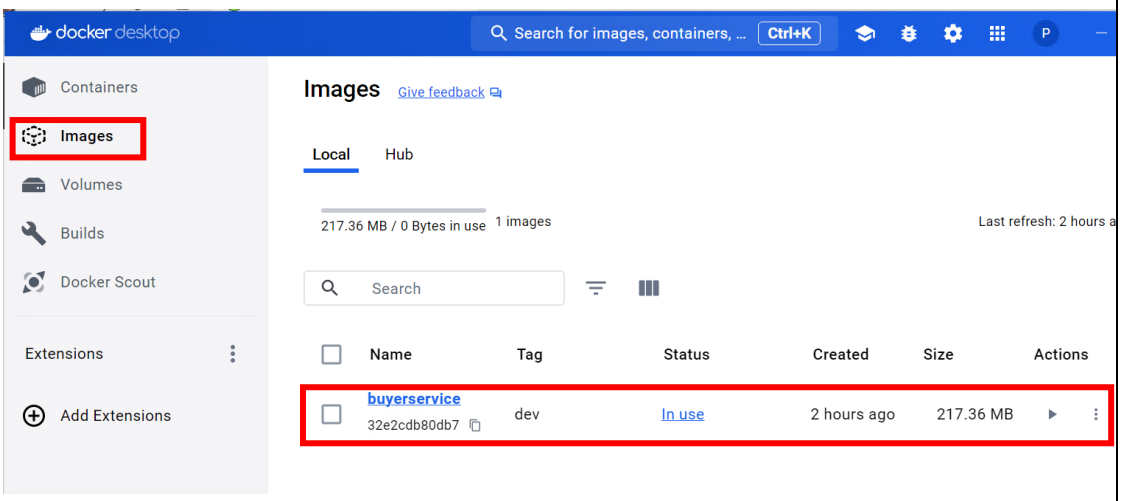
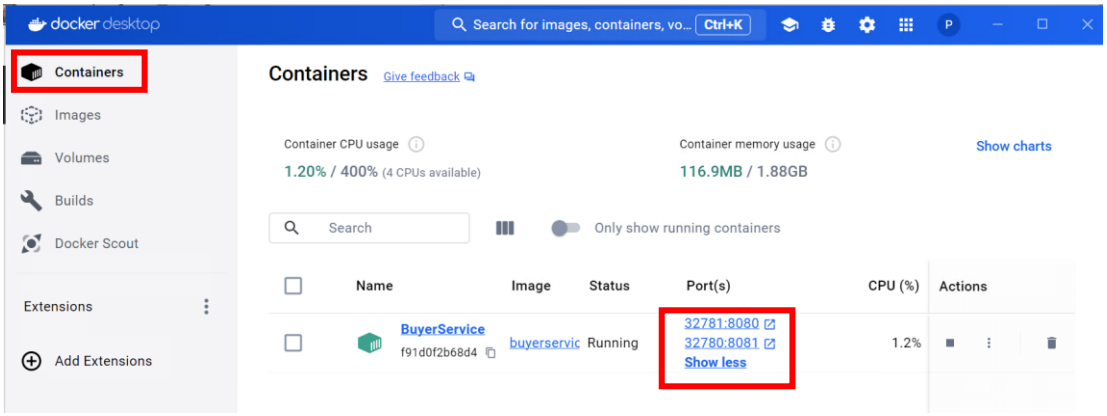
Launch and configure Docker Desktop.

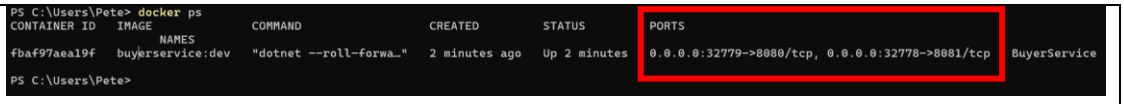
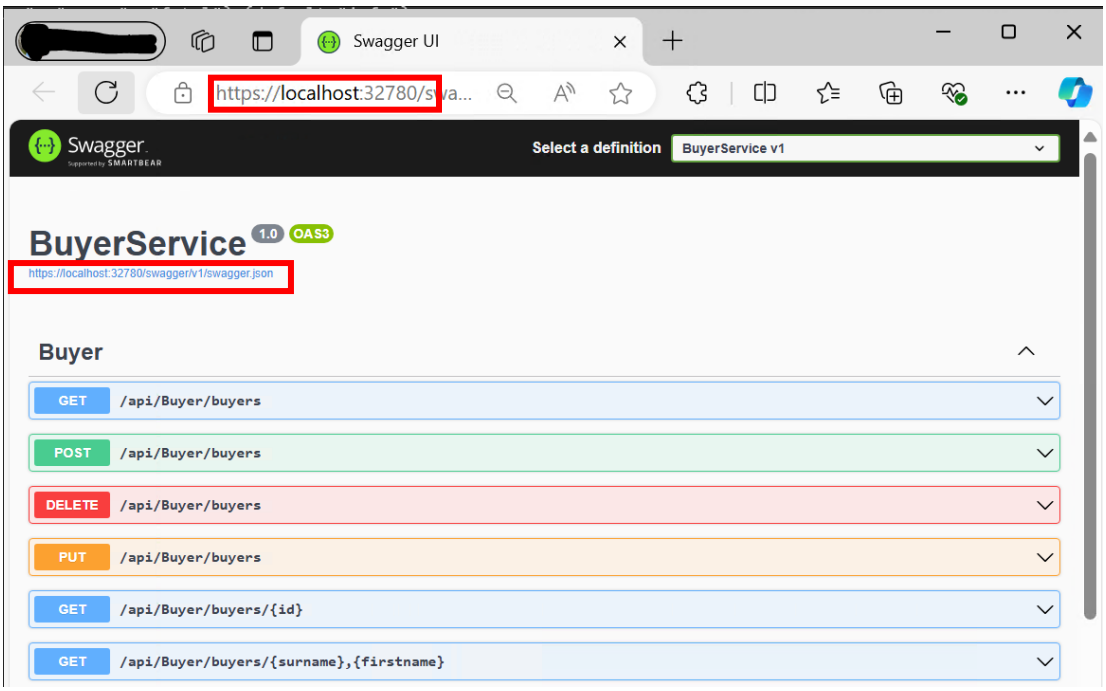
1	If you've not already used Docker before and/or don't have a login then register with Docker at Docker.com. If you already have an account then sign in.
2	Launch Docker Desktop answering any questions and taking defaults as appropriate.

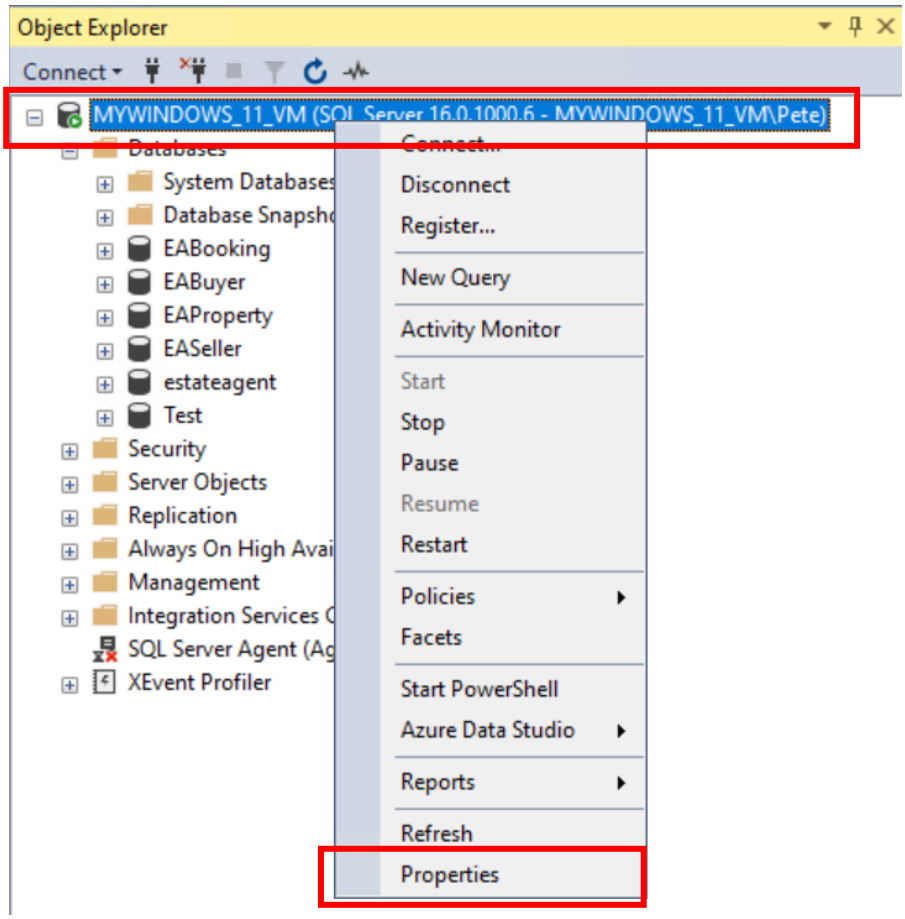
Add Docker Support to the Four projects.

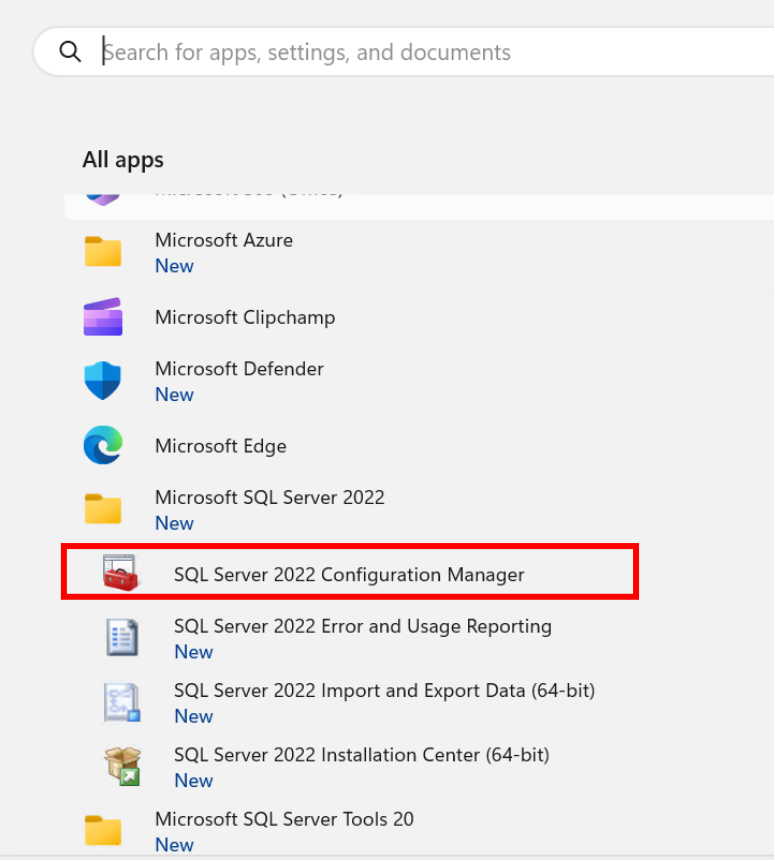
5	Open the Visual Studio starter solution located in the …" Labs\10 Docker Containerisation\Starter" folder.
6	Right click on the BuyerService in Visual Studio's Solution Explorer window and select Add | Docker Support...
7	Select Linux as the Target OS and Dockerfile as the Container build type and press OK. **Note: If you were creating a new Visual Studio project from scratch with the "ASP.NET Core Web Application" project templates you could select the Enable Docker Support" check box as part of the process.**
8	A Docker file should have been added to the project:

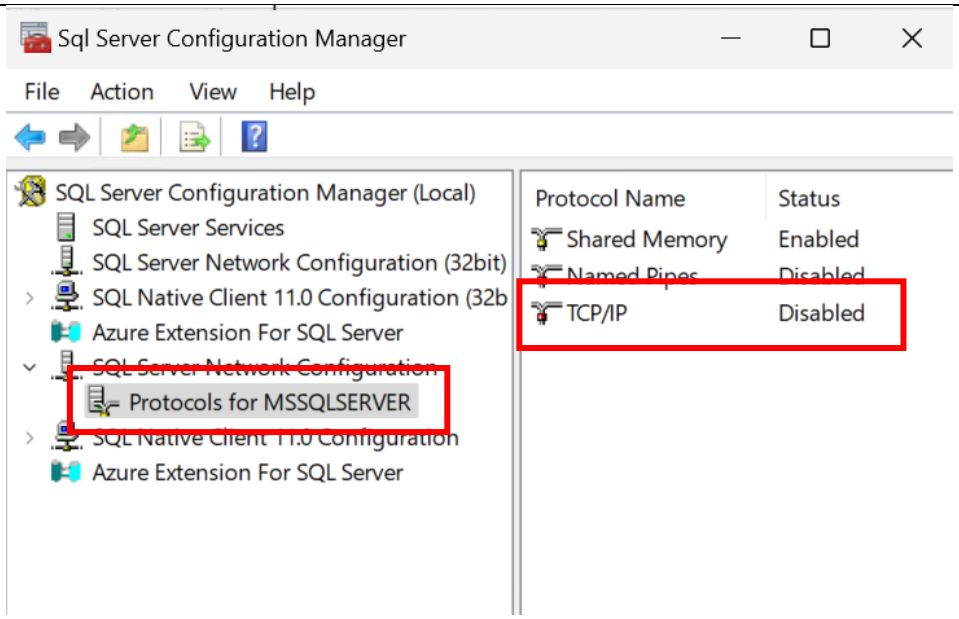
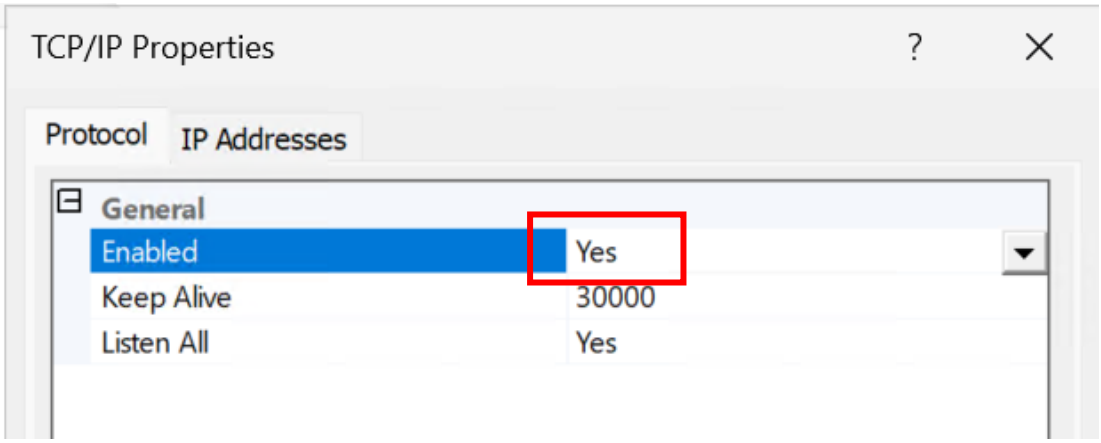
	
9	Inspect the file's content: `#See https://aka.ms/customizecontainer to learn how to customize your debug container and how Visual Studio` `FROM mcr.microsoft.com/dotnet/aspnet:8.0 AS base` `USER app` `WORKDIR /app` `EXPOSE 8080` `EXPOSE 8081` `FROM mcr.microsoft.com/dotnet/sdk:8.0 AS build` `ARG BUILD_CONFIGURATION=Release` `WORKDIR /src` `COPY ["BuyerService/BuyerService.csproj", "BuyerService/"]` `RUN dotnet restore "./BuyerService/BuyerService.csproj"` `COPY . .` `WORKDIR "/src/BuyerService"` `RUN dotnet build "./BuyerService.csproj" -c $BUILD_CONFIGURATION -o /app/build` `FROM build AS publish` `ARG BUILD_CONFIGURATION=Release` `RUN dotnet publish "./BuyerService.csproj" -c $BUILD_CONFIGURATION -o /app/publish /p:UseAppHost=false` `FROM base AS final` `WORKDIR /app` `COPY --from=publish /app/publish .` `ENTRYPOINT ["dotnet", "BuyerService.dll"]`
10	Everything you need to do to containerise the app has been configured for you! The only thing you may want to do is change the port numbers you want the app to operate and be exposed on. However, there is a gotcha. The port numbers are for internal use only. I.E. they are exposing the app to other services that would be running in the same container. Given we are creating microservices this isn't going to be terribly helpful to us.
11	Look at the launchSettings.json file in the BuyerService's Properties folder. Note that a new section called "Container (Dockerfile)" has been added (this was done at the same time the DockerFile was created). To be honest this new entry isn't terribly useful to us, but it does highlight a point of potential conflict because the listed ports are the same "internal" ports the app will be exposing to other services

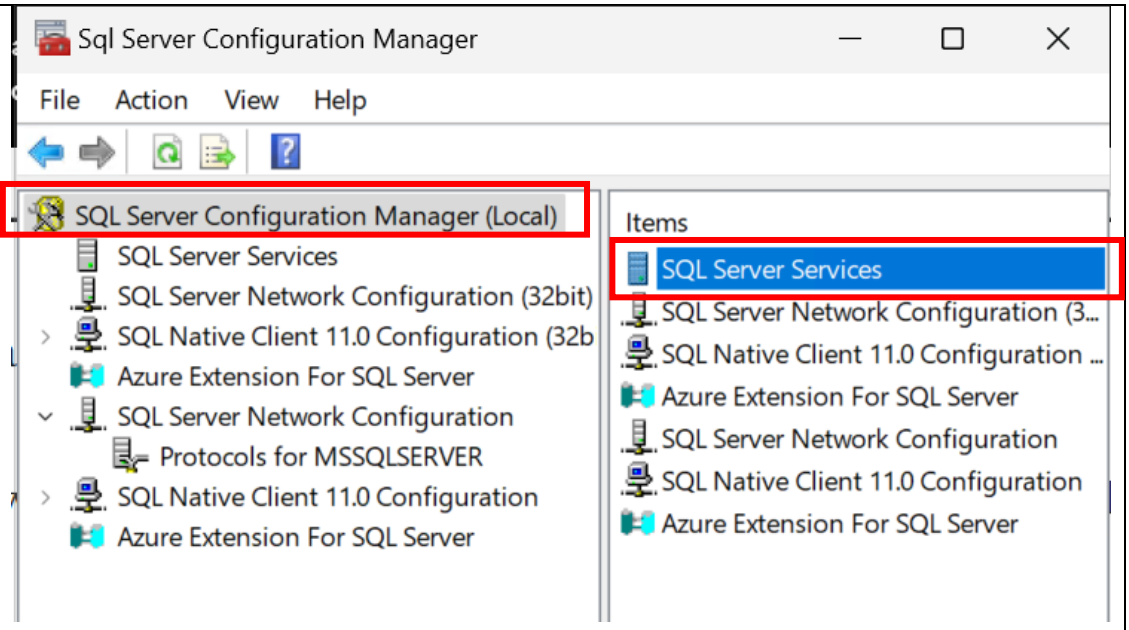
	running in the same container (as listed in the Dockerfile). If you do want to change these port numbers they should be kept in step with the ones specified in the DockerFile otherwise things will get confusing and we'll be entering a game of last in wins.
12	Remember the Solution is configured (from the last lab) to launch all 4 projects at the same time. We don't want this to happen so, right click on the BuyerService project in Visual Studio's Solution Explorer window and select "Debug | Start New Instance.
13	Look in the Docker Desktop window and notice the buyersservice image will appear (possibly after some time) in the Images tab: 
14	A short while after, if you click on the Containers tab you will see a buyerService container get up and running. If you are lucky, you may even see some port information:  However, don't worry if the port information is missing, Docker Desktop sometimes chooses not to show it! You can always see what ports are being used by firing up either a Command (cmd) or PowerShell window and entering: `Docker ps`

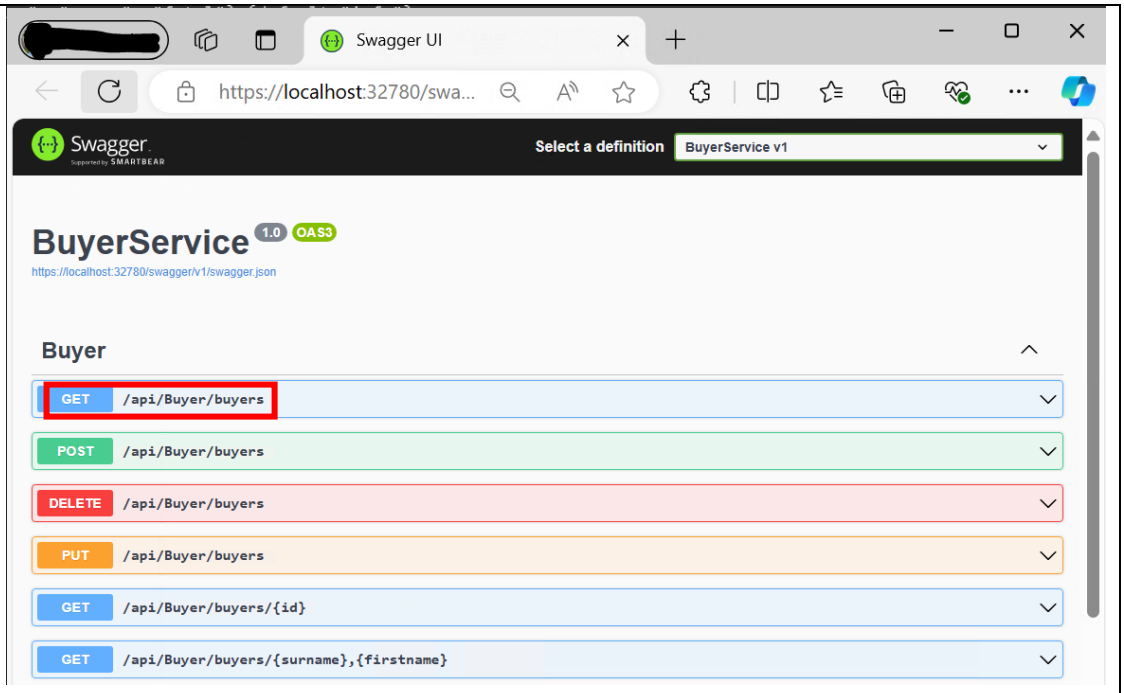
	
15	The port that is exposed to the external network is always specified to the left of the arrow (->) symbol and the first pair of ports will typically be exposed on HTTP whilst the second pair will be using HTTPS. So, in the above example you can see a client running on the same local machine could access the code running in the container by using a URL that starts with either: HTTP://localhost:32779/ Or: HTTPS://localhost:32778/
16	If everything is running smoothly Visual Studio should have opened up a browser window exposing the BuyerService via Swagger and you will notice it is using the HTTPS port number: 
17	Try testing the service by invoking the Get Buyers API function. Unfortunately, the application will fail with a 500 response. Digging into the response body you will see the issue lies around establishing a connection to the SQL Server database.
18	There are actually two issues that we need to solve. The first is we are trying to access the database using a Trusted Connection which requires a token associated with the ID of the calling process. In previous exercises that ID was the one given to you when you logged onto Windows. Unfortunately (or perhaps fortunately given the real-world need for security) the ID associated with the call coming from the Docker container isn't yours and is one that isn't associated with the database.

	Fortunately, the SQL script you ran that created the database also added a user called eauser. Locate the appsettings.json file in the BuyerService and amend the sqlestateagentdata connection string so that rather than using a Trusted_Connection setting it passes in a user id and password: `"Server=(local);Database=EABuyer;User Id=eauser;Password=Pa$$w0rd;MultipleActiveResultSets=true;Encrypt=False;TrustServerCertificate=True"`
19	There's another thing that needs to be done to resolve this first issue. In order to allow user ids and passwords SQL Server needs to be configured to allow both Windows and SQL Server authentication modes (when SQL Server is first installed it defaults to only allowing Windows authentication). In SSMS right click on the server name at the top of the Object Explorer window and select Properties.  Click on the Security tab and select the "SQL Server and Windows Authentication mode" radio button. Then press the OK button.
20	The second issue that needs to be resolved is the "Server" setting in the connection string. When it runs the code will be trying to access the database server that is

	running on the host machine from within the Docker container and the current setting of (local) isn't going to work.
21	Search Windows start for the "SQL Server Configuration Manager" and launch it. If it doesn't appear as an application you should be able to search for (and launch) it in C:\Windows\SysWOW64\SQLServerManager16.msc (the number 16 indicates it's SQL Server 2022). 
22	Open the SQL Server Configuration Manager (Local) | SQL Server Network Configuration menu and click the Protocols for MSSQLSERVER.

	
23	If `TCP/IP` protocol is `Disabled` as shown above, double click the TCP/IP protocol and toggle the Enabled setting to Yes.  Press OK
24	We next need to restart SQL Server so the changes will take effect. Go to "SQL Server Configuration Manager (Local)" | "SQL Server Services", right-click the "SQL Server (MSSQLSERVER) service" and press the `Restart` button to apply changes.

	
25	Now we are ready to access SQL Server from within the Docker container. The final thing we need to do is change the Server setting in the connection string (in appsettings.json) from "(local)" to "host.docker.internal". This special DNS name is helpful because it resolves to the internal IP address used by the host machine thus future proofing if the IP address of the host if it ever changes during the development process. So, change the connection string to: `"Server=host.docker.internal;Database=EABuyer;User Id=eauser;Password=Pa$$w0rd;MultipleActiveResultSets=true;Encrypt=False;TrustServerCertificate=True"`
26	Right click on the BuyerService project in Visual Studio's Solution Explorer window and select "Debug | Start New Instance.
27	If everything is running smoothly Visual Studio should have opened up a browser window exposing the BuyerService via Swagger and you will notice it is using the HTTPS port number:

	
28	Try testing the service by invoking the Get Buyers API function. Hopefully, all will be fine, and the Buyer data will be returned from the database. You can try out the other API function calls to guarantee all is working.

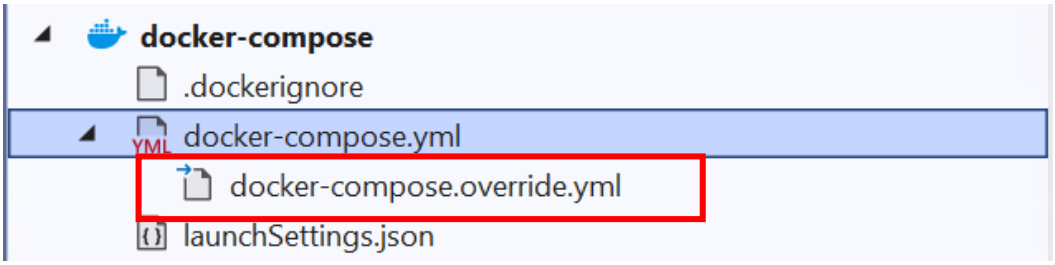
Add Container Orchestrator Support

29	Having to worry about changing container and host machine IP addresses is rapidly going to become tedious if we don't do anything about it. Fortunately, it is possible to add additional configuration files to the solution which can be used to orchestrate settings such as these. This is achieved through the use of Docker Compose.
30	Right click on the BuyerService project in Visual Studio's Solution Explorer Window and select Add | Container Orchestrator Support… If you have a choice, select Docker Compose as the Container Orchestrator and press OK. Then select a Target OS of Linux and click OK. If a pop up message saying “the SVsStartupProjectsListService service is unavailable” then it’s safe to ignore it. Visual Studio will add a docker-compose project to the solution.
31	The docker-compose project will contain a yaml file called docker-compose.yml. Open this now. The file contains information that is used to define the collection of images that will be built and run whenever the `docker-compose build` and `docker-compose run` commands are invoked.

```
version: '3.4'

services:
  buyerservice:
    image: ${DOCKER_REGISTRY-}buyerservice
    build:
      context: .
      dockerfile: BuyerService/Dockerfile
```

As it stands the code specifies the name that will be given to the Docker image created for the BuyerService and also specifies the location of the service's Dockerfile.

32 If you click on the black arrow in Solution Explorer that sits to the left of the docker-compose.yml file you will reveal another file called docker-compose.override.yml.



This file is optional but is read and used by Docker and contains configuration overrides for services. In this case you can see it is specifying the internal ports of 8080 and 8081 that will be used by services running inside the container.

Using the configuration-specific override files, you can specify different configuration settings (such as environment variables or entry points) for Debug and Release build configurations.

Change the file so it specifies the use of port 3011 rather than 8080 for ASPNETCORE_HTTP_PORTS and **delete** the - ASPNETCORE_HTTPS_PORTS = 8081 and – 8081 lines:

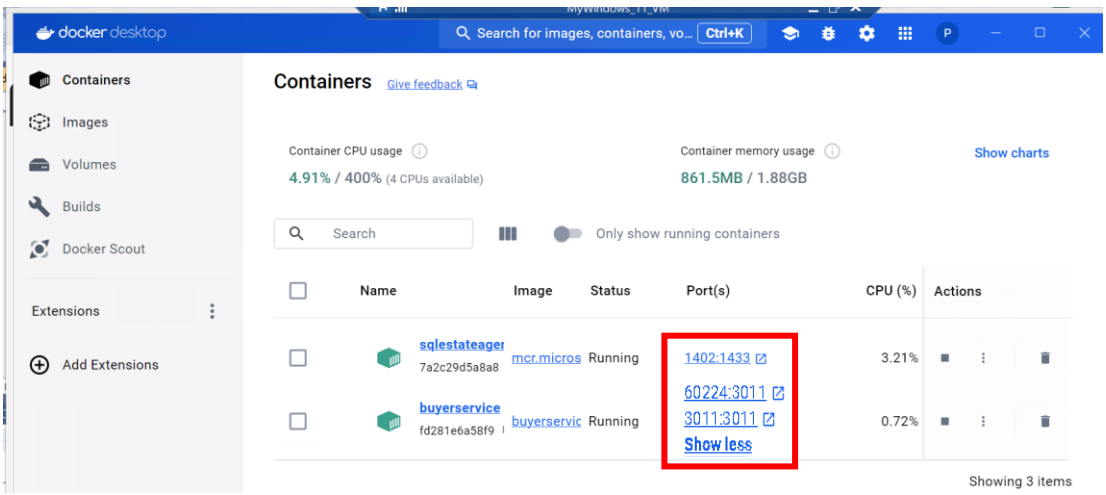
```
version: '3.4'

services:
  buyerservice:
    environment:
      - ASPNETCORE_ENVIRONMENT=Development
      - ASPNETCORE_HTTP_PORTS=3011
    ports:
      - "3011"
    volumes:
      -
${APPDATA}/Microsoft/UserSecrets:/home/app/.microsoft/usersecrets:ro
      - ${APPDATA}/ASP.NET/Https:/home/app/.aspnet/https:ro
```

Adding a SQL Server Container

33 In the world of microservices we would consider each of our services be run in a separate container and this goes for our SQL Server databases as well. In this section we are going to edit the docker-compose.yml file to spin up a Docker container that hosts an instance of a SQL Server EABuyer database and get the BuyerService to use it.

	We will also configure a network so we can specify the IP addresses that will be used by our services.
34	Add the following to the foot of the docker-compose.yml file: `networks:` `  EstateAgentMicroservicenetwork:` `  driver: bridge` `  ipam:` `  driver: default` `  config:` `  - subnet: 172.19.0.0/16` Take care with the indentations, Yaml is fussy about them. The "networks:" label should sit at the same level of indentation as the "services" label (i.e. **not** indented)
35	Edit the buyerservice entry to look like the following: `buyerservice:` `image: ${DOCKER_REGISTRY-}buyerservice` `environment:` `- ConnectionString=sqlestateagentdata` `build:` `context: .` `dockerfile: BuyerService/Dockerfile` `container_name: buyerservice` `ports:` `- "3011:3011"` `depends_on:` `- sqlestateagentbuyerdata` `networks:` `EstateAgentMicroservicenetwork:` `ipv4_address: 172.19.10.211` Note, the "buyerservice:" label is indented to lie within the "services" section. Note too, we've specified an IP address that belongs to the subnet specified in the networks section. The buyerservice also makes mention of a dependency called `sqlestateagentbuyerdata` which we will need to set up next.
36	Add the following to sit within the services section with the same level of indentation as the buyerservice: `sqlestateagentbuyerdata:` `image: mcr.microsoft.com/mssql/server:2019-latest` `environment:` `- SA_PASSWORD=PaSSwOrdPaSSwOrd` `- ACCEPT_EULA=Y` `container_name: sqlestateagentbuyerdata` `ports:` `- "1402:1433"` `networks:` `EstateAgentMicroservicenetwork:` `ipv4_address: 172.19.10.202` Note, we are specifying what the password of the new SQL Server installation within the sqlestateagentbuyerdata service will be. The SQL Server image will be pulled from Microsoft's web site. We have also specified an IP address that belongs to the subnet specified in the networks section.
37	Open the BuyerService project's appsetting.json file and amend the ConnectionStrings entry to be: `"sqlestateagentdata": ))`

	Notice the server is specified as sqlestateagentbuyerdata which happens to be the name given to the name of the code we have just added to the docker-compose.yaml file and this is what links the two (we don't need to know the IP address of the database server, docker-compose will sort that out for us).
38	Given the database and its table need be created and populated within the running SQL Server container. It would be sensible to do this (when the apps are running in Development mode rather than Release mode) when they are first run and this can be done by making use of the AutoFixture external assembly. Use NuGet to add the AutoFixture package to the BuyerService project. Add a new class to the BuyerService's Infrastructure folder called BuyerSeeder. Add the following code to it: `using AutoFixture;` `using BuyerService.Models;` `namespace BuyerService.Infrastructure` `{` `  public static class BuyerSeeder` `  {` `  public static void Seed(this BuyerContext buyerContext)` `  {` `  if (!buyerContext.Buyers.Any())` `  {` `  Fixture fixture = new Fixture();` `  fixture.Customize<Buyer>(buyer =>` `  buyer.Without(p => p.Id));` `  //--- The next two lines add 100 rows to your database` `  List<Buyer> buyers =` `  fixture.CreateMany<Buyer>(100).ToList();` `  buyerContext.AddRange(buyers);` `  buyerContext.SaveChanges();` `  }` `  }` `  }` `}` The fixture.CreateMany method generates 100 Buyer objects and populates each property with Guid's. Not very real world but good enough for our requirements.
39	Next, we will need to add code that runs when the web app starts that checks to see if the database exists and if not invokes the Seed() method we've just written. Remember we only want this code to run if the code is operating in Development mode so add the following lines to the if expression in Program.cs that tests to see if the app.Environment.IsDevelopment is true. `  using (var scope = app.Services.CreateScope())` `  {` `  var buyerContext =` `  scope.ServiceProvider.GetRequiredService<BuyerContext>();` `  buyerContext.Database.EnsureCreated();` `  buyerContext.Seed();` `  }`
40	It is time to test our code. You will have noticed when we added docker orchestration the docker-compose project was made to be the startup project (if it isn't then configure this now). You may have also noticed the debug option in Visual Studio's toolbar has been labelled as "Docker Compose".

	 If you expand the dropdown options we could simply launch the app in a Web Browser but we don't want to do this, we want the Docker-Compose code to do its thing. So, click on the green triangle (or press F5). Docker will create a dockercompose section in DockerDesktop's Containers tab. Launch the BuyerService and pull the SQL Server image from Microsoft and run it in a container (this will take some time to complete). Eventually, you should see a browser window open with the traditional Swagger options that will allow you to test the BuyerService API. If you get any build errors then try stopping and deleting all the containers and all of the images in Docker Desktop. Or, if you still have no joy, click on the bug symbol in DockerDesktop's menu and select the option to clean and purge data.
41	If you look at the Containers tab in Docker Desktop you will see two containers that are running on the ports that we specified in the docker-compose file (plus one that has been randomly allocated): 
42	When the browser finally opens it may be using a random port on HTTPS but if you amend the url to use port 3011 on HTTP the swagger API options should still be made available to you and should still work: http://localhost:3011/swagger/index.html
43	Note, even though Visual Studio is deploying and running code in Docker containers it is fully debuggable. Any break points you add to your code will be hit in the conventional manner. The only potential issue is the process will probably be a lot slower than if you were not using Docker.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you have time:

45	Repeat steps 29 to 44 (ignoring step 34) for the SellerService giving it an HTTP port number of 3013 and an IP address of 172.19.10.213. When specifying the new database service use the following: `sqlestateagentsellerdata:` `  image:  mcr.microsoft.com/mssql/server:2019-latest` `  environment:` `  - SA_PASSWORD=PaSSwOrdPaSSwOrd` `  - ACCEPT_EULA=Y` `  container_name: sqlestateagentsellerdata` `  ports:` `  - "1404:1433"` `  networks:` `  EstateAgentMicroservicenetwork:` `  ipv4_address: 172.19.10.204`
46	Repeat steps 29 to 44 (ignoring step 34) for the PropertyService giving it an HTTP port number of 3012 and an IP address of 172.19.10.212. ~~When configuring the propertyservice entries in the docker-compose.yml file add another dependency for rabbitmq:~~ ~~`depends_on:`~~ ~~`- rabbitmq`~~ ~~`- sqlestateagentbuyerdata`~~ When specifying the new database service use the following: `sqlestateagentpropertydata:` `  image:  mcr.microsoft.com/mssql/server:2019-latest` `  environment:` `  - SA_PASSWORD=PaSSwOrdPaSSwOrd` `  - ACCEPT_EULA=Y` `  container_name: sqlestateagentpropertydata` `  ports:` `  - "1403:1433"` `  networks:` `  EstateAgentMicroservicenetwork:` `  ipv4_address: 172.19.10.203`
47	Repeat steps 29 to 44 (ignoring step 34) for the BookingService giving it an HTTP port number of 3010 and an IP address of 172.19.10.210. ~~When configuring the bookingservice entries in the docker-compose.yml file add another dependency for rabbitmq:~~ ~~`depends_on:`~~ ~~`- rabbitmq`~~ ~~`- sqlestateagentbuyerdata`~~ When specifying the new database service use the following: `sqlestateagentbookingdata:` `  image:  mcr.microsoft.com/mssql/server:2019-latest` `  environment:`

	`` - SA_PASSWORD=PaSSw0rdPaSSw0rd - ACCEPT_EULA=Y container_name: sqlestateagentbookingdata ports: - "1401:1433" networks: EstateAgentMicroservicenetwork: ipv4_address: 172.19.10.201 ```
48	Next, we need to think about managing the delete property and add booking functionality. Remember both methods make calls to other services and we need to ensure these continue to work but somewhat strangely, in their current form they won't. Test this out by making (via Swagger or PostMan) a call to the BookingService's Post method and notice the app crashes with a Connection refused error. The fix is surprisingly simple rather than mentioning "localhost" in the embedded calls to the property and buyer services (that check to ensure the passed in ids are genuine) we simply need to specify the docker container_name we specified in the docker-compose file.
49	Locate the app.MapPost("/bookings"… lambda function declared in the BookingService's Program.cs file. Then find the line that sets up the url for the call to the Property Service and replace "localhost" with "propertyservice": `string url = $"https://propertyservice:3012/properties/{booking.PropertyId}";`
50	Further down in the same method edit the line that sets up the url for the call to the buyer service again replacing "localhost" but this time with "buyerservice" so the line ends up as follows: `url = $"https://buyerservice:3011/api/buyer/buyers/{booking.BuyerId}";`
51	Relaunch the services and test the altered functionality confirming that you can now add new bookings but only if the two tests pass.
52	Now try to do something similar for the app.MapDelete("/Properties"… lambda function located in the PropertyService's Program.cs file.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 11: Estate Agent Microservice – Creating an Event Bus

Objective

Your goal is to reengineer the Estate Agent Property and Booking services, so they don't directly rely on each other when a property and any related bookings are deleted. Instead, we are going to create a loosely coupled relationship by implementing an event bus.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

STEPS

Reengineer the PropertyService.

1	In this lab we will be working with and adapting code that focuses on the deletion of properties and any related bookings which was the very last element of the "if you have time" section of the previous lab. Consequently, unless you managed to complete the entire lab you would be best advised to open up the Visual Studio solution located in the Starter folder.
2	Add a new class library project to the solution called Events.
3	Rename the `Class.cs` file to be `PropertyDeletedEvent.cs` taking the Yes option to rename all references.
4	Add a single integer property to the class called `PropertyId`. An instance of this class will be sent from the property service to the booking service as part of the Event Bus mechanism.
5	Locate the PropertyService project in Solution Explorer, right click on the Dependencies tab and select "Manage NuGet Packages…" and install the following packages: • DotNetCore.CAP • DotNetCore.CAP.Dashboard • DotNetCore.CAP.SqlServer • DotNetCore.CAP.RabbitMQ
6	Add a Project reference from the PropertyService project to the Events project.
7	We need to configure the service to support the use of a CAP service and RabbitMQ Message Queue. Open the project's `Program.cs` file and add the following just beneath the code that configures the `DbContext` service. `builder.Services.AddCap(options => {` `});`
8	The Cap service needs to use a database to ensure its messages aren't lost. We will hook it up to use the EAProducts database rather than create a whole new one. Add the following code to the lambda:

	`options.UseEntityFramework<PropertyContext>();` `options.UseSqlServer(` `  builder.Configuration.GetConnectionString("sqlestateagentdata"));`
9	It will be helpful to view the Cap dashboard to monitor how things are going when the app is executed so add the following lines to the lambda: `options.UseDashboard(d => {` `  d.AllowAnonymousExplicit = true;` `});`
10	Next, we need to get the `Cap` service to use `RabbitMQ` so add the following code to the lambda: `options.UseRabbitMQ(options =>` `{` `  options.ConnectionFactoryOptions = options => {` `  options.Ssl.Enabled = false;` `  options.HostName = "rabbitmq";` `  options.UserName = "guest";` `  options.Password = "guest";` `  options.Port = 5672;` `  };` `});`
11	Now we need to edit the code in the `app.MapDelete("/Properties"{id}…` function located towards the end of the `Program.cs` file. Add an `ICapPublisher` parameter called `capPublisher` to the function declaration (such that it takes three parameters). This parameter will be injected by the runtime from the service we set up at the higher up the page. Add a using clause for DotNetCore.CAP to the list of using statements at the top of the file.
	Delete the four lines of code in the if expression that set up the: • HttpClient • url • HttpResponseMessage variable • line that returns a result
12	Replace them with the following: `PropertyDeletedEvent propertyDeletedEvent =` `  new PropertyDeletedEvent { PropertyId = property.Id };` `var content = JsonConvert.SerializeObject(propertyDeletedEvent);` `await capPublisher.PublishAsync("PropertyDeleted", content);` `return Results.NoContent();` You will need to add a using clause for the `Events` namespace.
13	Next, we need to sort out the BookingService so it responds to messages that have been added to the Event Bus's queue.

	Locate the BookingService project in Solution Explorer, right click on the Dependencies tab and select "Manage NuGet Packages…" and install the following packages: • DotNetCore.CAP • DotNetCore.CAP.Dashboard • DotNetCore.CAP.SqlServer • DotNetCore.CAP.RabbitMQ Add a Project reference from the BookingService project to the Events project and add "using Events;" to the list of existing using statements at the top of the file.
14	Right click on the `BookingService` project in Solution Explorer and select "Add | New Folder" calling it `DomainEventHandler.`
15	Add a new class to the folder calling it `PropertyDeletedEventSubscriber` and make it inherit `ICapSubscribe`.
16	Add the following code to the class that deals with the injection of a BookingContext: `private readonly BookingContext _bookingContext;` `public PropertyDeletedEventSubscriber(BookingContext bookingContext) { _bookingContext = bookingContext; }`
17	Add a new `public async Task<IResult>` function called `Consumer` that takes a `string` parameter called `content`.
18	Decorate the function with a `CapSubscribe` attribute passing it "PropertyDeleted" as a `string`: `[CapSubscribe("PropertyDeleted")]`
19	Add the following line of code that uses JsonConvert to deserialize the `content` parameter into a PropertyDeletedEvent object: `var property = JsonConvert.DeserializeObject<PropertyDeletedEvent>(content);`
20	Add the following code to the method that uses the property object's propertyId property to retrieve any relevant bookings from the database and deletes them if any are found: `var bookings = _bookingContext.Bookings .Where(b => b.PropertyId == property.PropertyId).ToList(); if (bookings is null || bookings.Count() == 0) return Results.NotFound(); _bookingContext.Bookings.RemoveRange(bookings); _bookingContext.SaveChanges(); return Results.NoContent();`
21	We need to configure the BookingService to use CAP so return to the PropertyService's program.cs file and copy all the code that creates and configures the CAP service and paste it into the equivalent position in the BookingService's Program.cs file. Change the `options.UseEntityFramework <PropertyContext>()` to use `BookingContext.`

22	The last thing we need to in the BookingService is to add the event handler service. Add the following to the service's Program.cs file just beneath the code you added in the previous step: `builder.Services.AddScoped<PropertyDeletedEventSubscriber>();`
23	Finally, we need to edit the docker-compose.yml and docker-compose.override.yml files in the docker-compose project to spin up a rabbitmq container and add it as a dependency to the property service and bookingservice containers.
24	Open the docker-compose.yml file and add the following service details: `rabbitmq:` `  image: rabbitmq:latest` `  restart: always` `  container_name: rabbitmq` `  ports:` `  - "5672:5672"` `  - "15672:15672"` `  volumes:` `  - Rabbitmq_data:/var/lib/rabbitmq` `  networks:` `  EstateAgentMicroservicenetwork:` `  ipv4_address: 172.19.10.205`
25	Edit the bookingservice entry to look like the following: `bookingservice:` `  image: ${DOCKER_REGISTRY-}bookingservice` `  restart: on-failure` `  environment:` `  - ConnectionString=sqlestateagentdata` `  - "EventBusSettings:HostAddress=amqp://guest:guest@rabbitmq:5672"` `  depends_on:` `  - rabbitmq` `  - sqlestateagentbookingdata` `  build:` `  context: .` `  dockerfile: BookingService/Dockerfile` `  container_name: bookingservice` `  ports:` `  - "3011:3011"` `  networks:` `  EstateAgentMicroservicenetwork:` `  ipv4_address: 172.19.10.210`
26	Edit the propertyservice entry to look like the following: `propertyservice:` `  image: ${DOCKER_REGISTRY-}propertyservice` `  restart: on-failure` `  environment:` `  - ConnectionString=sqlestateagentdata` `  - "EventBusSettings:HostAddress=amqp://guest:guest@rabbitmq:5672"` `  depends_on:` `  - rabbitmq` `  - sqlestateagentpropertydata` `  build:` `  context: .` `  dockerfile: PropertyService/Dockerfile` `  container_name: propertyservice` `  ports:` `  - "3012:3012"` `  networks:` `  EstateAgentMicroservicenetwork:` `  ipv4_address: 172.19.10.210`
27	Add the following at the bottom of the file just before the networks section:

	`volumes:` `  rabbitmq_data:`
28	You should now be in the position where you can test your amendments and ensure the Event Bus technology is working. Set the following breakpoints in your code: • On the line in the Property Service's app.MapDelete("/Properties/{id}" function that awaits the call of the capPublisher object's PublishAsync method call. • On the first line of code inside the Booking Service's PropertyDeletedEventSubscriber class's Consumer method
29	Make sure the docker-compose project is set as the startup project. Press F5 (or press the green triangle) to launch the docker-compose project in debug mode.
30	When the services are up and running use Postman or swagger pages (`http://localhost:3012/swagger/index.html`) to insert a new Property to the database making a note of the (property) id that gets generated. Then insert a number of new bookings (`http://localhost:3010/swagger/index.html`) that use the newly generated property id and a number of genuine buyer id's (anything between 1 and 100).
31	Finally try to delete the newly generated property (`http://localhost:3012/swagger/index.html`) and wait for the first breakpoint to be hit. Ensure the "content" variable contains a PropertyId that has been set to the right value. Press the green triangle to continue running the code and wait for the second breakpoint to be hit. Check to make sure the content parameter has the same Id value and step through the code to ensure the corresponding bookings have been deleted. Press F5 to continue running the code.
32	Use swagger (or Postman) to retrieve all the properties and ensure the recently added property and all of its related bookings have been removed.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you have time:

Reconfigure the code in the BookingService so that when trying to add a new booking and the code checks to see if the Buyer Id and Property Id are valid (i.e. they already exist in the relevant databases) we will make use of environment variables in the docker-compose file (rather than hardcoding the service names).

33	Open the Docker-compose file and locate the bookingservice section.
34	Add the following lines to the environment section (just beneath the ConnectionString variable): `PROPERTYSERVICE=http://propertyservice:3012` `BUYERSERVICE=http://buyerservice:3011`
35	Add the following lines to the depends_on section (beneath the two entries that are currently there): `- propertyservice` `- buyerservice`
36	Open the BookingService's Program.cs file and locate the `app.MapPost("/bookings",..` lambda function.
37	Replace the line that declares and sets the `url` variable with the following: `string PROPERTYSERVICE =` `  Environment.GetEnvironmentVariable("PROPERTYSERVICE");` `//Check to see if PropertyId is valid` `string url = "";` `if (PROPERTYSERVICE == null)` `  url = $"http://propertyservice:3012/properties/{booking.PropertyId}";` `else` `  url = $"{PROPERTYSERVICE}/properties/{booking.PropertyId}";`
38	Do something similar for the code that sets up the url to the BuyerService.
39	Test your program.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 12: Estate Agent Microservice – Kubernetes

Objective

Your goal is to use Kubernetes to configure the Estate Agent Microservices ready for deployment.

Overview

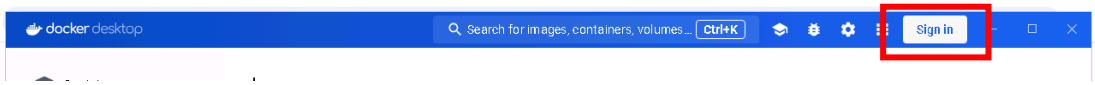
In this lab you will configure the image names in docker-compose.yml file to prepare them for deployment to Docker Hub. Then you will create a set of YAML files, one for each service, with configuration settings that will be used in a Kubernetes deployment. You will then invoke the relevant kubectl commands to carry out the deployment. Finally, you will test the endpoints to ensure everything works as expected.

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

STEPS

Upload Docker Images to Docker Hub

1	Make sure you are signed in to Docker Hub. You can do this from within Docker Desktop by clicking the Sign in button on the top right of the window. 
2	Either open your EstateAgentBackEnd Visual Studio solution to the previous lab or use the solution found in this lab's Starter folder.
3	Open the `docker-compose.yml` file and locate the image name setting for the bookingservice. Note it's currently set to the following: `image: ${DOCKER_REGISTRY-}bookingservice` Replace the ${DOCKER_REGISTRY-} text with your docker username followed by a forward slash (/). **Note, docker is case sensitive to make sure you use the correct casing**. For example, if your docker username is "anonymous" then the line should look like the following: `image: anonymous/bookingservice`
4	Repeat step 3 for each of the other services (buyer, property and seller).
5	Make sure the solution has been built, the docker images and containers exist (use Docker Desktop or run "docker ps" from a command window or PowerShell.
6	Open a command or PowerShell window. Run the following instruction: `Docker images`

	You should see something like the following: `PS C:\Users\Admin\Downloads\QACSADV-main\12 Kubernetes\Solution> docker images` `REPOSITORY TAG IMAGE ID CREATED SIZE` `amynonymous/sellerservice dev afd6a7900fce 3 hours ago 217MB` `amynonymous/buyerservice dev 88221e543c6a 3 hours ago 217MB` `amynonymous/propertyservice dev 38a4fd49e6f5 3 hours ago 217MB` `amynonymous/bookingservice dev c3568f19402c 3 hours ago 217MB` `rabbitmq latest 292a52e58259 8 days ago 221MB` `mcr.microsoft.com/mssql/server 2019-latest 667e9439de8d 13 days ago 1.47GB` `spurin/diveintokubernetes-introduction-lab-extension 1.0.2 d17e29a19b2e 7 weeks ago 7.8MB` `spurin/diveintokubernetes-introduction-lab portal e901b3b150cc 8 months ago 196MB` `spurin/diveintokubernetes-introduction-lab control-plane a1fad110a480 8 months ago 1.49GB` `PS C:\Users\Admin\Downloads\QACSADV-main\12 Kubernetes\Solution>`
7	Before pushing your images to Docker Hub you first have to change their tags from "dev" to "latest". For **each image in turn** enter and run the following. Remember docker is case sensitive so make sure you use the correct casing for your username: `docker tag [YOUR DOCKER USER NAME]/[ [IMAGE NAME]:[TAG] [YOUR DOCKER USER NAME]/[IMAGE NAME]` For example, if your docker username is anonymous, an image name of bookingservice and a tag of dev, then type the following: `docker tag anonymous/buyerservice:dev anonymous/buyerservice`
8	Upload the images to Docker Hub. You can do this in one of two ways: • From the Images tab within Docker Desktop in the Actions column select the 3 vertical dots for each of your images (you **don't** need to do this for the rabbitmq or sql server images) and select "Push to Docker Hub" • Within a cmd or PowerShell window and type the following: `docker push [YOUR DOCKER USER NAME]/[IMAGE NAME]` Repeat for each image
9	Browse to hub.docker.com to ensure all the images have arrived safely.

Some Housekeeping

10	Before we get stuck into Kubernetes there's a little bit of housekeeping that needs to be done. Each of the services has some code that tests to see if the code is running in a "Development" mode and sets up the dummy database data only if this is true. When the code gets deployed to a Kubernetes environment it will be considered to be operating in "Release" mode. Unfortunately, this means the databases will be empty. Rather than waste time trying to sort out sets of more genuine looking data we are going to be lazy. For each of the four service's Program.cs files, locate the and cut the following lines of code from within the `if (app.Environment.IsDevelopment())` expression and paste it just beneath the if's closing curly brace so that it will always be invoked:

```
if (app.Environment.IsDevelopment())
{
    app.UseSwagger();
    app.UseSwaggerUI();
}

using (var scope = app.Services.CreateScope())
{
    var bookingContext =
        scope.ServiceProvider.GetRequiredService<BookingContext>();
    bookingContext.Database.EnsureCreated();
    bookingContext.Seed();
}
```

Deploy the microservice containers to Kubernetes

11	In order to use Kubernetes within Docker Desktop you will need to do a bit of configuration. We have already done the first step for you by adding the relevant Kubernetes extensions to Docker Desktop, **but we haven't enabled it**. To do this open Docker Desktop and click on the Settings button (the cog symbol top right). Select the Kubernetes tab and check the Enable Kubernetes check box. Press Apply & restart. The installation will take a few minutes, so while you are waiting you can get on with the following steps:
12	When deploying to Kubernetes, you will need to create a new set of YAML files that are different from the Docker-Compose files. This is necessary because Kubernetes and Docker Compose are fundamentally different orchestration platforms with distinct features, paradigms, and configurations. Both sets of files do similar things (specify container names, port numbers, environment variables…) However, the Kubernetes YAML can also be used to handle not only deployment but also scaling, self-healing, service discovery, and rolling updates. Note, we won't be doing much of this because it's beyond the scope of this course.
13	Add a new folder to the docker-compose project called K8s.
14	Add a new item to the new folder called buyerservice-deploy.yml
15	Add the following code to the file replacing the [your-name-here] section with you docker username name: `---` `apiversion: apps/v1` `kind: Deployment` `metadata:` `  name: buyerservice` `spec:` `  replicas: 1` `  template:` `  metadata:` `  labels:` `  app: buyerservice` `  spec:` `  containers:` `  - name: buyerservice` `  image: [your-name-here]/buyerservice:latest` `  imagePullPolicy: Always` `  ports:` `  - containerPort: 3011` `  env:`

```
          - name: ASPNETCORE_ENVIRONMENT
            value: "Production"
          - name: ASPNETCORE_URLS
            value: http://*:3011
          - name: ConnectionStrings__sqlestateagentdata
            value: "Server=sqlestateagentbuyerdata;Database=EABuyer;User
Id=sa;Password=PaSSwOrdPaSSwOrd;MultipleActiveResultSets=true;Encrypt=False
;TrustServerCertificate=True"
  selector:
    matchLabels:
      app: buyerservice

---
apiVersion: v1
kind: Service
metadata:
  name: buyerservice
spec:
  type: NodePort
  ports:
  - protocol: TCP
    port: 3011
    targetPort: 3011
    nodePort: 32011
  selector:
    app: buyerservice
```

The code is split into two parts which define two different Kubernetes resources:

- Deployment: This section is responsible for managing the application pods, including how many replicas should run, which Docker image to use, and the environment variables for the application. The key elements of a Deployment are:
  - Replicas which specify how many instances of the pod should run.
  - Template describes the pods, including their labels, the container image to use, and the ports to expose inside the container.
  - Env defines environment variables for the application.
- Service: This section exposes the application to the network, allowing other services or external users to access it via a specific port. The key elements of a Service are:
  - type: NodePort: Exposes the service on a static port on each node in the cluster.
  - ports: Defines the ports on which the service is exposed.
  - port: The port the service exposes inside the cluster.
  - targetPort: The port on the pod that the service will forward traffic to.
  - nodePort: The port on the node that will be used to access the service from outside the cluster.
  - selector: Specifies which pods the service should forward traffic to by matching the labels defined in the Deployment.

You will notice how the database's connection string has been specified as an environmental variable.

16 Add a new item to the K8s folder called sellerservice-deploy.yml

16 17 Add the following code to the file (again replacing the [your-name-here] section with your Docker username:

```
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: sellerservice
spec:
  replicas: 1
  template:
    metadata:
      labels:
        app: sellerservice
    spec:
      containers:
      - name: sellerservice
        image: [your-name-here]/sellerservice:latest
        imagePullPolicy: Always
        ports:
        - containerPort: 3013
        env:
        - name: ASPNETCORE_ENVIRONMENT
          value: "Production"
        - name: ASPNETCORE_URLS
          value: http://*:3013
        - name: ConnectionStrings__sqlestateagentdata
          value: "Server=sqlestateagentsellerdata;Database=EASeller;User
Id=sa;Password=PaSSwOrdPaSSwOrd;MultipleActiveResultSets=true;Encrypt=False
;TrustServerCertificate=True"
  selector:
    matchLabels:
      app: sellerservice

---
apiVersion: v1
kind: Service
metadata:
  name: sellerservice
spec:
  type: NodePort
  ports:
  - protocol: TCP
    port: 3013
    targetPort: 3013
    nodePort: 32013
  selector:
    app: sellerservice
```

There's no surprise that it is very similar to the buyerservice-deploy content.

18 Add a new item to the K8s folder called bookingservice-deploy.yml

19 Add the following code to the file (don't forget to change the [your-name-here] section to your Docker username):

```
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: bookingservice
spec:
  replicas: 1
  template:
    metadata:
      labels:
        app: bookingservice
    spec:
      containers:
      - name: bookingservice
        image: [your-name-here]/bookingservice:latest
        imagePullPolicy: Always
        ports:
        - containerPort: 3010
        env:
          - name: ASPNETCORE_ENVIRONMENT
            value: "Production"
```

	`` - name: ASPNETCORE_URLS value: http://*:3010 - name: ConnectionStrings__sqlestateagentdata value: "Server=sqlestateagentbookingdata;Database=EABooking;User Id=sa;Password=PaSSwOrdPaSSwOrd;MultipleActiveResultSets=true;Encrypt=False ;TrustServerCertificate=True" - name: PROPERTYSERVICE value: http://propertyservice:3012 - name: BUYERSERVICE value: http://buyerservice:3011 selector: matchLabels: app: bookingservice --- apiVersion: v1 kind: Service metadata: name: bookingservice spec: type: NodePort ports: - protocol: TCP port: 3010 targetPort: 3010 nodePort: 32010 selector: app: bookingservice ```
20	Add a new item to the K8s folder called propertyservice-deploy.yml
21	Add the following code to the file (changing the [your-name-here] section to your Docker username: ``` --- apiVersion: apps/v1 kind: Deployment metadata: name: propertyservice spec: replicas: 1 template: metadata: labels: app: propertyservice spec: containers: - name: propertyservice image: [your-name-here]/propertyservice:latest imagePullPolicy: Always ports: - containerPort: 3012 env: - name: ASPNETCORE_ENVIRONMENT value: "Production" - name: ASPNETCORE_URLS value: http://*:3012 - name: ConnectionStrings__sqlestateagentdata value: "Server=sqlestateagentpropertydata;Database=EAProperty;User Id=sa;Password=PaSSwOrdPaSSwOrd;MultipleActiveResultSets=true;Encrypt=False ;TrustServerCertificate=True" selector: matchLabels: app: propertyservice --- apiVersion: v1 kind: Service metadata: name: propertyservice spec: type: NodePort ```

	`` ports: - port: 3012 targetPort: 3012 nodePort: 32012 selector: app: propertyservice ```
22	Add a new item to the K8s folder called sqlestateagentbuyerdata-deploy.yml
23	Add the following code to the file: ``` apiVersion: apps/v1 kind: Deployment metadata: name: sqlestateagentbuyerdata spec: replicas: 1 selector: matchLabels: app: sqlestateagentbuyerdata template: metadata: labels: app: sqlestateagentbuyerdata spec: containers: - name: sqlestateagentbuyerdata image: mcr.microsoft.com/mssql/server:2019-latest ports: - containerPort: 1433 env: - name: ACCEPT_EULA value: "Y" - name: SA_PASSWORD value: "PaSSwOrdPaSSwOrd" --- apiVersion: v1 kind: Service metadata: name: sqlestateagentbuyerdata spec: type: NodePort selector: app: sqlestateagentbuyerdata ports: - protocol: TCP port: 1433 targetPort: 1433 name: tcpsql ``` This is a standard configuration for a SQL server database pod.
24	Add a new item to the K8s folder called sqlestateagentsellerdata-deploy.yml
25	Add the following code to the file: ``` apiVersion: apps/v1 kind: Deployment metadata: name: sqlestateagentsellerdata spec: replicas: 1 selector: matchLabels: app: sqlestateagentsellerdata template: metadata: labels: app: sqlestateagentsellerdata ```

```
  spec:
   containers:
   - name: sqlestateagentsellerdata
     image: mcr.microsoft.com/mssql/server:2019-latest
     ports:
     - containerPort: 1433
     env:
     - name: ACCEPT_EULA
       value: "Y"
     - name: SA_PASSWORD
       value: "PaSSwOrdPaSSwOrd"
---
apiVersion: v1
kind: Service
metadata:
  name: sqlestateagentsellerdata
spec:
  type: NodePort
  selector:
    app: sqlestateagentsellerdata
  ports:
    - protocol: TCP
      port: 1433
      targetPort: 1433
      name: tcpsql
```

26 Add a new item to the K8s folder called sqlestateagentbookingdata-deploy.yml

27 Add the following code to the file:

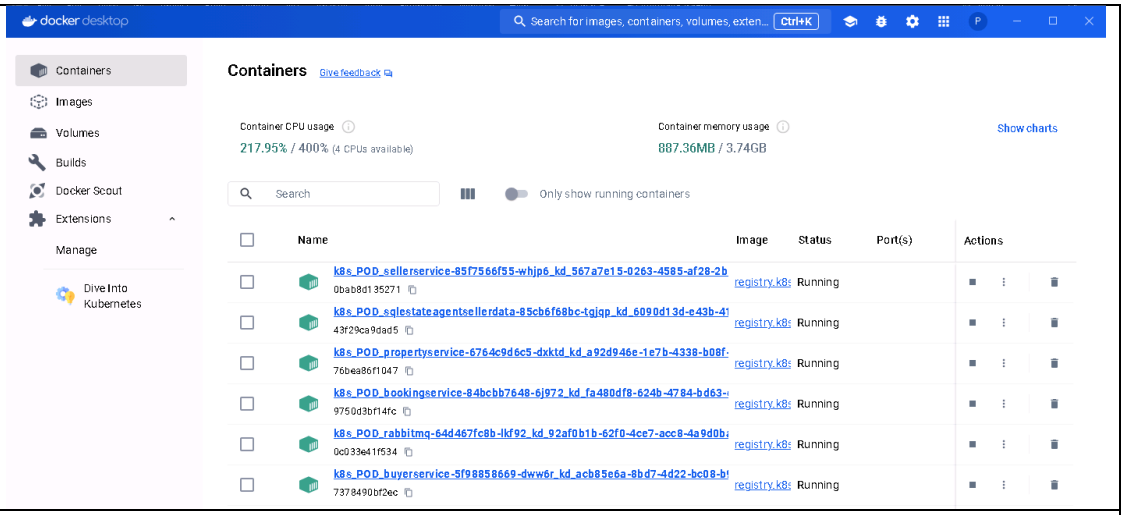
```
apiVersion: apps/v1
kind: Deployment
metadata:
 name: sqlestateagentbookingdata
spec:
 replicas: 1
 selector:
  matchLabels:
   app: sqlestateagentbookingdata
 template:
  metadata:
   labels:
    app: sqlestateagentbookingdata
  spec:
   containers:
   - name: sqlestateagentbookingdata
     image: mcr.microsoft.com/mssql/server:2019-latest
     ports:
     - containerPort: 1433
     env:
     - name: ACCEPT_EULA
       value: "Y"
     - name: SA_PASSWORD
       value: "PaSSwOrdPaSSwOrd"
---
apiVersion: v1
kind: Service
metadata:
  name: sqlestateagentbookingdata
spec:
  type: NodePort
  selector:
    app: sqlestateagentbookingdata
  ports:
    - protocol: TCP
      port: 1433
      targetPort: 1433
      name: tcpsql
```

28 Add a new item to the K8s folder called sqlestateagentpropertydata-deploy.yml

29	Add the following code to the file: `apiVersion: apps/v1` `kind: Deployment` `metadata:` ` name: sqlestateagentpropertydata` `spec:` ` replicas: 1` ` selector:` `  matchLabels:` `  app: sqlestateagentpropertydata` ` template:` `  metadata:` `  labels:` `  app: sqlestateagentpropertydata` `  spec:` `  containers:` `  - name: sqlestateagentpropertydata` `  image: mcr.microsoft.com/mssql/server:2019-latest` `  ports:` `  - containerPort: 1433` `  env:` `  - name: ACCEPT_EULA` `  value: "Y"` `  - name: SA_PASSWORD` `  value: "PaSSwOrdPaSSwOrd"` `---` `apiVersion: v1` `kind: Service` `metadata:` `  name: sqlestateagentpropertydata` `spec:` `  type: NodePort` `  selector:` `  app: sqlestateagentpropertydata` `  ports:` `  - protocol: TCP` `  port: 1433` `  targetPort: 1433` `  name: tcpsql`
30	Add a new item to the K8s folder called rabbitmq-deploy.yml
31	Add the following code to the file: `apiVersion: apps/v1` `kind: Deployment` `metadata:` `  name: rabbitmq` `spec:` `  replicas: 1` `  selector:` `  matchLabels:` `  app: rabbitmq` `  template:` `  metadata:` `  labels:` `  app: rabbitmq` `  spec:` `  containers:` `  - name: rabbitmq` `  image: rabbitmq:latest` `  ports:` `  - containerPort: 5672` `  - containerPort: 15672` `---` `apiVersion: v1` `kind: Service` `metadata:` `  name: rabbitmq` `spec:` `  ports:` `  - name: amqp` `  port: 5672`

	`` protocol: TCP targetPort: 5672 - name: http port: 15672 protocol: TCP targetPort: 15672 selector: app: rabbitmq ```
31	Now we are ready to start deploying our services to Kubernetes. Here is an overview of the steps we will need to follow: • For clarity of demo, it will be helpful to stop and delete any containers that are currently running in Docker. You can do this from the Containers tab in Docker Desktop. • Make sure you are signed in to both: ○ Docker Desktop ○ Https://Hub.Docker.Com via a browser • Carry out a `docker compose build` to ensure we have a current set of Docker images. • Carry out a `docker compose push` to push the built Docker images to a remote container registry. In this case Docker Hub. • Create resources in a Kubernetes cluster based on the configuration specified in the (Kubernetes) YAML files • Check to see if all the pods are up and running • Check to see the details of the running services • Expose the service ports to the outside world • Browse to the service endpoints and ensure everything is working. We will action the steps now:
32	Stop and delete any containers that are currently running in Docker Desktop by clicking on the Containers tab, selecting all the containers and clicking the Delete button.
33	Make sure you are signed into Docker Desktop by clicking the Sign In option in the Docker Desktop menu in the top right of the window (Note, this signs you in to app.Docker.com)
34	Browse to Https://Hub.Docker.com and sign in. Note, whilst your credentials will be the same as the ones you used in the previous step, you are signing into a different site.
35	Open a PowerShell (or command) window and browse to the folder where your Visual Studio solution is located by entering something like: `cd "C:\A Folder\Another Folder\...\12 Kubernetes\Starter"`
36	Enter the following line of code: `docker compose build` This command processes each service defined in the `docker-compose.yml` file that has a `build` section. For each service, Docker Compose reads the corresponding

	`Dockerfile` and uses it to build a Docker image. Each image will be tagged and stored in the local Docker environment. This process is carried out automatically by Visual Studio whenever you run your service applications when the start up project configured to be docker-compose meaning that, in your case, it is probably unnecessary given you have already got a complete set of Docker images stored in the Docker environment.
37	Once the previous step has completed. Enter the following line of code: `docker compose push` This command is used to push built Docker images to a remote registry (in this case Docker Hub). It's useful to do this when you want to share your images with others or deploy them to a remote environment. The command pushes the Docker images for each service defined in the docker-`compose.yml` file that specifies an image tag. The images are uploaded to the remote registry specified in the image name, such as `myregistry.com/myproject/myimage`. If no registry is mentioned it defaults to Docker Hub.
38	Via a browser, have a look at https://hub.docker.com and the Repositories tab. You should see copies of all the relevant images (`yourname/bookingservice`, `yourname/propertyservice`, `yourname/buyerservice`, `yourname/sellerservice`). There will be no mention of the SQL Server or rabbitmq services because they already exist in other remote container registries.
39	The next step is to create resources in a Kubernetes cluster based on the configuration specified in the YAML files we've created in the K8s folder. Before we do this, we will create a namespace for our clusters to go into. Enter the following line and press enter: kubectl create namespace kd Note, the name kd has no significance and was chosen as a shorthand for **K**ubernetes and **D**ocker.
40	We are now in a position to create the Kubernetes cluster resources by using the Kubernetes `kubectl apply` command. You can do this on a file-by-file basis or make use of the command's `-f` parameter to create cluster resources from multiple YAML files. Enter the following: kubectl apply -n kd -f ./K8s/ (Note, the -n kd ensures the clusters are created in the kd namespace Hopefully everything will run cleanly and if you look at the Containers tab in Docker Desktop you will see a set of containers that are in the process of getting up and running:



41 Somewhat confusingly you may see round about double the number of containers you were expecting some with the letters “POD” towards the start of their names. This is likely to be happening because when you run Kubernetes on Docker Desktop, each Pod typically consists of at least one container, but the underlying infrastructure in Docker Desktop might show additional containers that support the Pod's operation. The actual application containers will be the ones that don’t contain “POD” in their names and these correspond directly to the containers defined in the Kubernetes YAML files. The containers that have “POD” in their names are probably “pause” containers. Kubernetes uses these containers as a “parent” container for the Pod. The pause container is responsible for holding the network namespace and other shared resources for the actual application containers in the Pod. Even though they don't run your application code, they are essential for maintaining the Pod's state, networking, and other infrastructure-level tasks. In Kubernetes, each Pod shares the same network namespace. The pause container helps establish this shared namespace, allowing all containers in the Pod to communicate over localhost.

41 The `kubectl get` command allows us to retrieve information about a number of different Kubernetes resources, including: pods, deployments, services, nodes, namespaces, endpoints and many more.

42 Invoke `kubectl -n kd get pods` to see information about the pods. You should see something like the following:

```
PS C:\temp\12 Kubernetes\Solution> kubectl -n kd get pods
NAME                                    READY   STATUS    RESTARTS      AGE
bookingservice-84bcbb7648-6j972         1/1     Running   5 (20m ago)   75m
buyerservice-5f98858669-dww6r           1/1     Running   5 (21m ago)   75m
propertyservice-6764c9d6c5-dxktd        1/1     Running   6 (21m ago)   75m
rabbitmq-64d467fc8b-lkf92               1/1     Running   2 (21m ago)   75m
sellerservice-85f7566f55-whjp6          1/1     Running   5 (21m ago)   75m
sqlestateagentbookingdata-79d4dd7685-vxjtp   1/1   Running   2 (21m ago)   75m
sqlestateagentbuyerdata-77b6747969-2np82     1/1   Running   2 (21m ago)   75m
sqlestateagentpropertydata-57588877c9-d5jw8  1/1   Running   2 (21m ago)   75m
sqlestateagentsellerdata-85cb6f68bc-tgjqp    1/1   Running   2 (21m ago)   75m
PS C:\temp\12 Kubernetes\Solution>
```

Pay particular attention to the Ready and Status columns. If the Ready column contains “0/1” it means the pod isn’t yet properly up and running (a “1/1” indicates the pod is ready to be used. The Status column should contain “Running“, if all is

	well but may contain other values that provide insights into a pods health and readiness e.g. Pending, Failed, Succeeded. The Restarts column often looks slightly concerning because if a value is greater than zero it suggests something went wrong when a service was starting up. In the screenshot above you can see every service restarted at least twice. There is no need to worry about this if everything stabilises there are often dependencies where one service needs another to be running. If a dependency is not available, the service may end and then be restarted. This process can occur multiple times until things sort themselves out.
43	Invoke `kubectl -n kd get services` to see information about the services. You should see something like the following: `PS C:\temp\12 Kubernetes\Solution> kubectl -n kd get services` `NAME TYPE CLUSTER-IP EXTERNAL-IP PORT(S) AGE` `bookingservice NodePort 10.98.160.246 <none> 3010:32010/TCP 81m` `buyerservice NodePort 10.106.174.207 <none> 3011:32011/TCP 81m` `propertyservice NodePort 10.107.46.174 <none> 3012:32012/TCP 81m` `rabbitmq ClusterIP 10.103.138.106 <none> 5672/TCP,15672/TCP 81m` `sellerservice NodePort 10.102.161.36 <none> 3013:32013/TCP 81m` `sqlestateagentbookingdata NodePort 10.108.80.182 <none> 1433:32390/TCP 81m` `sqlestateagentbuyerdata NodePort 10.109.243.58 <none> 1433:30288/TCP 81m` `sqlestateagentpropertydata NodePort 10.100.4.184 <none> 1433:32182/TCP 81m` `sqlestateagentsellerdata NodePort 10.100.125.47 <none> 1433:30165/TCP 81m` `PS C:\temp\12 Kubernetes\Solution>` The interesting thing here is the IP addresses that have been assigned to the services and the ports on which they are exposed. The lefthand port number is the one that is exposed to the outside world whilst the one on the right is the NodePort which is typically exposed to the other pods. So, in the example above the exposed port for the bookingservice is 3010 and its NodePort is 32010. You will notice that none of the services have been given an external IP address. This would make sense if they were meant to be exposed to a local web UI application that will be the exposed to the world. However, if we wanted to expose them as an API to external clients all we would have to do is change the service type in the YAML files from “NodePort” to “LoadBalancer”. Unfortunately, in the current set up we will not be able to do this because we are using local Kubernetes where external load balancers are not available to us. There is a simple workaround which is to browse to localhost with the NodePort being specified as the port. If you really want to test the services using the “external” port number then we will tackle this in the “If you have time” section.
44	Open a browser window and enter: http://localhost:<Node Port for the bookingservice>/bookings e.g. http://localhost:32010/bookings Press enter and verify appropriate data is returned from the service.

45	TROUBLE SHOOTING If you find the services are unavailable, you may find the following instructions of use: Perhaps the best tactic is to take the nuclear option and go back to first principles by: • Deleting the entire content of the Kubernetes' namespace (see below). • Deleting all the Docker images you uploaded to Hub.docker.com by clicking on each service, selecting Settings and scrolling down to the Delete repository option. • Stop and Delete any running containers in Docker Desktop. • Make sure everything in Visual Studio has been properly saved. • Running all the steps from step 36 onwards. We are trying to run a load of services and pods hosted in Docker containers. These can eat up considerable amounts of computer memory and processor power. You could consider only deploying a single service (e.g. the buyerservice along with the associated sqlestateagentbuyerservice). You can do this by commenting out all the code in the respective yml files located in the K8s folder. To delete a service: `kubectl delete service bookingservice` To delete a pod (note deleting a pod will NOT delete any services associated with it) `kubectl delete pod bookingservice-84bcbb7648-db2bc` Note your pod names To delete the entire content of a Kubernetes namespace: `kubectl delete all -n kd –all` To delete a namespace and everything in it: `kubectl delete namespace kd`
46	Open up Postman and run a few tests against the deployed services to ensure they support full CRUD capability. Pay particular attention to the deletion of properties that have associated Bookings (you'll need to set this test up in a similar way to how you did it in a previous lab (adda new property making a note of the generated ID and then add some new bookings for using the id as the propertyid). Also ensure Bookings can only be added for existing properties and buyers.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you have time:

Configure the services to be exposed on the required port number.

If you want the services to be exposed on the port numbers specified in the YAML files but are unable to use specify a service type of LoadBalancer then you can use a technique known as port forwarding. You will need to start up four separate instances of PowerShell if you want to apply this to all of the ASP.NET API services.

For each service (in a separate PowerShell instance) run the following:

```
kubectl port-forward -n kd pods/<pod  name> <external port>:<internal port>
```

```
PS C:\temp\12 Kubernetes\Solution> kubectl -n kd get pods
NAME                                READY   STATUS    RESTARTS      AGE
bookingservice-84bcbb7648-6j972     1/1     Running   5 (79m ago)   135m
buyerservice-5f9885866b-qwwbr       1/1     Running   5 (80m ago)   135m
```

```
PS C:\temp\12 Kubernetes\Solution> kubectl -n kd get services
NAME                TYPE        CLUSTER-IP       EXTERNAL-IP   PORT(S)          AGE
bookingservice      NodePort    10.98.160.246    <none>        3010:32010/TCP   135m
buyerservice        NodePort    10.106.174.207   <none>        3011:32011/TCP   135m
```

So, for the bookingservice above the command would look like the following:

```
kubectl port-forward -n kd pods/bookingservice-84bcbb7648-6j972 3010:3010
```

The port that will be exposed via localhost is the one highlighted in green.

Browsing to http://localhost:3010/bookings should bring back the appropriate data.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

Lab 13: Estate Agent Microservice – Adding Jason Web Token (JWT) Security

Objective

Your goal is to alter the logic of the Estate Agent Microservices SellerService project so that none of its methods can be called unless the user's credentials have been authenticated. Proof of successful authentication will be demonstrated in the passing and receival of a Jason Web Token (JWT).

GITHUB

Before starting on the lab please think seriously about using GitHub as a repository for the code.

STEPS

Install the necessary NuGet Package

1	Open the SellerService project in Visual Studio. You can use your solution to the previous lab or use the provided starter project. Note, given we are only worrying about providing JWT security to the Seller Service we have commented out references to all of the services in the docker-compose.yml and docker-compose.override.yml files except for the sellerservice and sqlestateagentsellerdata services. We have done this to make things run a little quicker but there is no need to do this if you don't want to. Note, if you use our starter code you will need to update the [your-name-here] sections replacing them with your Docker username.
2	Use NuGet to install the Install the `Microsoft.AspNetCore.Authentication.JwtBearer` package, which will allow the service to authenticate requests using JWT

Configure JWT Authentication

3	Locate Program.cs file and add the following using directives to the top of the file: `using Microsoft.AspNetCore.Authentication.JwtBearer;` `using Microsoft.IdentityModel.Tokens;` `using Microsoft.IdentityModel.Tokens.Jwt;` `using System.Text;`
4	Add the JWT authentication configuration to the builders Services collection. Place this just beneath the AddDBContext code: `builder.Services.AddAuthentication(options =>` `{` `  options.DefaultAuthenticateScheme =` `  JwtBearerDefaults.AuthenticationScheme;` `  options.DefaultChallengeScheme =` `  JwtBearerDefaults.AuthenticationScheme;` `}).AddJwtBearer(options =>` `{` `  options.TokenValidationParameters = new` `  Microsoft.IdentityModel.Tokens.TokenValidationParameters` `  {` `  ValidateIssuer = true,` `  ValidateAudience = true,` `  ValidateLifetime = true,` `  ValidateIssuerSigningKey = true,` `  ValidIssuer = builder.Configuration["Jwt:Issuer"],`

```
        ValidAudience = builder.Configuration["Jwt:Audience"],
        IssuerSigningKey = new
            SymmetricSecurityKey(Encoding.UTF8.GetBytes(
                builder.Configuration["Jwt:Key"]))
    };
});

builder.Services.AddAuthorization();
```

The first section of code `builder.Services.AddAuthentication` is registering the authentication services with the Dependency Injection container. The two lines of code within this section specify the default scheme the application will use for authentication (JWT Bearer tokens in this case) and the default scheme to use when a challenge is issued. Challenges occur when an unauthenticated user tries to access a resource that requires authentication. In this case the code will again be using JWT Bearer tokens)

The second section which starts with a call to `AddJwtBearer()`configures the JWT Bearer authentication scheme, providing options for how tokens should be validated. The `TokenValidationParameters` object contains settings that dictate how the incoming JWT tokens should be validated.

- `ValidateIssuer = true`: Ensures that the token's issuer claim matches the expected issuer, as defined in the ValidIssuer parameter. The issuer is the entity that issued the token, usually your application or organization.
- `ValidateAudience = true`: Ensures that the token's audience claim matches the expected audience, as defined in the ValidAudience parameter. The audience will be the recipients of the token (e.g., your API).
- `ValidateLifetime = true`: Ensures that the token has not expired. It checks the expiration claims of the token to ensure that it's still valid in terms of time.
- `ValidateIssuerSigningKey = true`: Ensures that the token's signature is valid and that it was signed using the correct key. The signing key is defined by the IssuerSigningKey parameter.
- `ValidIssuer = builder.Configuration["Jwt"]`: Specifies the expected issuer of the token, retrieved from your configuration (appsettings.json). The token's issuer claim must match this value.
- `ValidAudience = builder.Configuration["Jwt"]`: Specifies the expected audience of the token, also retrieved from your configuration. The token's audience claim must match this value.
- `IssuerSigningKey = new SymmetricSecurityKey( Encoding.UTF8.GetBytes(builder.Configuration["Jwt"]))`
  This sets the key that will be used to validate the token's signature. The key is created from a string stored in your configuration and is converted to a byte array using UTF-8 encoding.

Create a User Model and Service

5	Add a `User` class to the Models folder. This will be used to represent the credentials of individual users of the system.

```
namespace SellerService.Models
{
    public class User
    {
        public string? UserName { get; set; }
        public string? Password { get; set; }
        public string? Role { get; set; }
    }
}
```

6 For simplicity we will not use a genuine database to host our users. Instead, we will create a simple “in-memory” user store. Converting it to be a genuine database can be an “If you have time” task.
Add a new `static` class called `UserStore` to the Infrastructure folder.

```
Namespace SellerService.Infrastructure{
    public static class UserStore
    {
        public static List<User> Users = new()
        {
            new User {
                Username = "Ady Admin",
                Password = "PaSSwOrd",
                Role = "Admin"
            },
            new User {
                Username = "Kamran Senhadi",
                Password = "PaSSwOrd",
                Role = "Clerk"
            }
        };
    }
}
```

Create an Endpoint for Login and Generation of JWT’s

7 Add an `app.MapPost` function to Program.cs siting it at the bottom of the listing just before the `app.Run()` line. Make it take a User object called loginUser as a parameter and use a lambda notation into which we will add further code.

```
app.MapPost("/login", (User loginUser) =>
{

});
```

8 Add a line to the function that uses a FirstOrDefault method call to see if the passed in loginUser object’s credentials can be found in the “database”.

```
User user = UserStore.Users.FirstOrDefault(
    u => u.Username == loginUser.Username
         && u.Password == loginUser.Password);
```

9 Follow this with a test to see if the `user` variable is null. If it is return `Results.Unauthorized()` from the function.

10 Create a new `List` of `Claim` objects called `claims`. Populate it with two new `Claim` objects passing the following to their constructors:

- `ClaimTypes.Name, user.UserName`
- `ClaimTypes.Role, user.Role`

Claims are key-value pairs that represent data about the user. They are embedded within the JWT and can be used by the server to authorize the user. These claims

	will be part of the JWT's payload and can be used by the server to identify and authorize the user.
11	Create a new `SymmetricSecurityKey` object called `key` passing the following to its constructor. `SymmetricSecurityKey key = new SymmetricSecurityKey(` `  Encoding.UTF8.GetBytes(builder.Configuration["Jwt:Key"]));` A `SymmetricSecurityKey` represents the secret key used to sign the JWT. It ensures that the token can be validated by the server. The key (a `string`) gets converted to a `byte` array via the call to `Encoding.UTF8.GetBytes`. Its value is stored in the project's appsettings.json file and should be kept secret and should be a strong, random key to ensure security. We will set this up in a later step.
12	Create a new `SigningCredentials` object called `creds` passing `key` and `SecurityAlgorithms.HmacSha256` to its constructor. `SigningCredentials` creds = new SigningCredentials(key, SecurityAlgorithms.HmacSha256); A `SigningCredentials` object represents the credentials (i.e., the security key and algorithm) used to create the digital signature of the JWT. The signature ensures the token hasn't been tampered with and verifies the authenticity of the token. In this example we are using the HmacSha256 hashing algorithm that uses the key to create the signature.
13	We have now created or have access to all of the values needed to create our JWT security token. Its constructor needs to be given the following information: • issuer: Typically, the URL of your application or organization. This can come from an entry in appsettings.json. • audience: The intended recipient of the token. Again, this is typically the URL of your API or service which can be stored alongside the listener information in appsettings.json. • claims: This includes the claims collection that was created earlier. These claims are embedded in the payload of the JWT and provide information about the user. • expires: sets the expiration time of the token. In this example we are setting it to expire 30 minutes after it has been issued. After this time, the token will be invalid, and the user will need to obtain a new one. • signingCredentials: This includes the credentials used to sign the token, created earlier. It will ensure the token is securely signed and can be verified by the server. `JwtSecurityToken token = new JwtSecurityToken(` `  issuer: builder.Configuration["Jwt:Issuer"],` `  audience: builder.Configuration["Jwt:Audience"],` `  claims: claims,` `  expires: DateTime.Now.AddMinutes(30),` `  signingCredentials: creds);`
14	Add the following code to the foot of the function:

```
return Results.Ok(new
{
    token = new JwtSecurityTokenHandler().WriteToken(token)
});
```

The code is returning a response with a status code of "200 OK" that contains a JSON object with a JWT token. The `new { token = …}` section creates an anonymous object with a single property called `token`. This object is serialized to JSON and will end up looking something like the following:

```
{
    "token": "your_jwt_token_here"
}
```

`new JwtSecurityTokenHandler().WriteToken(token)` creates a JWT security token handler object whose `WriteToken()` method takes a `JwtSecurityToken` (created earlier) and serializes it into a compact, URL-safe string format.

Protect the relevant API Endpoints with JWT Authentication

15 Add protection to **ALL** the other Seller Service endpoints so that they require authentication. For example:

```
app.MapGet("/sellers", async (SellerContext db) =>
    await db.Sellers.ToListAsync()).RequireAuthorization();
```

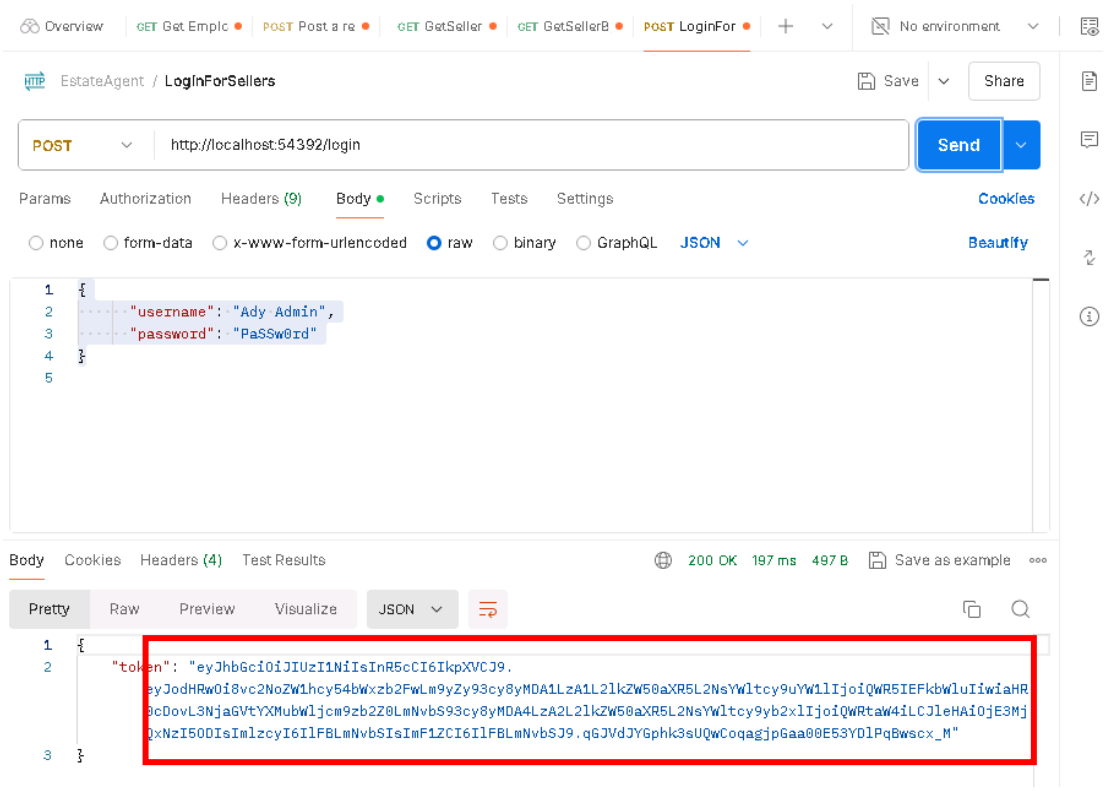
Configure JWT Settings in "appsettings.json"

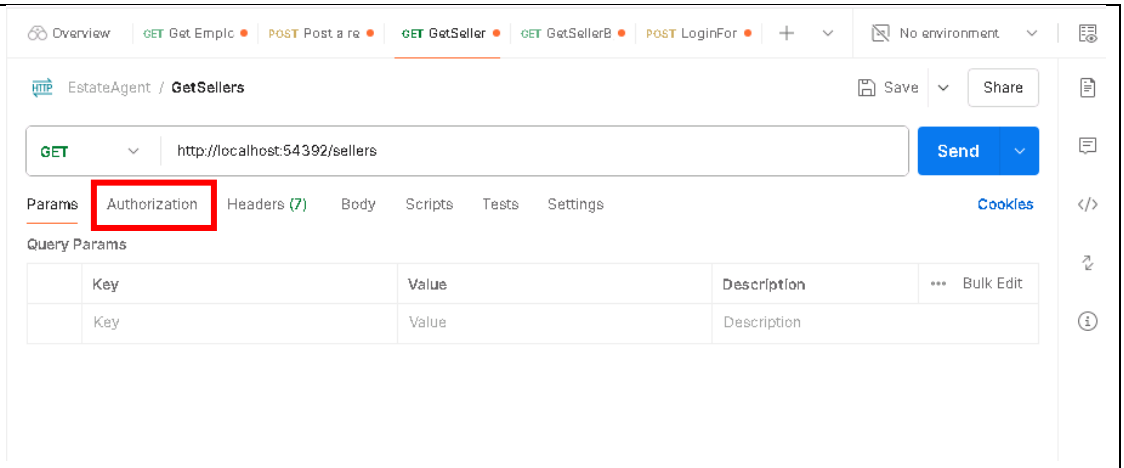
16 Open the appsettings.json file and add the following JWT settings:

```
{
  "ConnectionStrings": {
    "sqlestateagentdata":
"Server=sqlestateagentsellerdata;Database=EASeller;User
Id=sa;Password=PaSSwOrdPaSSwOrd;MultipleActiveResultSets=true;Encrypt=False
;TrustServerCertificate=True"
  },

  "Logging": {
    "LogLevel": {
      "Default": "Information",
      "Microsoft.AspNetCore": "Warning"
    }
  },

  "Jwt": {
    // The key should be a long, random string such as a GUID
    "Key":
        "Yh2k7QSu4l8CZg5p6X3Pna9L0Miy4D3Bvt0JVr87UcOj69Kqw5R2Nmf4FWs03Hdx",
    "Issuer": "QA.com",
    "Audience": "QA.com"
  },

  "AllowedHosts": "*"
}
```

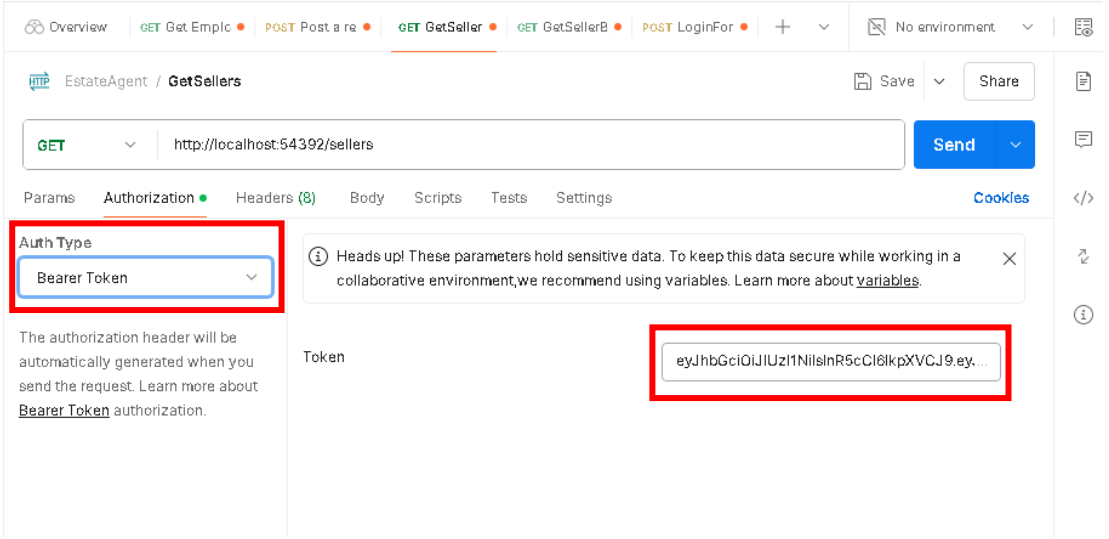
Test the program

17 Launch the app using docker-compose as the startup project. Use Postman (or equivalent tool) to test the logic.

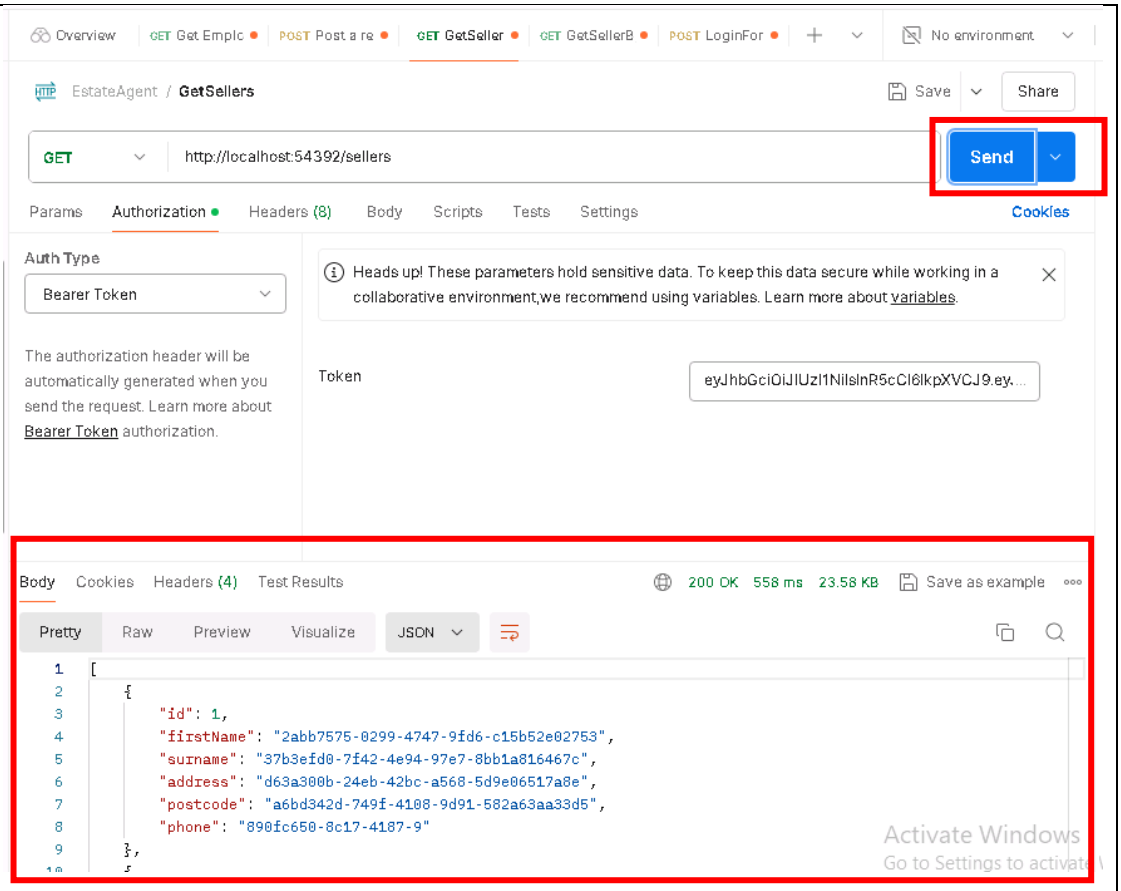
18	First, perform a GET request to /sellers and ensure your request is rejected with a 401 Unauthorized message.
19	Second, perform a POST request to /login with the following JSON body: `{ "username": "Ady Admin", "password": "PaSSw0rd" }` Note, your port number **may not** be the same as the one used in the screenshot below:  If the credentials are valid, the API will return a JWT token.
20	Use the returned token to access the secure endpoints: • Copy the returned JWT token. Everything inside the quotes but **not** the word "token" or the colon • Go to the "Authorization" tab.



- Choose "Bearer Token" from the dropdown.
- Paste the JWT token into the field provided.
- Enter the appropriate URL into the “URL” box. Note, your port number **may not** be the same as the one used in the screenshot



- Press send



Observe the function works and returns appropriate data.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

If you have time:

Add JWT security to the other services and/or test the security works for a Kubernetes deployment.

21	Rework the Seller Service JWT security to use a SQL server database that gets deployed with the estateagent seller database.
22	Add JWT security to some (or all) of the other services.
23	Try doing a Kubernetes deployment and confirm the JWT security features work as expected.

Note, the model solutions do not cover any of the above “If you have time” ideas.

GITHUB

Before moving on don't forget to commit and push your work to GitHub.

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