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Multi-Factor Authentication Design with IdentityServer4 and ASP.NET Core 2.0 (1)



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Chapter 1

Currently, Almost of login system verify an account not just username/password also including with OTP through SMS as well as normal login is not safe anymore ..



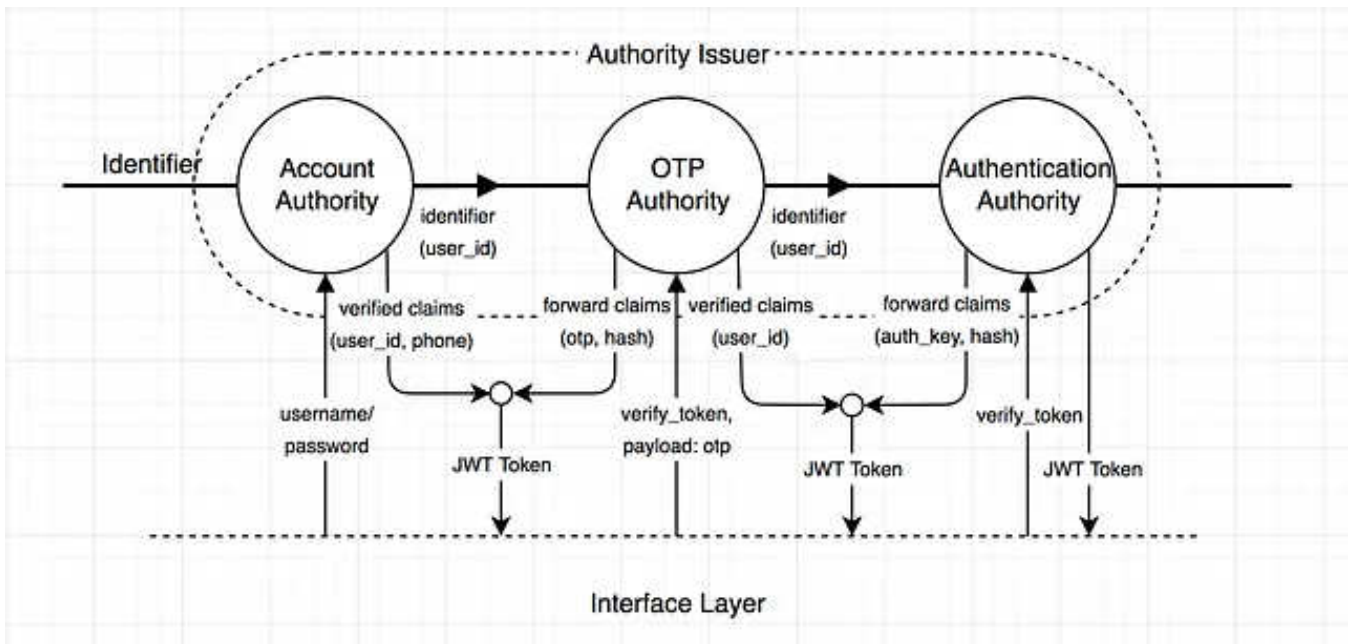
ASP.NET / IdentityServer4 has built-in MFA, or in the case of above is 2FA. This article will introduce how to design and implement own MFA without build-in of ASP.NET / IdentityServer4.

The challenges are ...

1. Make RESTful Authentication
2. No UI in Identity Server for Authentication.
3. Stateless Authentication based on JWT.
4. Enrollment process is unlimited. (2FA takes 2 steps)
5. Each part can verify individually.
6. All parts need to work together as steps of verification.

The challenges can be group into 3 groups

1. Apply Extension Grants which is once of Grant Types of Identity Server as authentication.
2. Apply JWT to be a Stateless Token between Client-Server, then set expiry time in each verification step.
3. It is important to create a Verification Unit to work on it, and then release the Claims as output and forward to next Verification Unit to operate continuously. Put them together (Wired) as a pipeline using the **Identifier**. Finally, make the Secret and Hashing.



Verification Pipeline

Chapter 2 : The explanation of the diagram and how it works.

Others Chapter

- [Multi-Factor Authentication Design with IdentityServer4 and ASP.NET Core 2.0, Chapter 2](#)
- [Multi-Factor Authentication Design with IdentityServer4 and ASP.NET Core 2.0, Chapter 3](#)

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MFA

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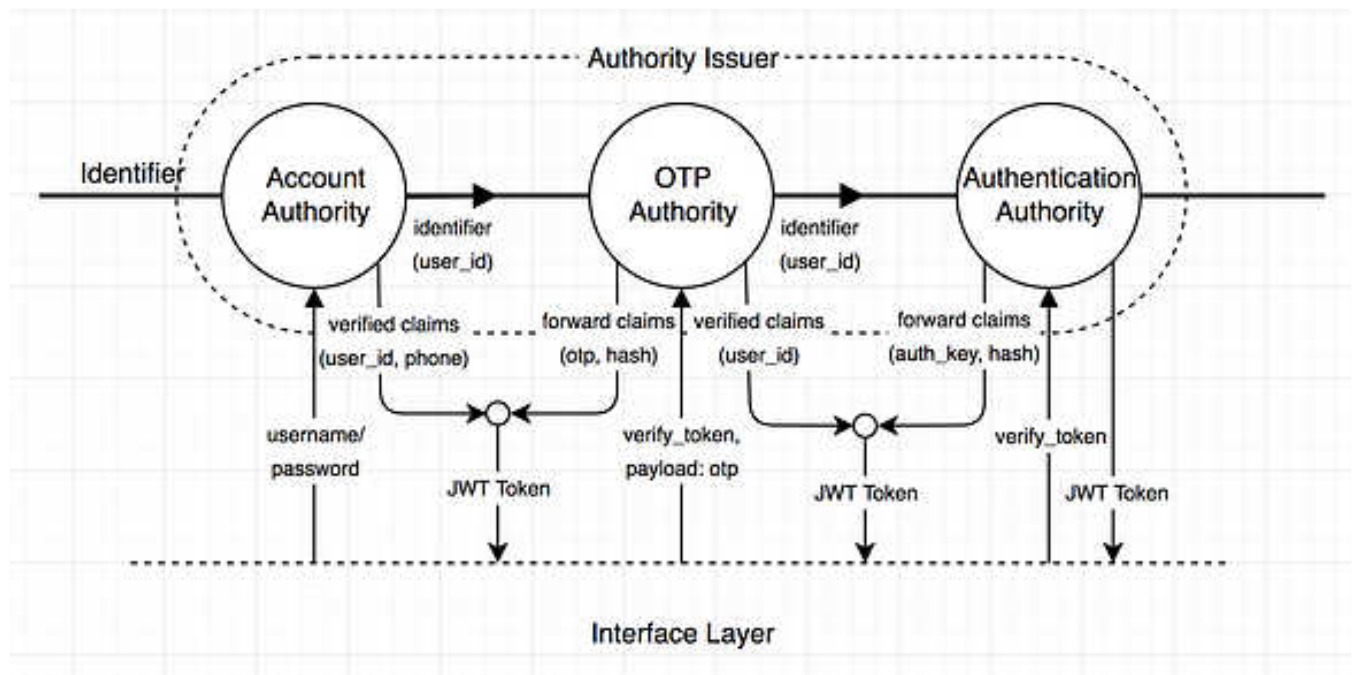


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Chapter 2

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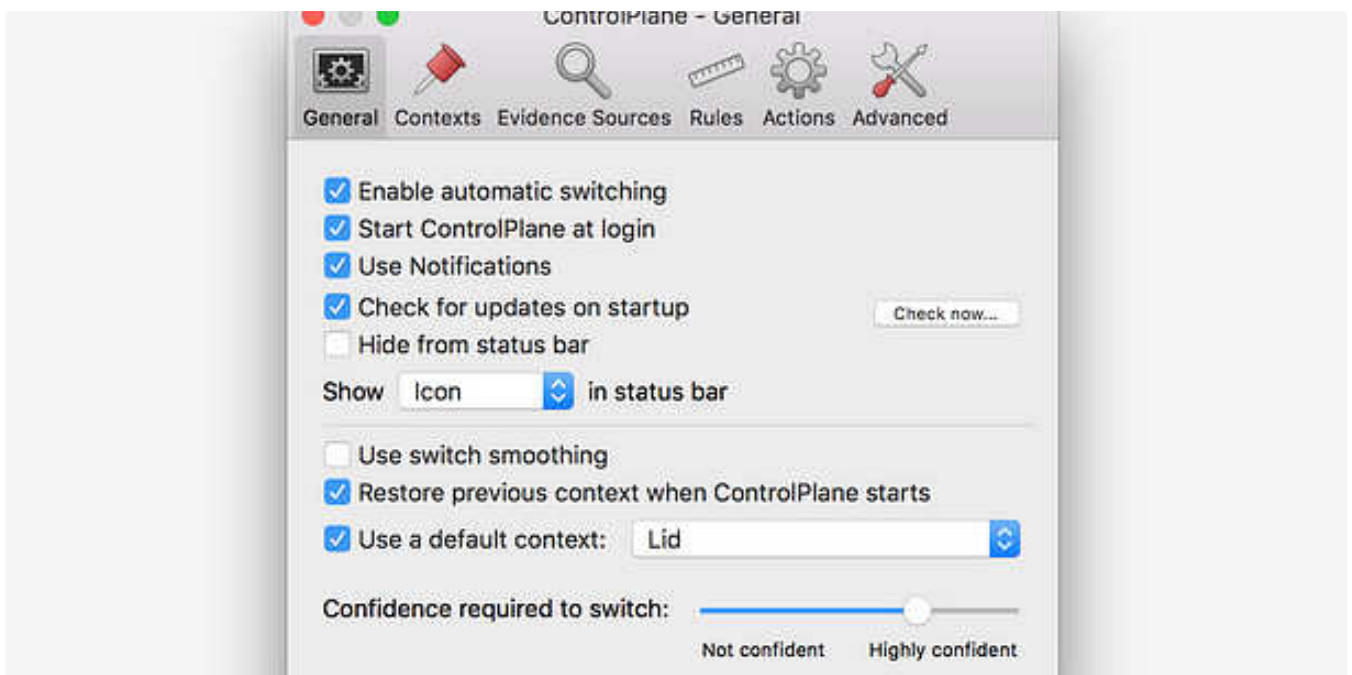
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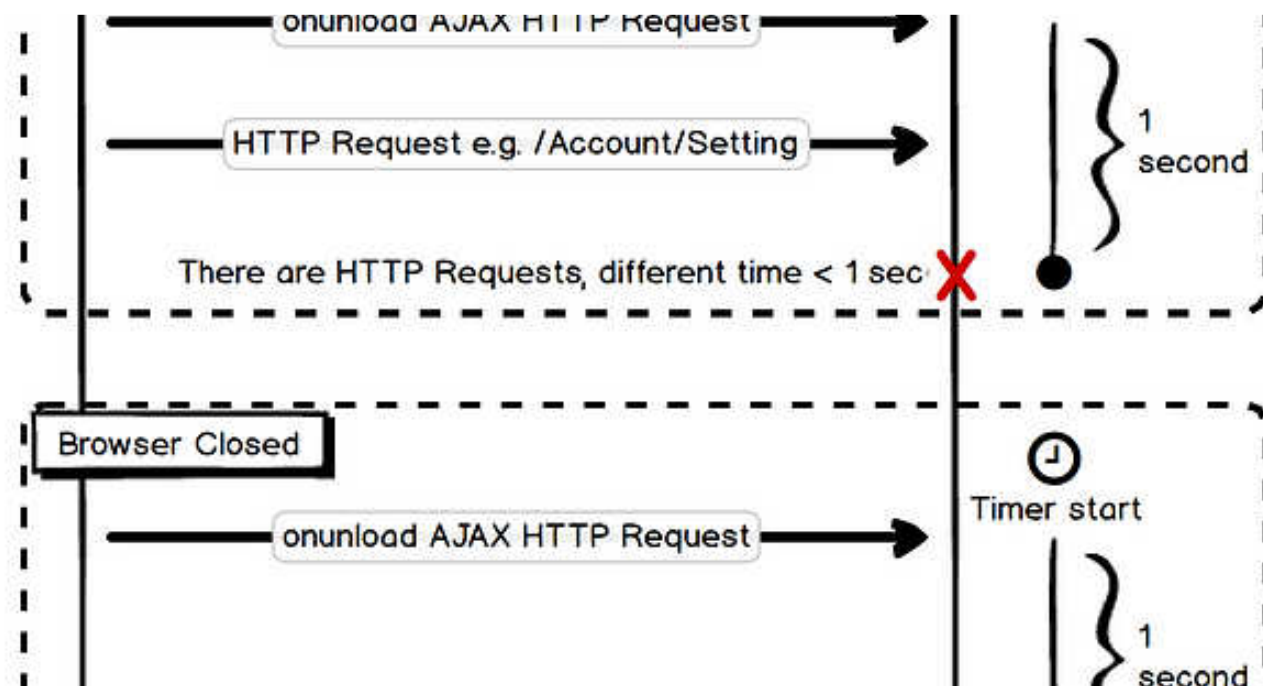
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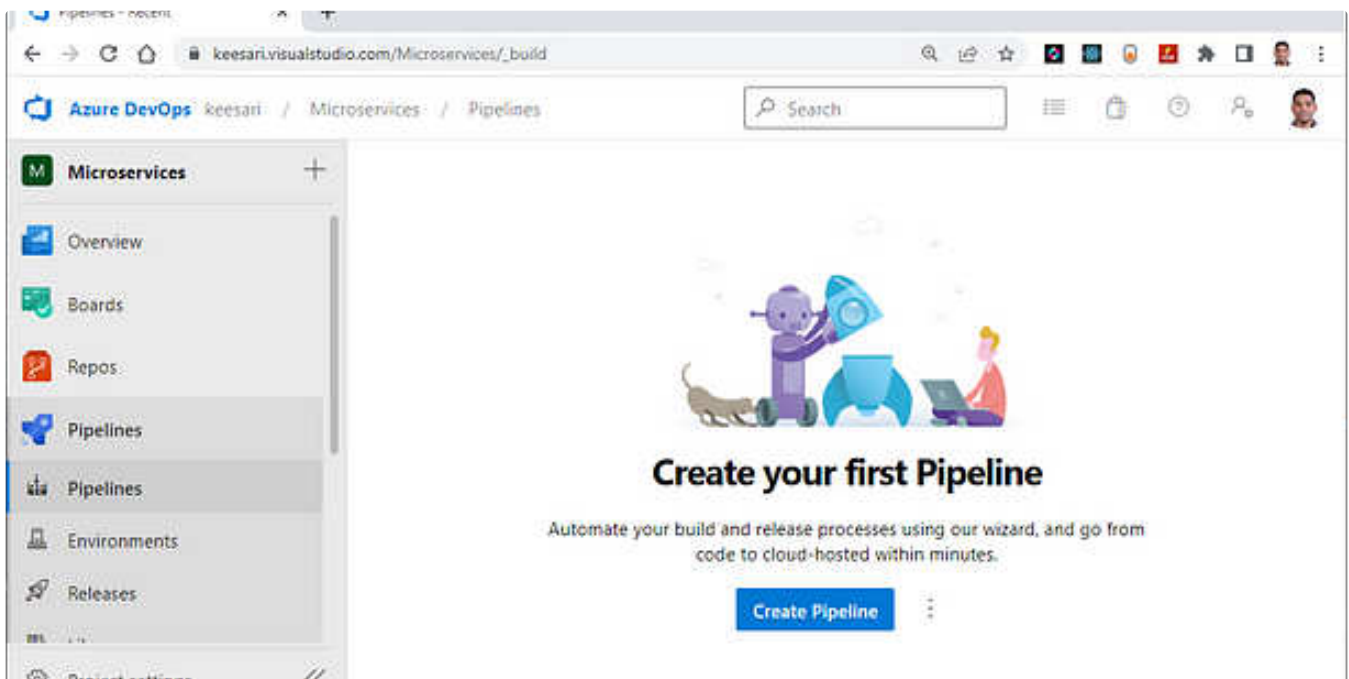
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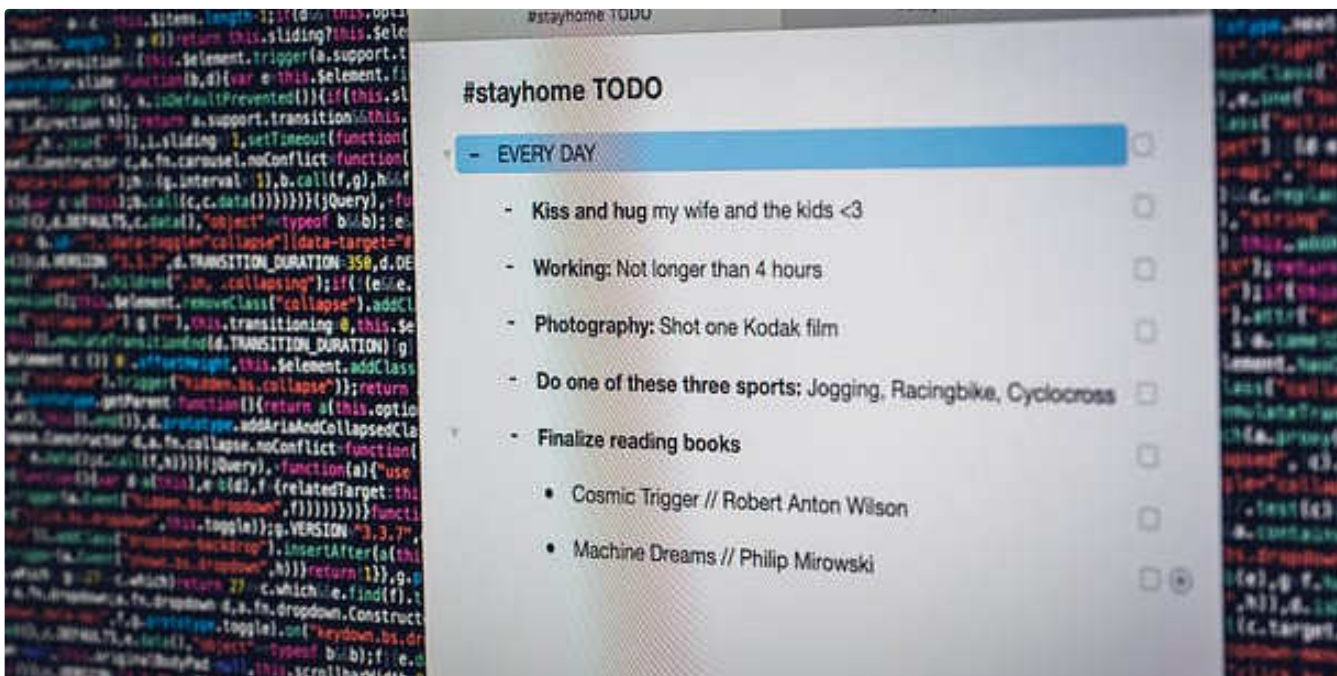


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Chapter 2

From previous chapter, I have designed the Verification Pipeline Diagram. There are 3 sections.

1. Verification Authority

The part used to verify each step by the input is **Identity Claims and Payload**. Identity Claims comes from the verified claims of previous step and Payload is derived from the input of the interface layer.

OnVerify was created as a method to get Identity Claims and Payload, then to verify the input and return the claims.

OnForward was created as a method and instant execute after OnVerify of previous authority, because it was designed to work seamlessly.

Verification Authority requires a payload for verification, such as **OTPAuthority**. The **otp** value must be specified as well.

```
Payload => new string[] { "otp" }
```

IAuthority Interface

```

1  public interface IAuthority
2  {
3      string[] Payload { get; }
4      Claim[] OnVerify(Claim[] claims, JObject payload, string identifier, out bool valid);
5      Claim[] OnForward(Claim[] claims);
6  }

```

IAuthority.cs hosted with ❤ by GitHub

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IAuthority.cs

Implementation of AccountAuthority and OTPAuthority

```

1  public class AccountAuthority : IAuthority
2  {
3      private IAccount epository repository;
4
5      public AccountAuthority(IAccount epository repository)
6      {
7          repository repository;
8      }
9
10
11
12     public string[] Payload { get { return new string[] { username , password }; } }
13
14     public Claim[] OnForward(Claim[] claims)
15     {
16         throw new NotImplementedException();
17     }
18
19     public Claim[] OnVerify(Claim[] claims, JObject payload, string identifier, out bool valid)
20     {
21         valid = false;
22         var user = repository.GetAccount(payload[ username ].ToString(), payload[ password ]);
23         if (user == null)
24             throw new KeyNotFoundException();
25         valid = true;
26         return new Claim[]
27         {
28             new Claim(identifier, user.UserId.ToString()),
29             new Claim( phone , user.Phone)
30         };
31     }
32 }

```

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AccountAuthority.cs


```

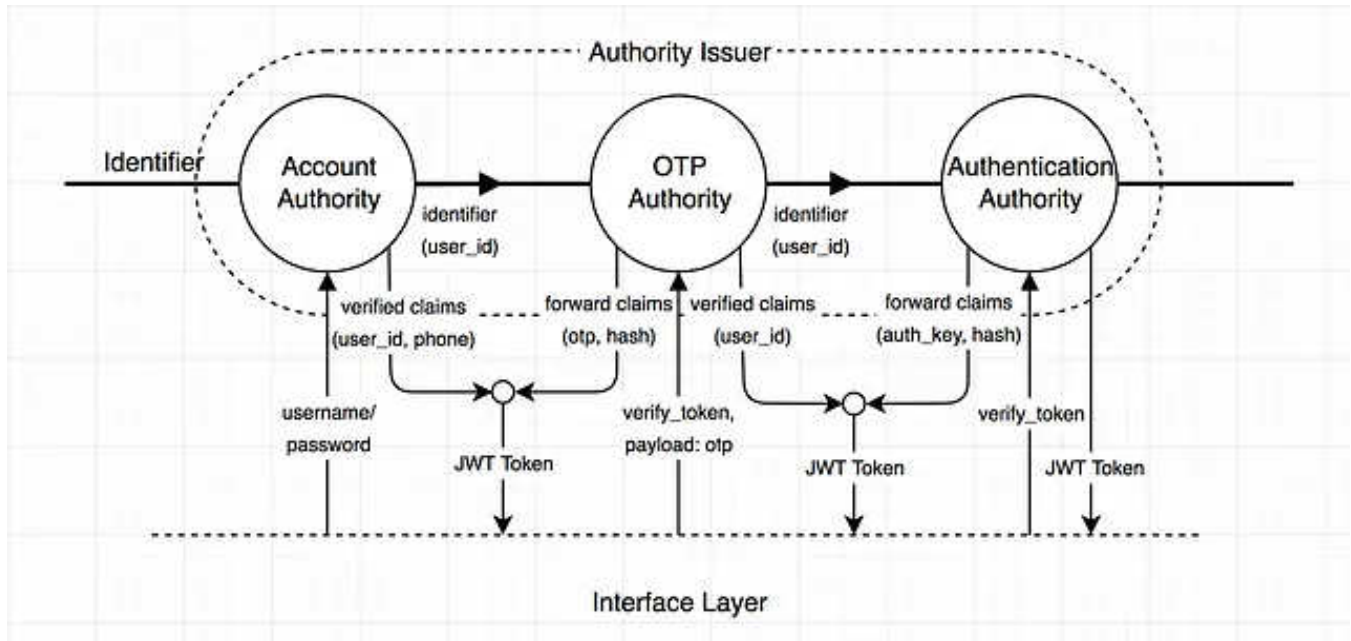
48         throw new ArgumentException();
49     }
50 }

```



OTPAuthority.cs

Example from the Verification Pipeline Diagram designed in Chapter 1



Verification Pipeline

OnVerify of AccountAuthority : The first is Empty Claims (because there is no previous Verify Authority).

At the same time, **OnForward** of **OTPAuthority** works immediately. Then we will get the first two claims from :

OnVerify — verified claims of **AccountAuthority**.

OnForward — forward claims of **OTPAuthority**.

2. Authority Issuer

The Verification Authority is in the pipeline. It must be managed. This is the responsibility of the **Authority Issuer**.

The main function of Authority Issuer is to support the Authority's Register for each verification step. And ordering OnVerify / OnForward When the Verify Authority is registered, such as **Verify AccountAuthority**, Authority Issuer will call **AccountAuthority.OnVerify**, **OTPAuthority.OnForward**, respectively.

Because **OTPAuthority.OnForward** will send OTP to the phone number obtained from verified claims at **AccountAuthority.OnVerify**. Then return to the forward claims, which contains otp_id, otp_hash

Authority Issuer will combine the two claim types together and then transform it into a JWT Token forwarded to the Interface Layer.

At the step of OTP verification, Authority Issuer converts a token to Identity Claims and then pushing together with incoming payload to **OTPAuthority.OnVerify**.

The process is repeated as above, according to the authorities that is registered in the Verification Pipeline.

Verification Pipeline that is created through Authority Issuer can have different verification procedures, but use the same Authority (reusable).

Implementation of Authority Issuer


```

48         if (verifyClaims.Any())
49         {
50             forwardClaims = nextAuthority.OnForward(verifyClaims);
51         }
52         if (valid)
53         {
54             var verifyToken = JwtHelper.GenerateToken(verifyClaims.Concat(forwardClaims).To
55             return new IssuerVerifyResult()
56             {
57                 Token = verifyToken,
58                 Authority = forwardAuthority,
59                 Payload = forwardPayload
60             };
61         }
62     }
63     else
64     {
65         if (valid)
66         {
67             var identifier = verifyClaims.SingleOrDefault(c => c.Type == _identifier);
68             var authenticationClaims = _authenticator.GetAuthenticationClaims(identifier.Va
69             return new IssuerVerifyResult()
70             {
71                 Token = JwtHelper.GenerateToken(authenticationClaims, _timeouts[authority])
72                 Authority = null,
73                 Payload = null
74             };
75         }
76     }
77     var token = JwtHelper.GenerateToken(verifyClaims, _timeouts[authority]);
78     return new IssuerVerifyResult()
79     {
80         Token = token,
81         Authority = authority,
82         Payload = verifyAuthority.Payload
83     };
84 }
85 }
86
87 public static class AuthorityIssuerExtension
88 {
89     public static AuthorityIssuer Register(this AuthorityIssuer issuer, string name, IAuthority
90     {
91         issuer.Register(authority, name, timeout);
92         return issuer;
93     }
94 }

```

3. Authenticator

The last ingredient that is indispensable is **Authenticator** which is related to the middle line in the diagram is written as **Identifier**.

Let's talk about Identifier first ... **Identifier** is the key-value to link each Authority together. It is the agreement to send the key-value among the verified process through the last Authority (**Authenticator**). Authenticated claims, which are the final claims to verify with the system.

Because Authenticator is the last authority to be restored the authenticated claims, which is different from the normal authority that returned the claims has come up with another Interface.

```
1  public interface IAuthenticator
2  {
3      Claim[] GetAuthenticationClaims(string identifier);
4  }
```

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IAuthenticator.cs

Authenticator has duty to twist /change the **Identifier** to match the system verification key. In this case, the identifier is in a format that matches the authentication system, so it does not twist / change anything.

```

1  public class AuthenticationAuthority : IAuthenticator
2  {
3      private static string authSecret = "authenticationsecretkey".Sha256();
4
5      public Claim[] GetAuthenticationClaims(string identifier)
6      {
7          if (!Guid.TryParse(identifier, out Guid guid))
8              throw new FormatException();
9          var hash = string.Format("{0}:{1}", identifier, authSecret).Sha256();
10         return new Claim[]
11         {
12             new Claim("auth_key", identifier),
13             new Claim("auth_hash", hash)

```

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AuthenticationAuthority.cs

The core of the system has been done. Here we will talk about the Interface Layer that is Integrate with Identity Server in the next chapter.

Chapter 3 : Implementation of the system

Others Chapter

- Multi-Factor Authentication Design with IdentityServer4 and ASP.NET Core 2.0, Chapter 1
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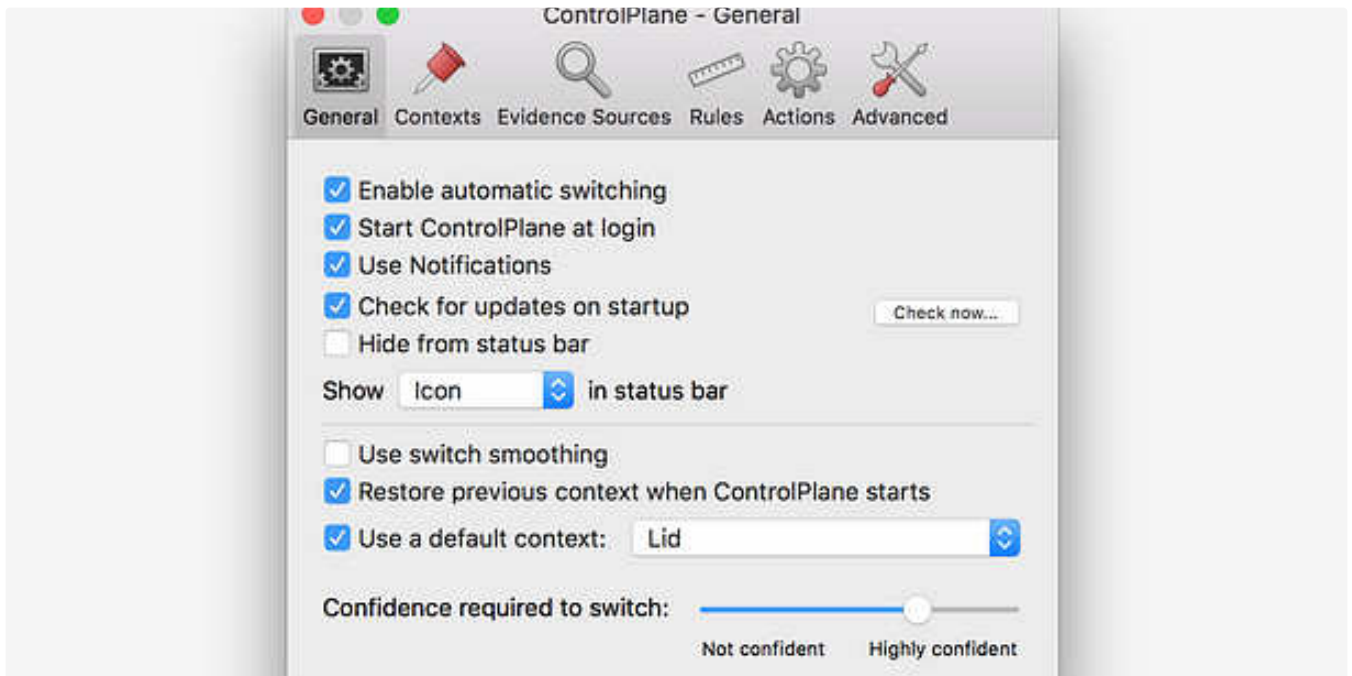
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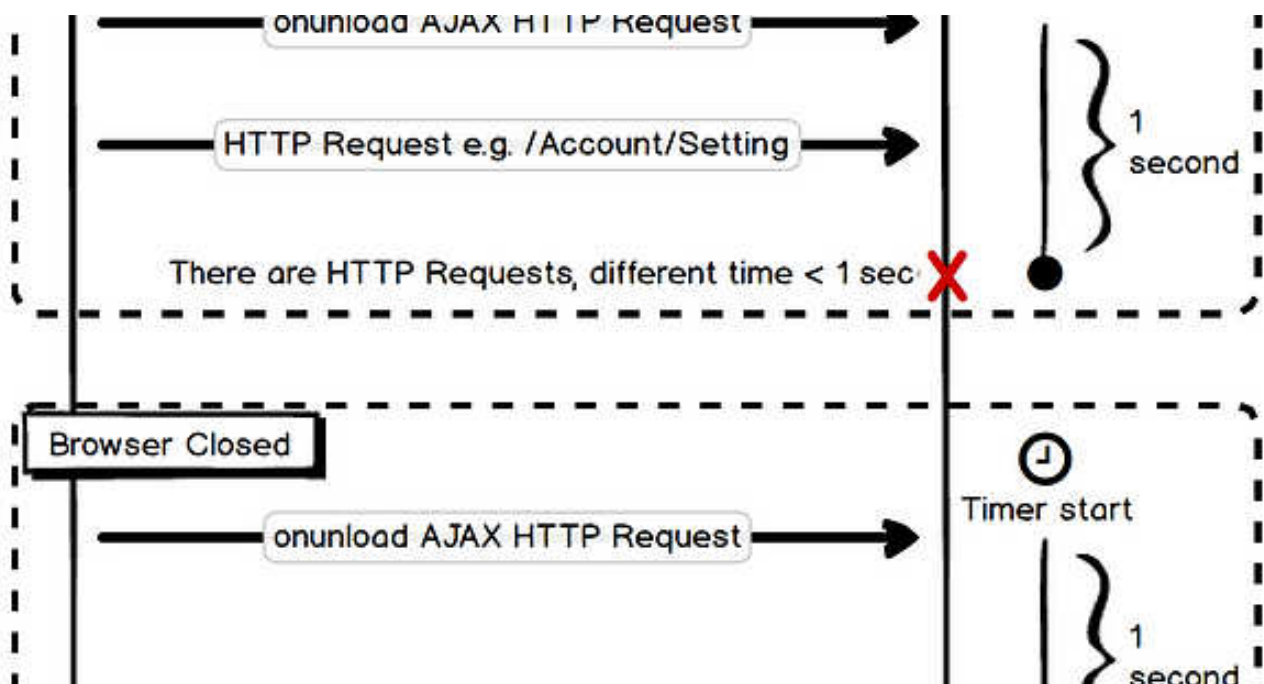
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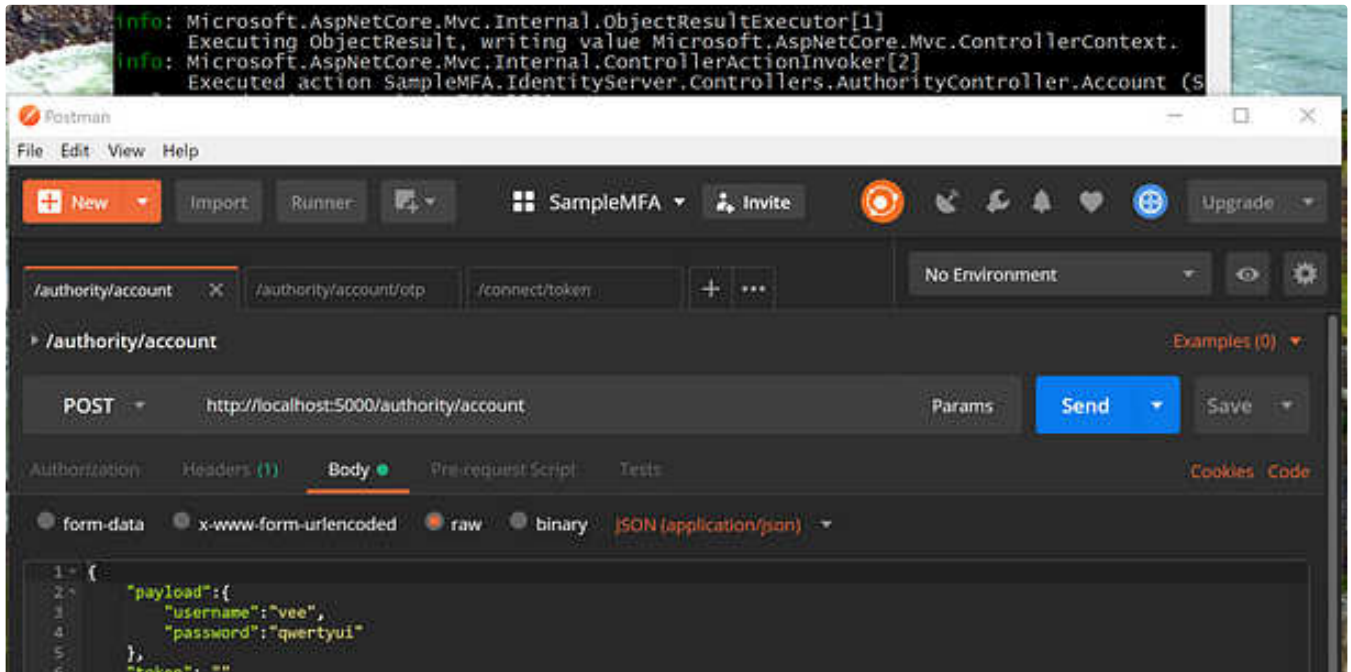
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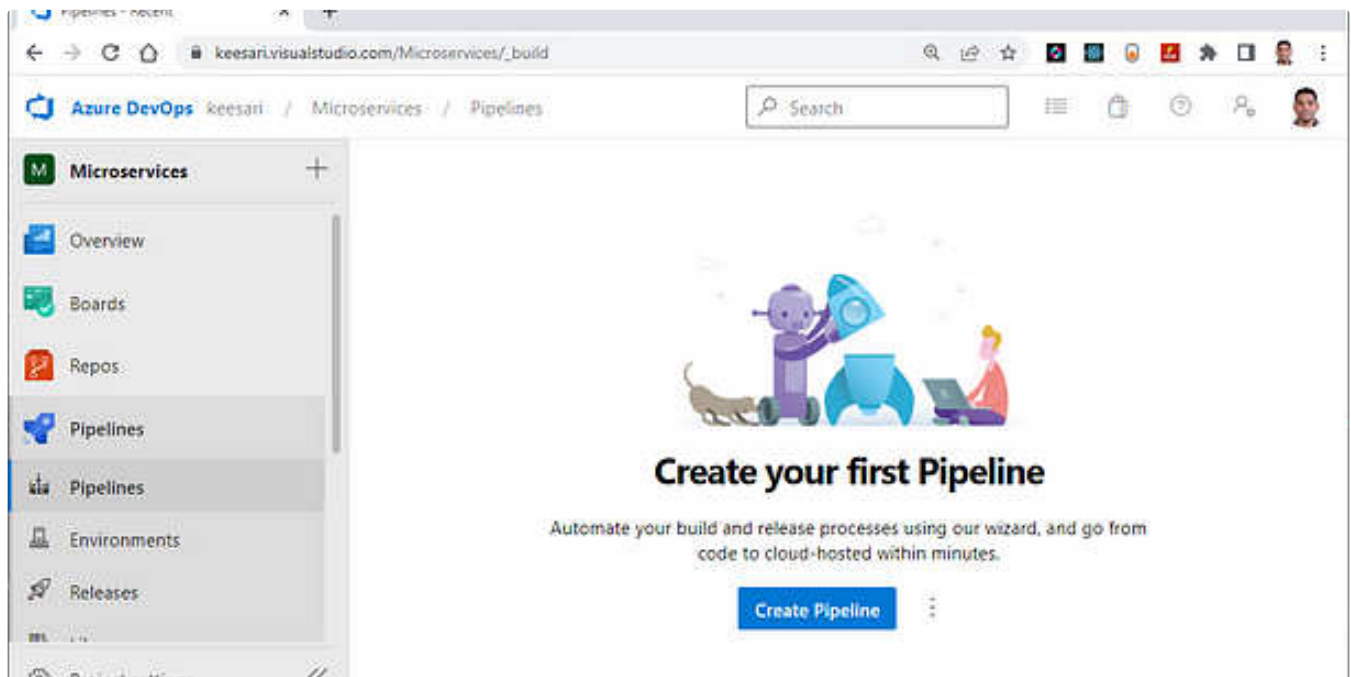
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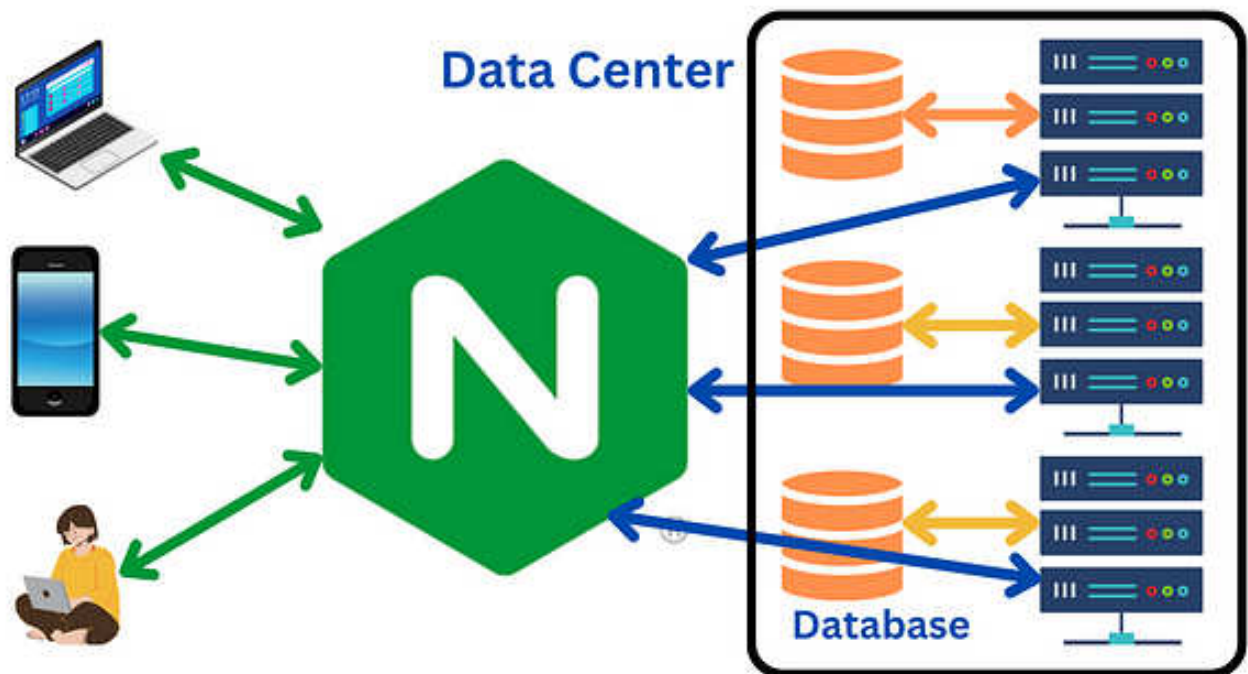
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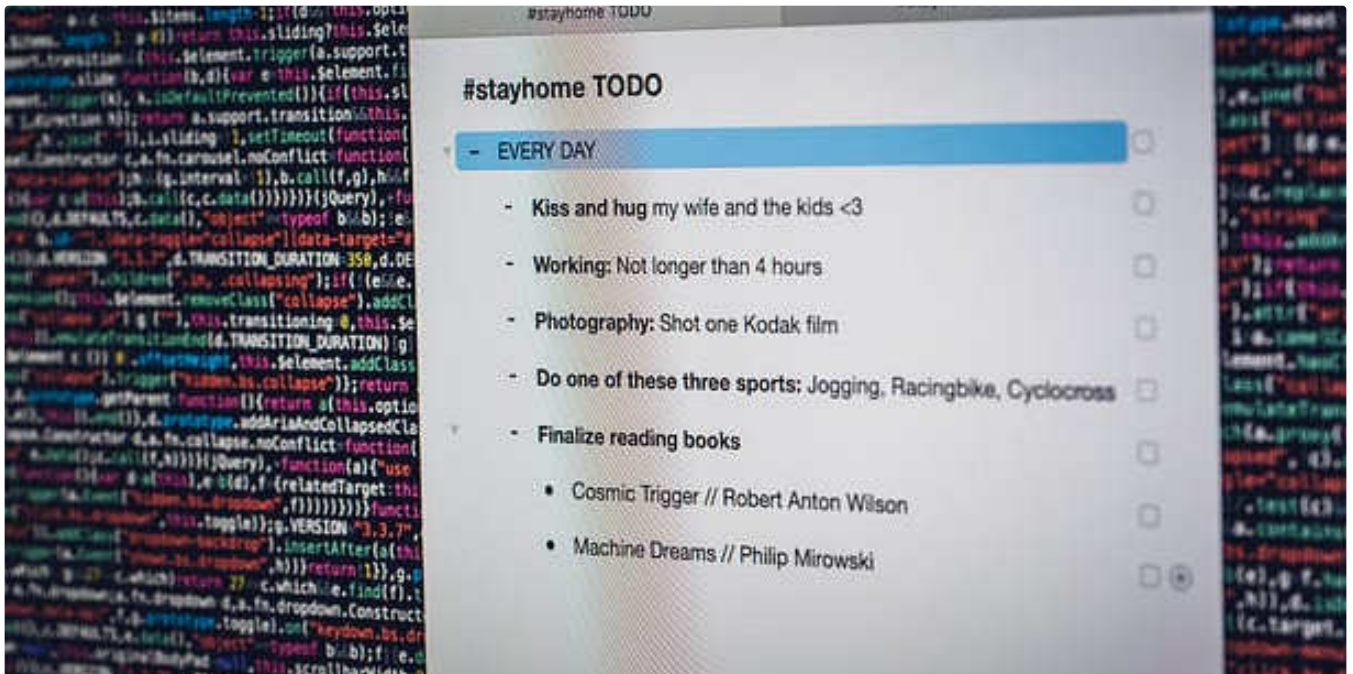


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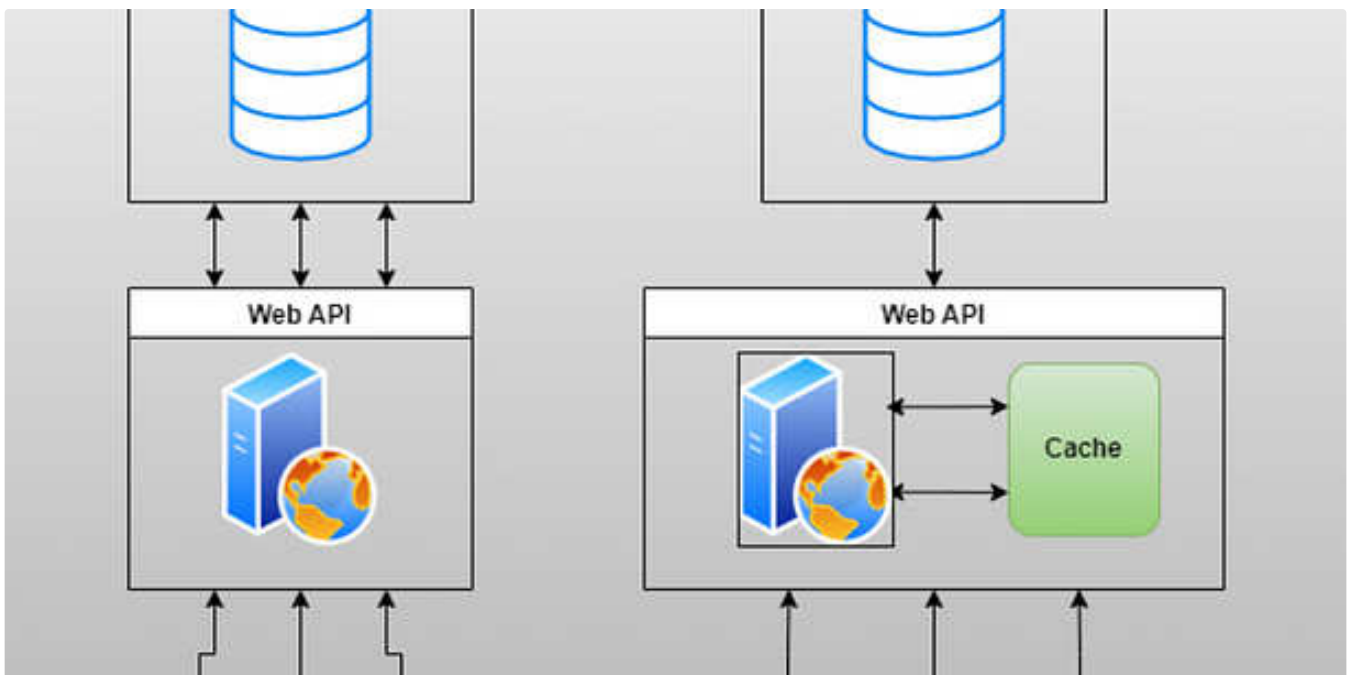
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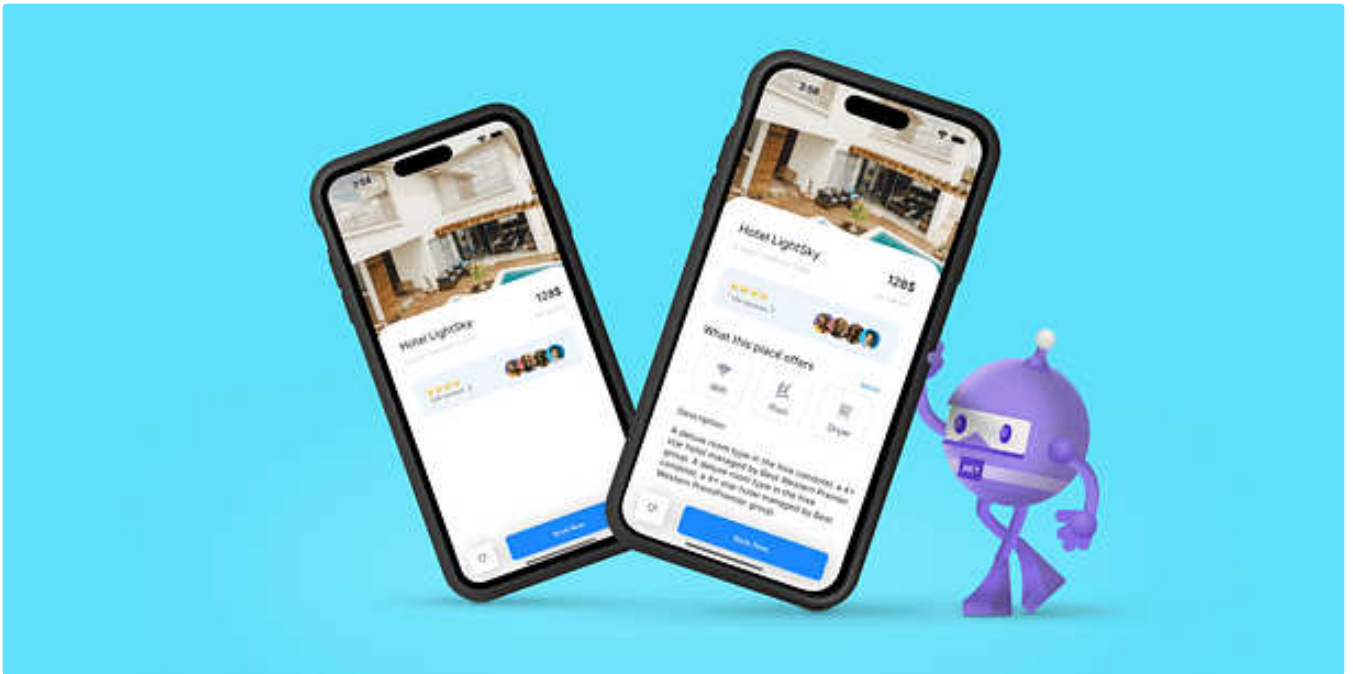
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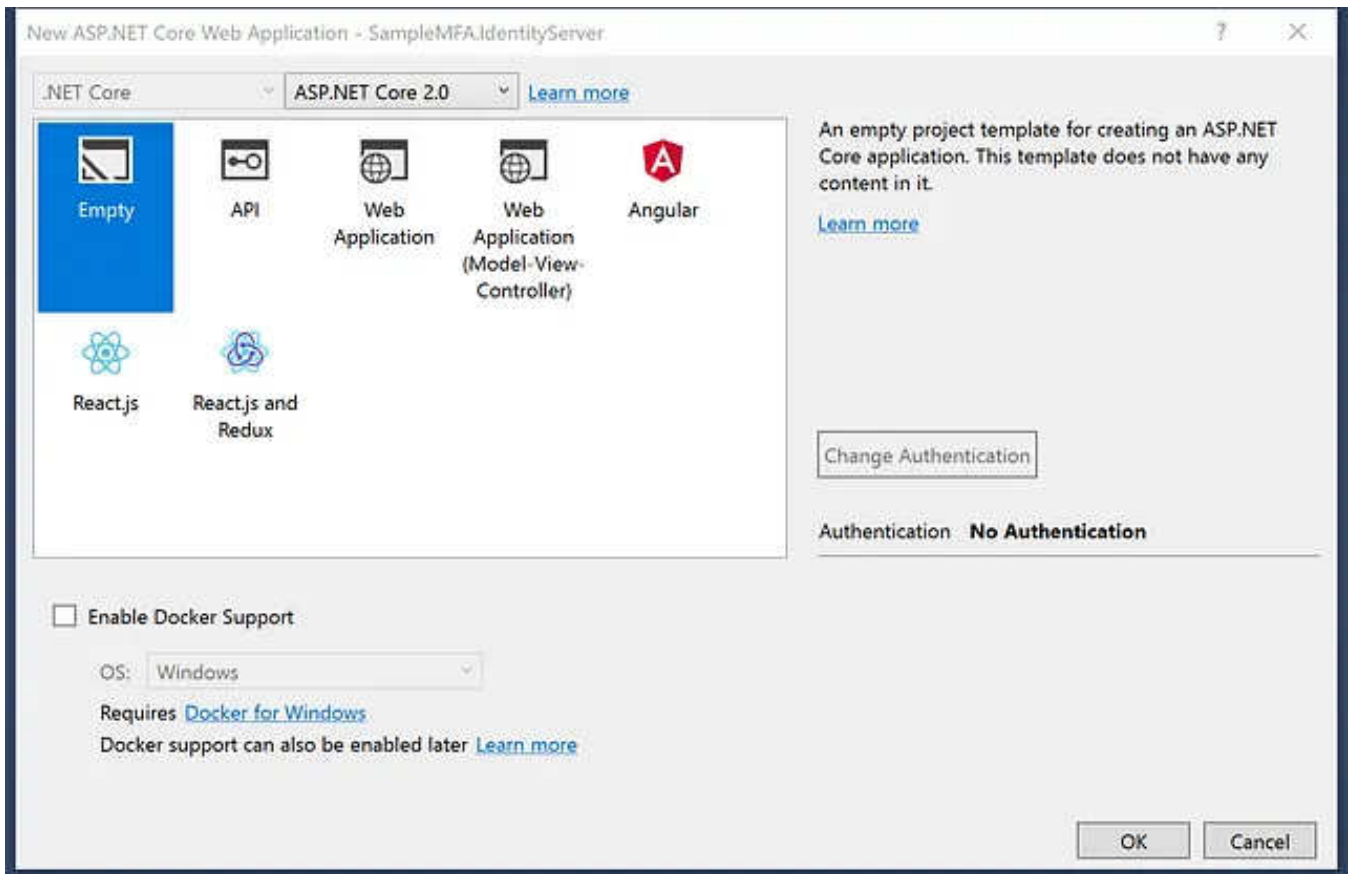
This is the last chapter of the Multi-Factor Authentication with IdentityServer4 and ASP.NET Core 2.0 series, which will discuss the implementation of the system we designed in Chapter 1 / 2.

Project Repository : [SampleMFA](#)

Tools

- [IdentityServer4](#)
- [Entity Framework Core](#)
- [Json.NET](#)
- [Postman](#)

Start by creating an ASP.NET Core Web Application Empty Project.



SampleMFA.IdentityServer.csproj

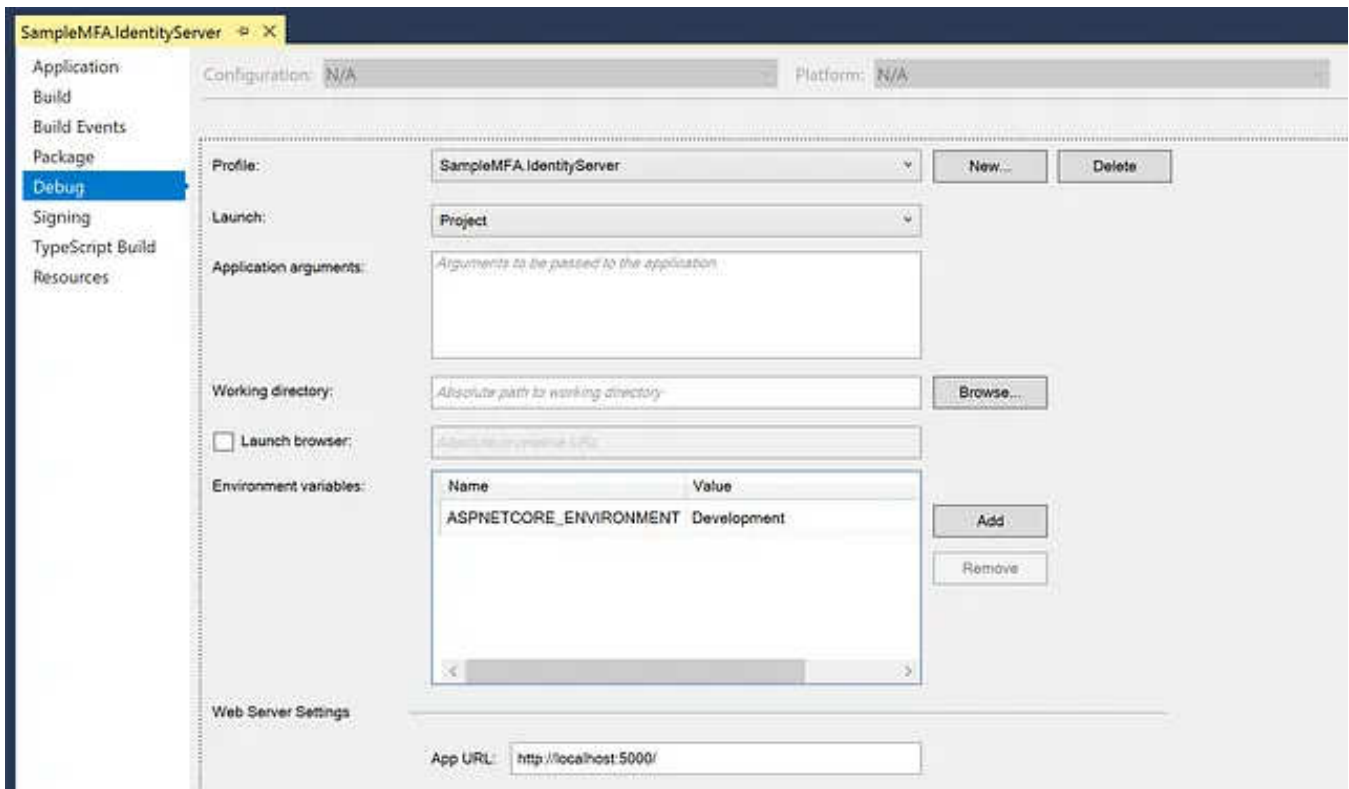
install packages with Package Manager Console

```
PM> Install-Package IdentityServer4 -Version 2.2.0
```

```
PM> Install-Package Newtonsoft.Json -Version 11.0.2
```

Interesting feature of ASP.NET Core is that it hosts itself without the need for IIS, but uses an event-driven, asynchronous I / O based server called Kestrel.

To use Kestrel as a web server, we will update the launch setting profile by selecting the project profile, ie SampleMFA.IdentityServer, and then modify the setting like this.



SampleMFA.IdentityServer launch setting

Modify **Program.cs** to use Kestrel as a web server, and specify URL as [http://localhost: 5000.](http://localhost:5000/)

```

1  using System.IO;
2  using Microsoft.AspNetCore;
3  using Microsoft.AspNetCore.Hosting;
4
5  namespace SampleMFA.IdentityServer
6  {
7      public class Program
8      {
9          public static void Main(string[] args)
10         {
11             BuildWebHost(args).Run();
12         }
13
14         public static IWebHost BuildWebHost(string[] args) =>
15             WebHost.CreateDefaultBuilder(args)
16                 .UseKestrel()
17                 .UseUrls("http://localhost:5000")
18                 .UseContentRoot(Directory.GetCurrentDirectory())
19                 .UseIISIntegration()
20                 .UseStartup<Startup>()
21                 .Build();
22     }
23 }

```



Line 18 is the content resource path, such as config files. In this case IdentityServer4 will generate the file tempkey.rsa to use as a Signing-Certificates Key.

Line 19 is enabled integration with IIS. When we host the application through IIS, the ASP.NET Core Module generates a dynamic port for our application, which is hosted by Kestrel.

Listen / Process operate by Kestrel web server. The ASP.NET Core Module is a link between IIS and Kestrel. By the way, the IIS respond for page request then forward to the port which is binding at ASP.NET Core Module. The request is forwarded and process by Kestrel which mapped with the dynamic port. You can read the great explanation [here](#).

Run the project with SampleMFA.IdentityServer profile. Kestrel will open up as Console Application Mode.

```
SampleMFA.IdentityServer
Hosting environment: Development
Content root path: C:\Users\vee\Documents\Visual Studio 2017\Projects\SampleMFA\SampleMFA.IdentityServer
Now listening on: http://localhost:5000
Application started. Press Ctrl+C to shut down.
```

Let's make web server to be Identity Server

Open **Startup.cs**. Add configuration to change service to be Identity Server. Use Developer Signing Credential as Signing JWT Token.

```
1 public void ConfigureServices(IServiceCollection services)
2 {
3     services.AddIdentityServer()
4         .AddDeveloperSigningCredential();
5 }
```

Startup1.cs hosted with ❤ by GitHub

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Add a Web API using for connect with the Identity Server by specifying name and description. The registered Web API can use the same access token generated by the Identity Server.


```

1  public void ConfigureServices(IServiceCollection services)
2  {
3      services.AddIdentityServer()
4          .AddDeveloperSigningCredential()
5          .AddInMemoryApiResources(new List<ApiResource>()
6              {
7                  new ApiResource("api.sample", "Sample API")
8              });
9  }

```



Finally, add a client to use as a channel for making authentication It can be set for each Web API by **AllowedScopes** property.

```

1  public void ConfigureServices(IServiceCollection services)
2  {
3      services.AddIdentityServer()
4          .AddDeveloperSigningCredential()
5          .AddInMemoryApiResources(new List<ApiResource>()
6              {
7                  new ApiResource("api.sample", "Sample API")
8              })
9          .AddInMemoryClients(new List<Client>()
10              {
11                  new Client
12                  {
13                      ClientId = "Authentication",
14                      ClientSecrets =
15                      {
16                          new Secret("clientsecret".Sha256())
17                      },
18                      AllowedGrantTypes = { "authentication" },
19                      AllowedScopes =
20                      {
21                          "api.sample"
22                      },
23                      AllowOfflineAccess = true
24                  }
25              });
26  }

```



We will use Entity Framework Core as the tool for making **Sample Accounts**.

Modeling and Creating a DB Context with Entity Framework Core

Since EF Core is Code-First, we started by creating a model by creating a Class **Account** and **ApplicationDbContext**.

```
1  using System;
2  using System.ComponentModel.DataAnnotations;
3
4  namespace SampleMFA.IdentityServer.Models
5  {
6      public class Account
7      {
8          [Key]
9          public Guid UserGuid { get; set; }
10
11         public string Username { get; set; }
12         public string EncryptedPassword { get; set; }
13
14         [Required]
15         [StringLength(20)]
16         public string Phone { get; set; }
17     }
18 }
```



Account.cs

```
1  using Microsoft.EntityFrameworkCore;
2  using SampleMFA.IdentityServer.Models;
3
4  namespace SampleMFA.IdentityServer
5  {
6      public class ApplicationDbContext : DbContext
7      {
8          public ApplicationDbContext() { }
9          public ApplicationDbContext(DbContextOptions<ApplicationDbContext> options) : base(options)
10         {
11             public virtual DbSet<Account> Accounts { get; set; }
12         }
13     }
14 }
```



ppl D C x



ApplicationDbContext.cs

Then create. **IAccountRepository**, **AccountRepository** as Data Access Layer.


```

10         void InsertAccount(string username, string password, string phone, out Guid userGuid);
11     }
12 }

```

Above coding of Data Access Layer is used for demonstration purposes only. Do not use it. I do not have secure password hashing.

Added a configuration service in **Startup.cs** to register in the memory database for the **ApplicationDbContext**, do the dependency injection in the **AccountRepository**.

```

1  public void ConfigureServices(IServiceCollection services)
2  {
3      ...
4
5      services.AddDbContext<ApplicationDbContext>(options =>
6          options.UseInMemoryDatabase("SampleMFA")
7      );
8
9      services.AddTransient<IAccountRepository, IAccountRepository>();
10 }

```



Now we have prepared environment that ready for assemblies in the Controller.

- **AuthorityController** is provided as an endpoint for testing the sign-in account.

In the article, I will detail only the **AuthorityController** to see how it works.

Start by creating an **AuthorityModel** to store Payload and Token from the Client.

```

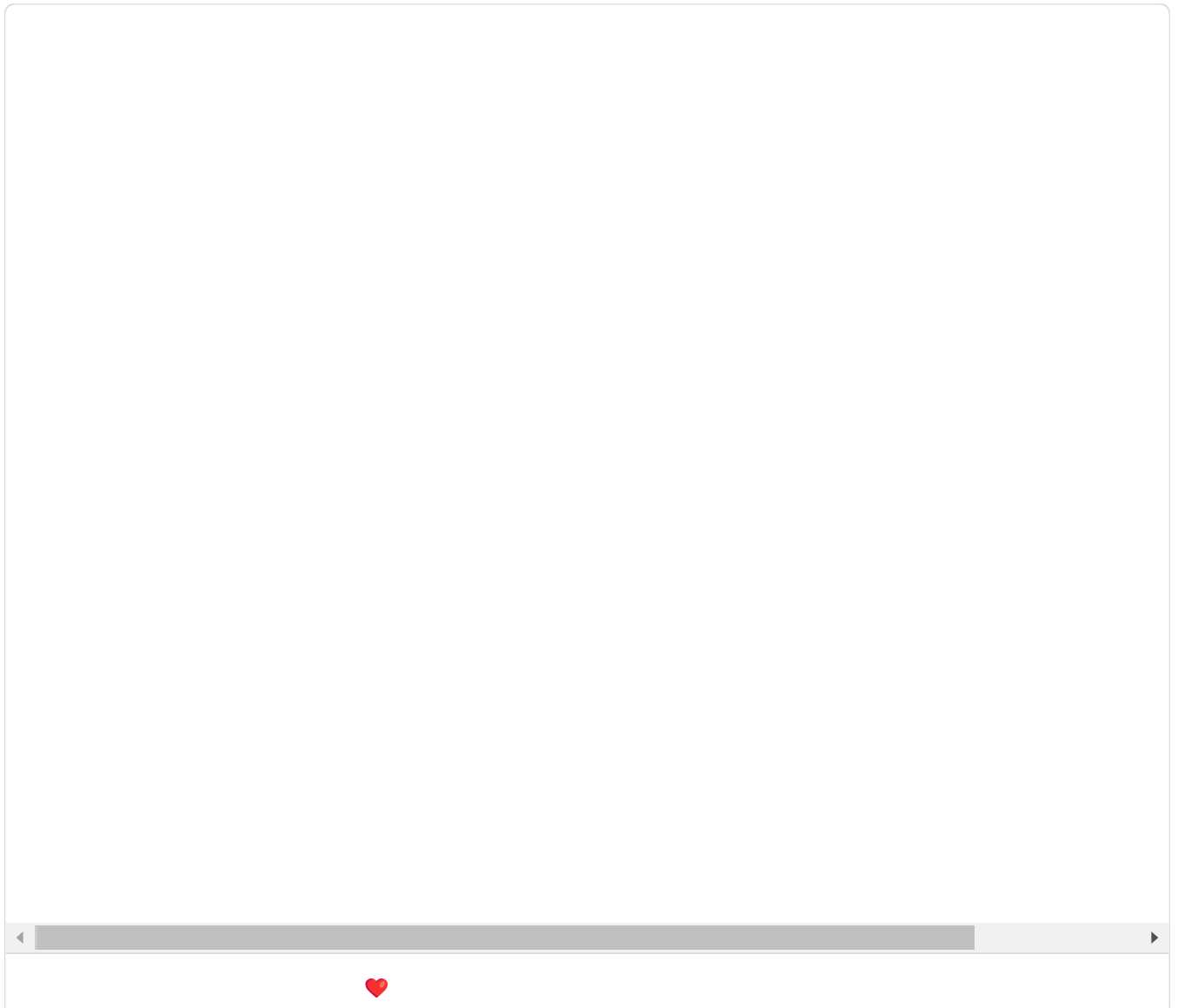
1  public class AuthorityModel
2  {
3      public JObject payload { get; set; }
4      public string token { get; set; }
5  }

```

A ho yCon oll 1



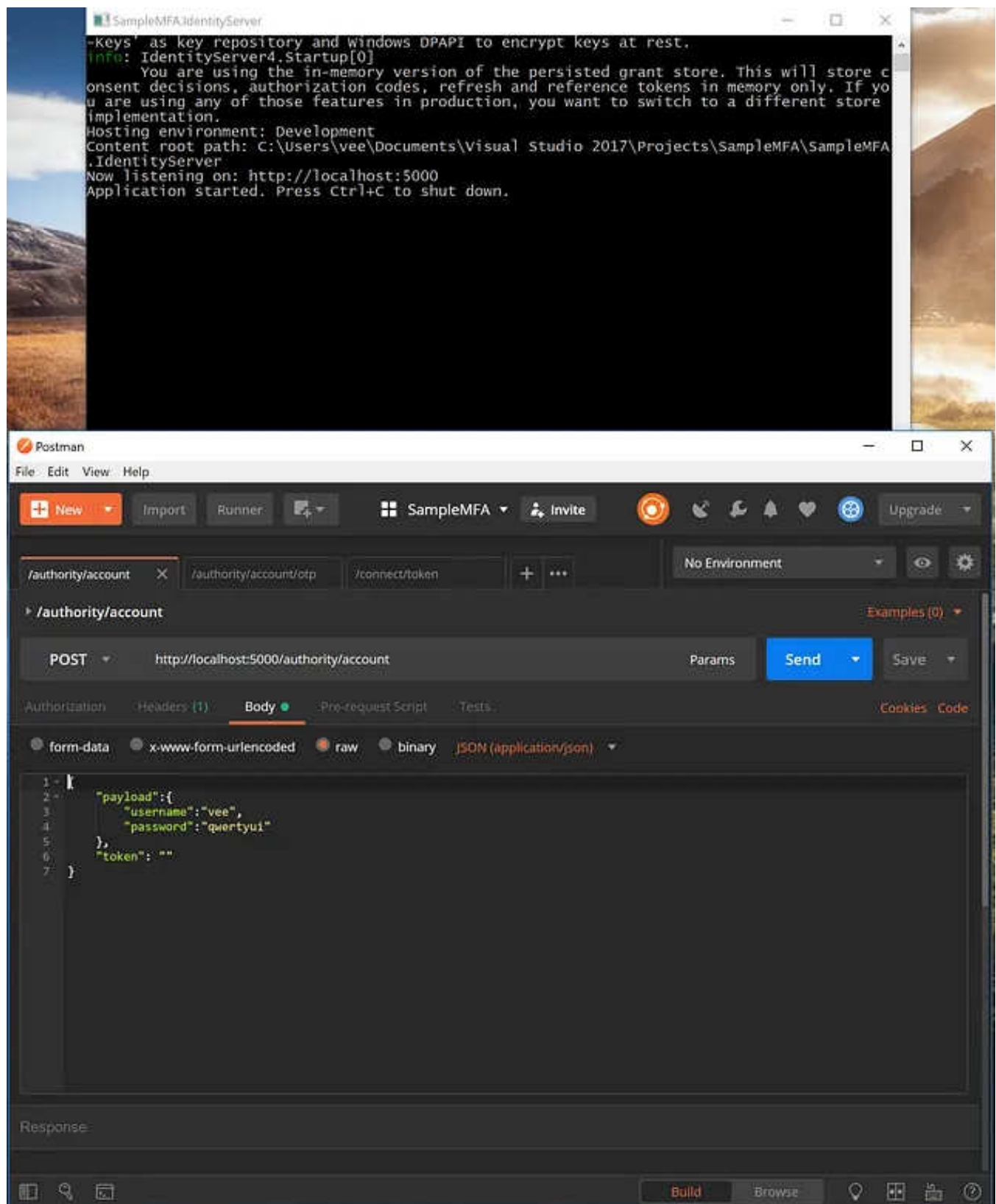
Create the **AuthorityController** class by initializing the Issuer named “owner”, then initialize the **Authority Pipeline** and register **AccountAuthority** and **OTPAuthority**.



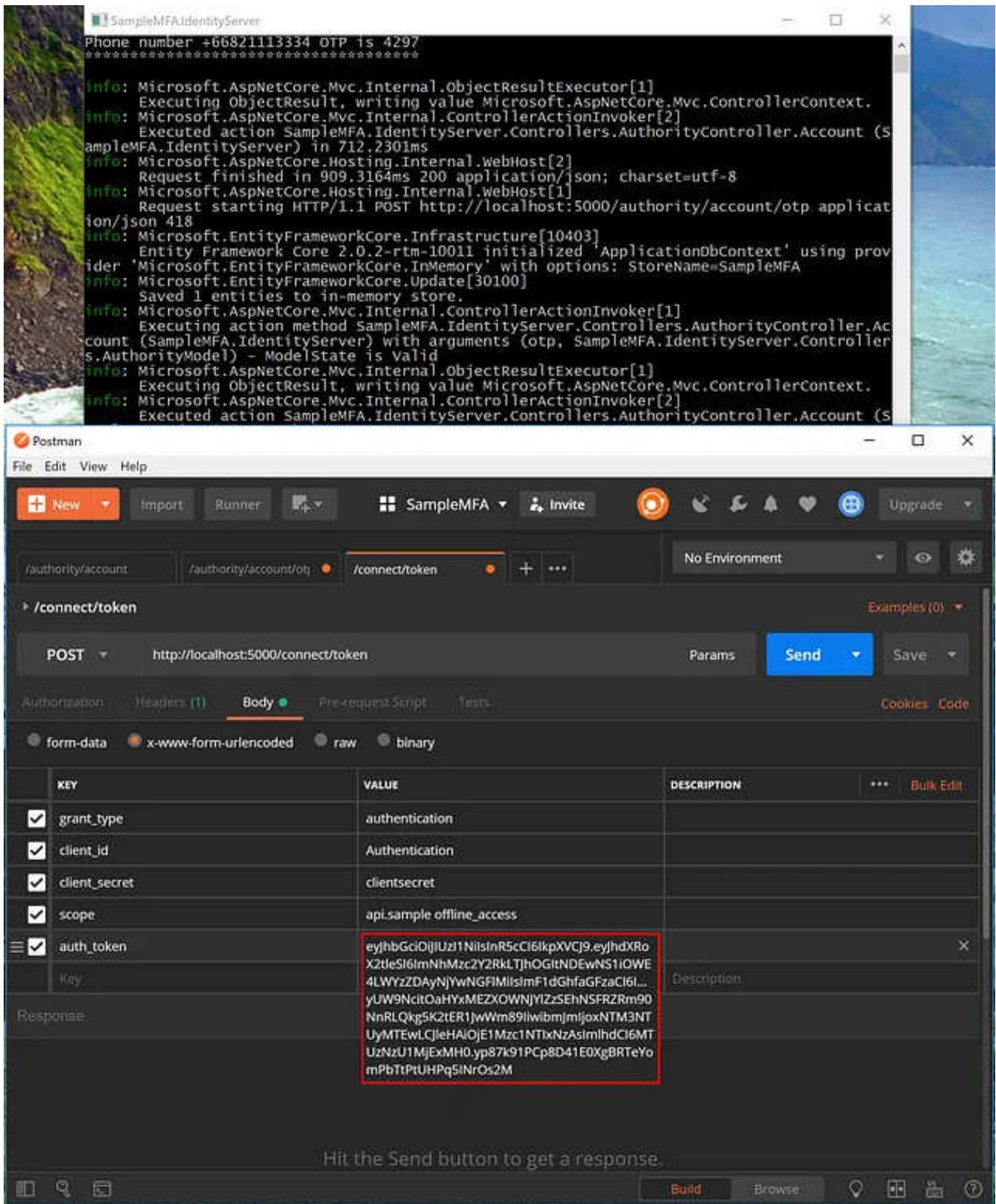
Define remaining method that working with the **Issuer** which manages the Payload / Token in order of Authority.

```
Account(string authority, [FromBody] AuthorityModel model)
```

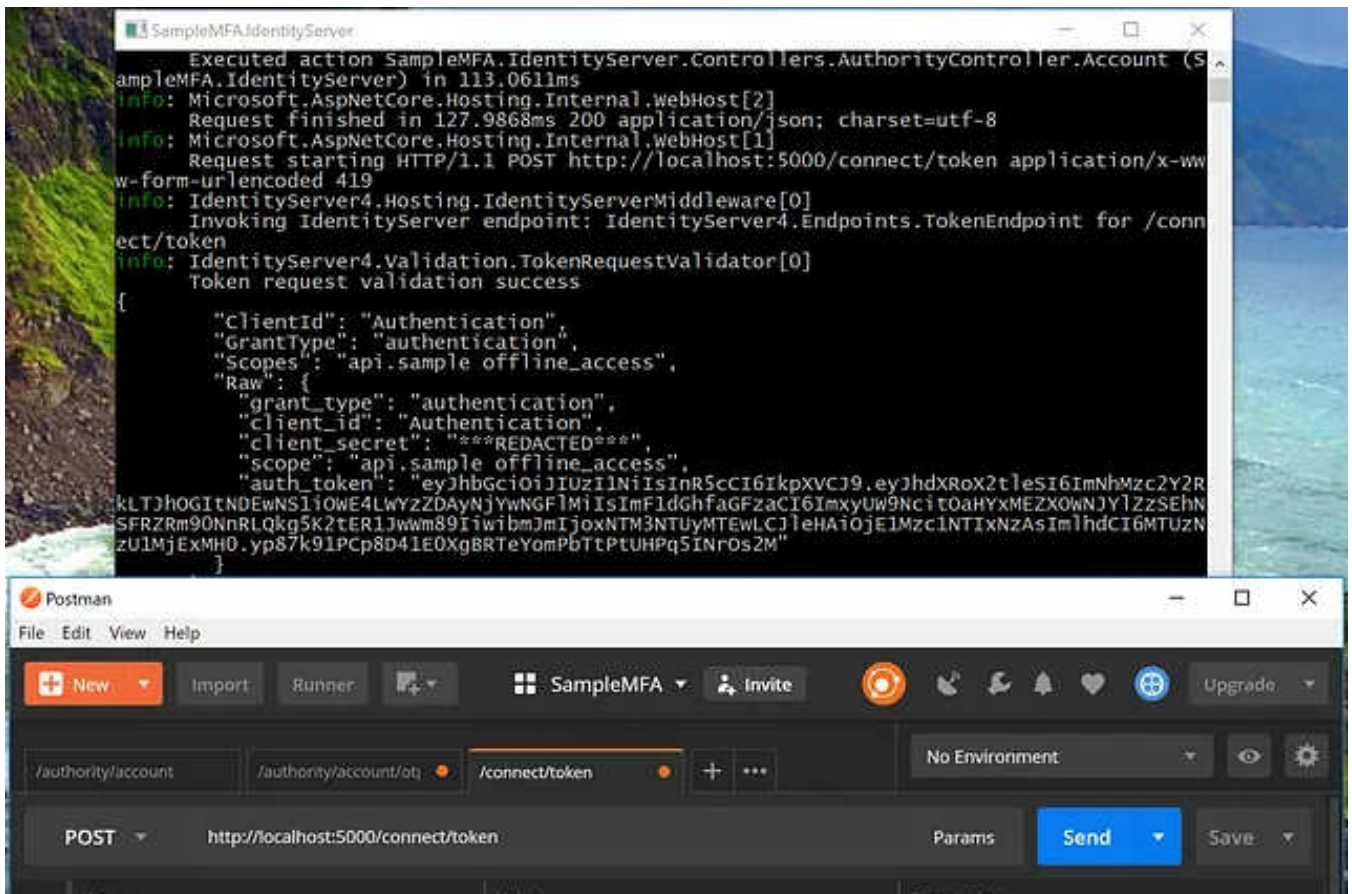

After everything done, let's try it out by running a project and the Postman.



Invoke service with above settings.



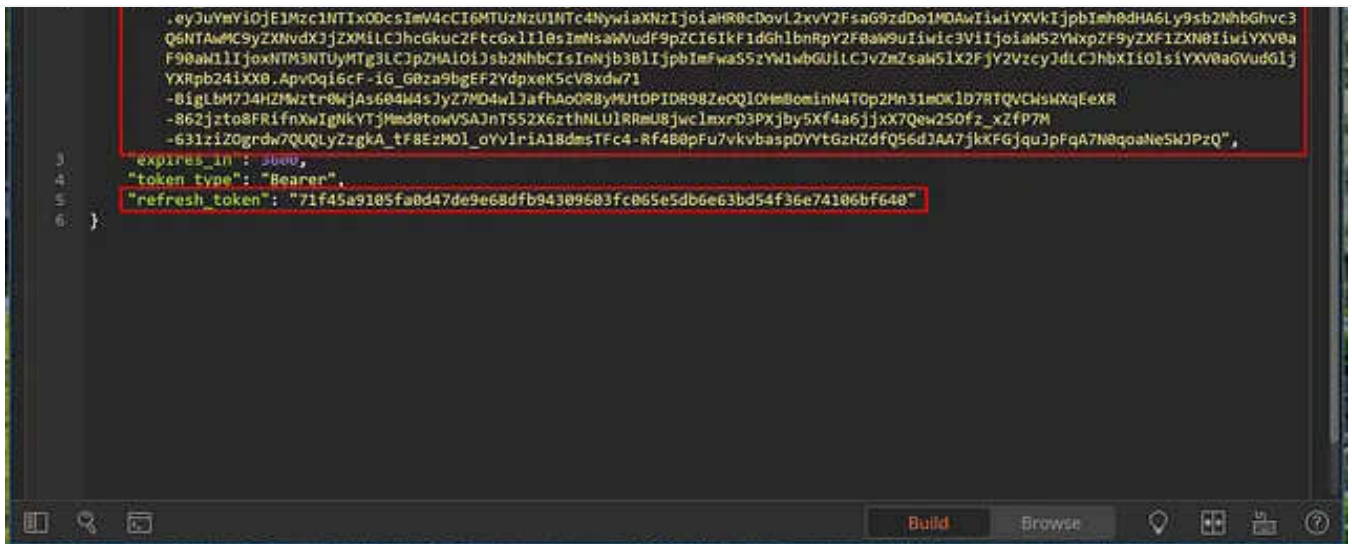
The last step will be access_token with refresh_token for authenticate with the API.



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Many of code not included in this article. GitHub repository is included all of code in this article with project [SampleMFA](#) for anyone interested in implementation details.

This article was created to prove the concept. The application of Identity Server can be different. There are more security, configuration, database topic not included in this article.

Others Chapter

- [Multi-Factor Authentication Design with IdentityServer4 and ASP.NET Core 2.0, Chapter 1](#)
- [Multi-Factor Authentication Design with IdentityServer4 and ASP.NET Core 2.0, Chapter 2](#)

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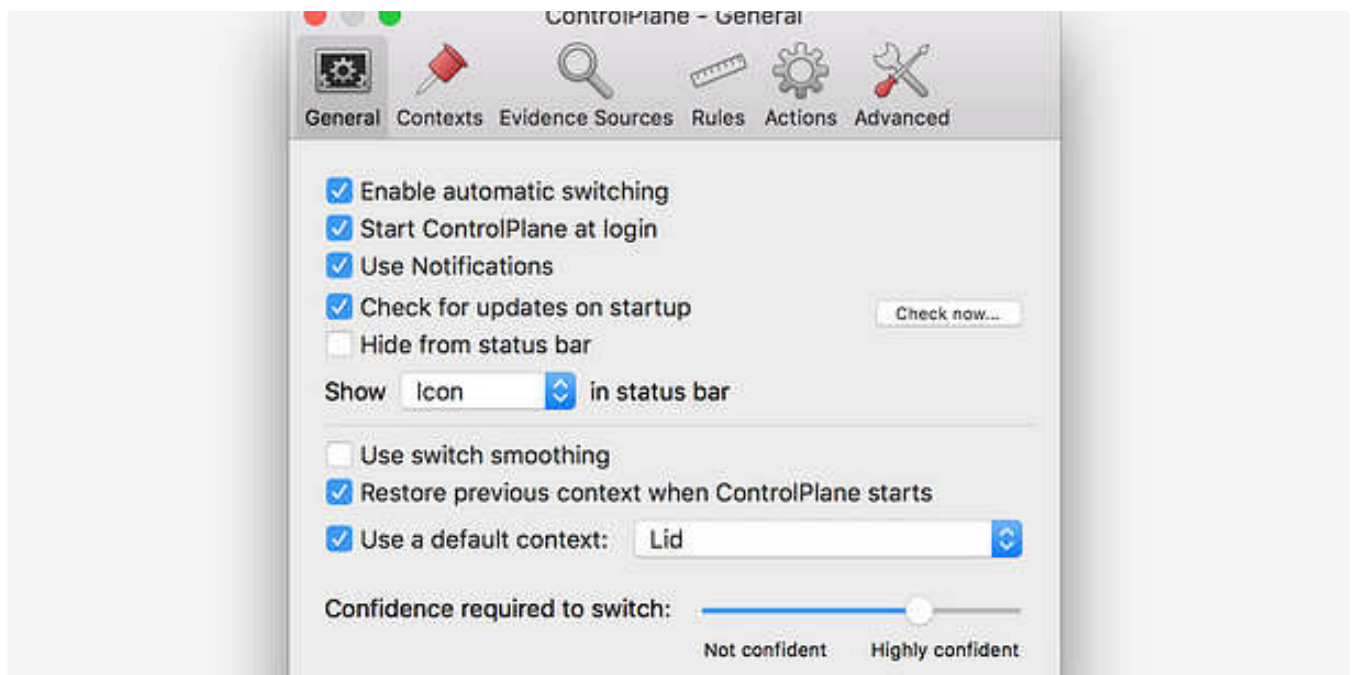
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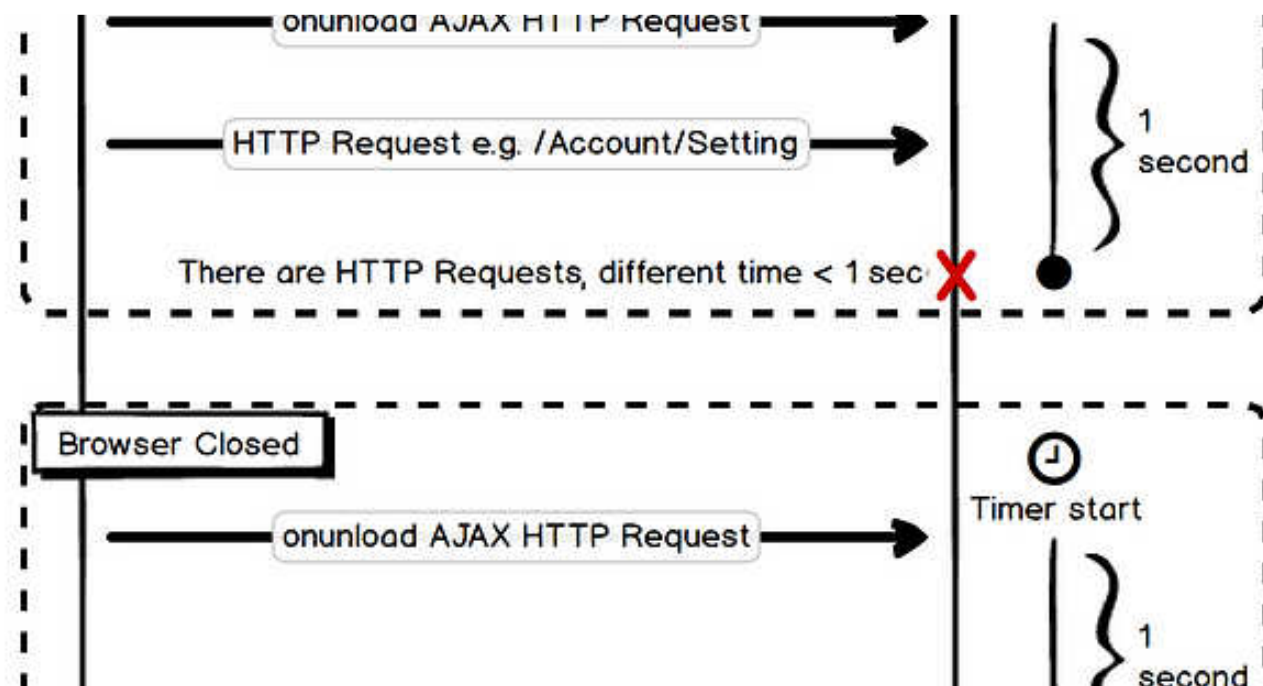
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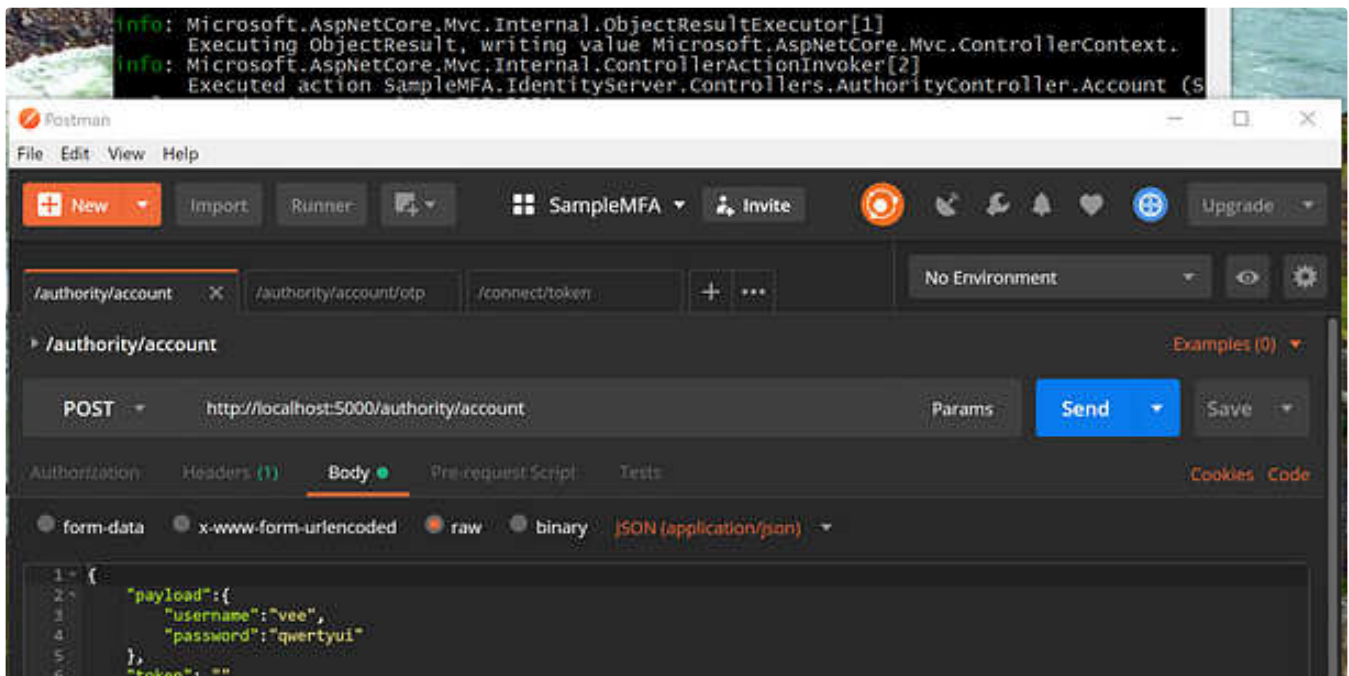
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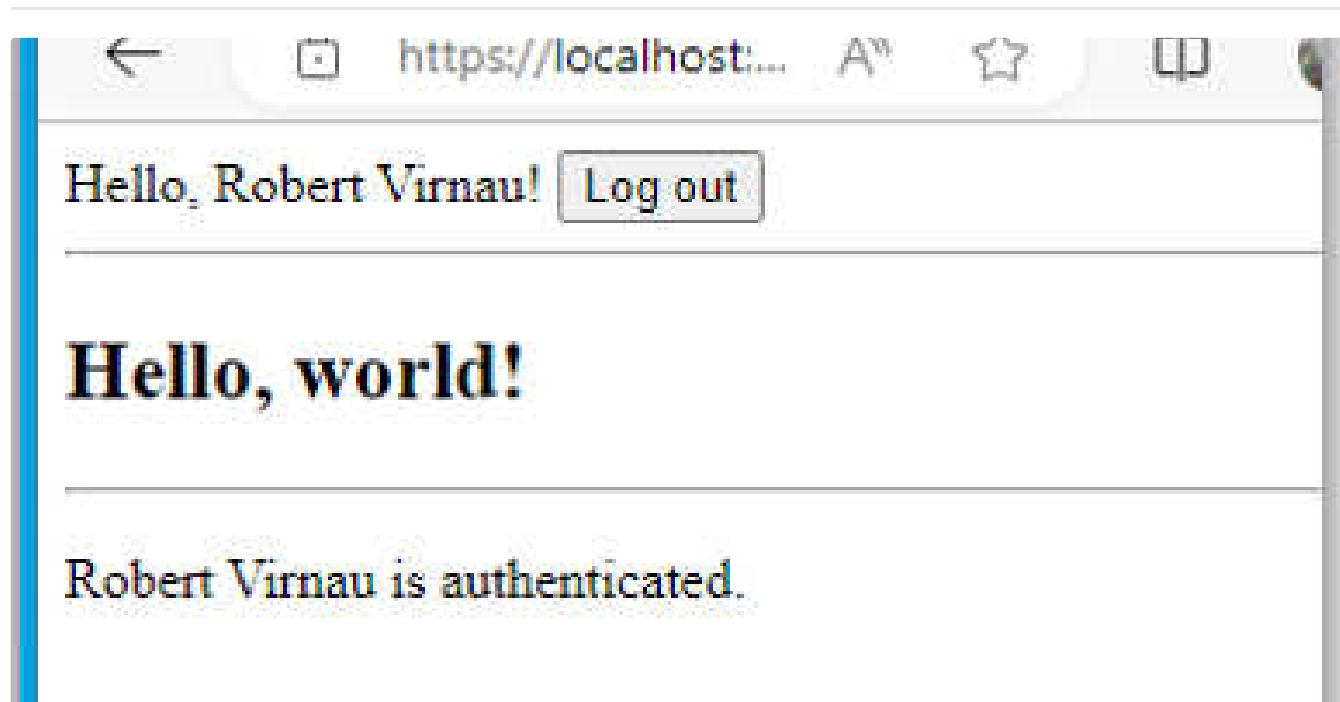
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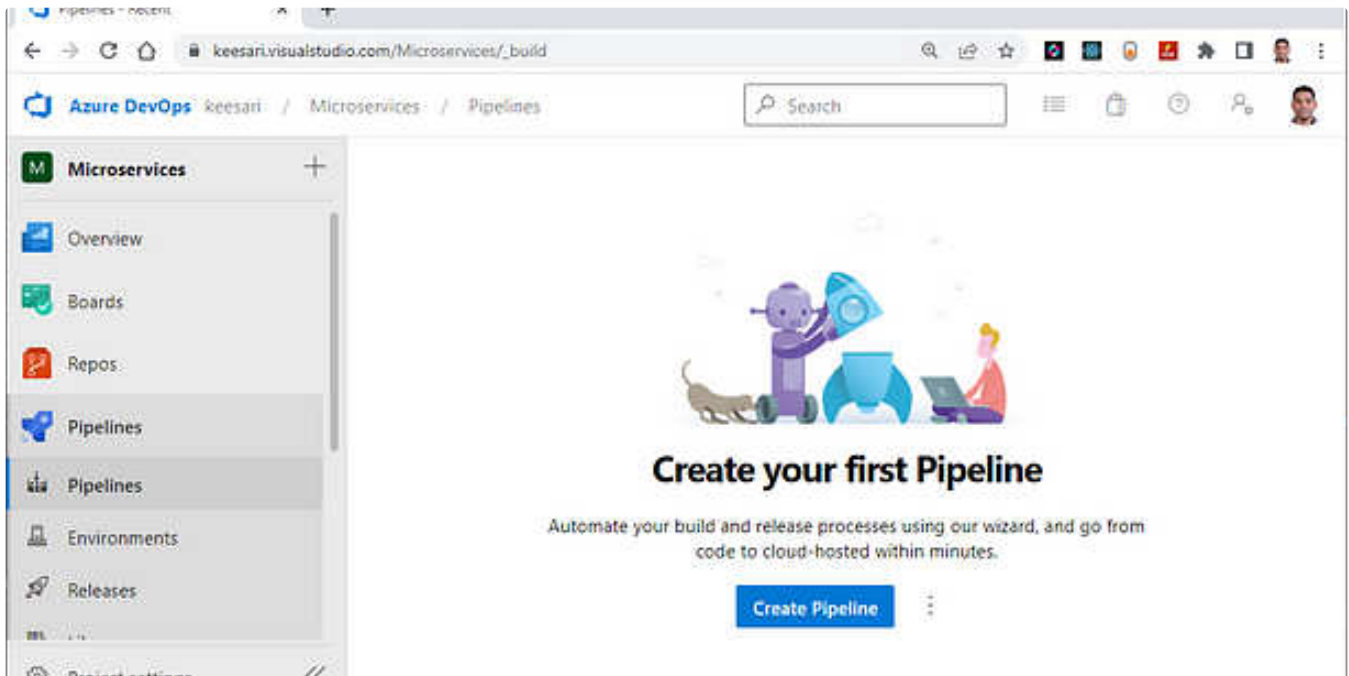
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