# .NET Conf China 2023

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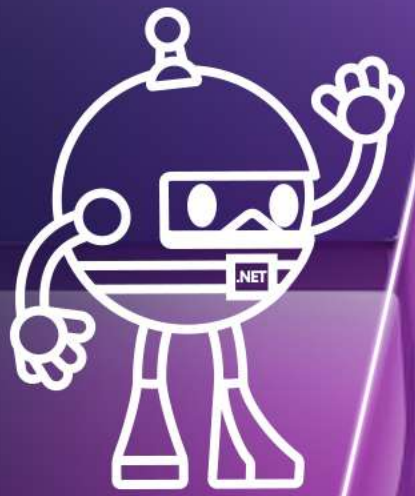
中国・北京



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# .NET Conf China 2023

## 探索 Interceptor 的魔力

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# 目录
AGENDA



# What’s Interceptor

***拦截器*** 是一种可以在 ***编译时*** 以 ***声明方式*** 用对其自身的调用来替换对可拦截方法的调用的 ***方法***。

An ***interceptor*** is a method which can declaratively substitute a call to an interceptable method with a call to itself at compile time.

方法

编译时

声明式

调用替换

# How it intercepts

```
Console.WriteLine("Hello, World!");

namespace InterceptorPlayground.Generated
{
    public static class Generators
    {
        [System.Runtime.CompilerServices.InterceptsLocation(
            @"C:\projects\sources\SamplesInPractice\InterceptorSamples\InterceptorPlayground\Program.cs",
            1,
            9
            )]  // 拦截调用的源位置声明
        public static void ConsoleWriteLineInterceptor(string text)
        {
            Console.WriteLine($"Intercepted: {text}");
        }
    }
}
```

Interceptor 方法

This substitution occurs by having the interceptor declare the source locations of the calls that it intercepts.

这种替换是通过让拦截器声明它拦截的调用的源位置来实现的。

# What happens when compile

Program

```
1   // InterceptorPlayground, Version=1.0.0.0, Culture=neutral, PublicKeyToken=null
2   // Program
3   using ...
5
6   [CompilerGenerated]
7   internal class Program
8   {
9       private static void <Main>$(string[] args)
10      {
11          Generators.ConsoleWriteLineInterceptor("Hello, World!");
12      }
13  }
14
```

```
// Methods
.method private hidebysig static
    void '<Main>$' (
        string[] args
    ) cil managed
{
    // Method begins at RVA 0x2050
    // Header size: 1
    // Code size: 12 (0xc)
    .maxstack 8
    .entrypoint

    // Generators.ConsoleWriteLineInterceptor("Hello, World!");
    IL_0000: ldstr "Hello, World!"
    IL_0005: call void InterceptorPlayground.Generated.Generators::ConsoleWriteLineInterceptor(string)
    // }
    IL_000a: nop
    IL_000b: ret
} // end of method Program::'<Main>$'
```

# Why Interceptor

性 能

AOT

临时测试

AOP

# How to implement an interceptor

```
Console.WriteLine("Hello, World!");

namespace InterceptorPlayground.Generated
{
    public static class Generators
    {
        [System.Runtime.CompilerServices.InterceptsLocation(
            @"C:\projects\sources\SamplesInPractice\InterceptorSamples\InterceptorPlayground\Program.cs",
            1,
            9
            )]  //拦截调用的源位置声明
        public static void ConsoleWriteLineInterceptor
        {
            Console.WriteLine($"Intercepted: {text}");
        }
    }
}
```

```
<PropertyGroup>
  <!-- <Features>InterceptorsPreview</Features> -->
  <InterceptorsPreviewNamespaces>
    $(InterceptorsPreviewNamespaces);InterceptorPlayground.Generated
  </InterceptorsPreviewNamespaces>
</PropertyGroup>
```

```
namespace System.Runtime.CompilerServices
{
    [AttributeUsage(AttributeTargets.Method, AllowMultiple = true)]
    file sealed class InterceptsLocationAttribute(string filePath, int line, int character)
      : Attribute;
}
```

# Must && Limitation

- 只拦截普通方法调用
- 只支持本地代码
  不支持类库内部调用
- 方法签名应一致
- 只支持 C#
  不支持 VB
- 定义在非泛型类型中

## Not Supported

- Constructor 构造方法
- Property 属性
- Operator 操作符
- Delegate 委托
- Local Function 本地函数

# Intercepts instance method

```
[System.Runtime.CompilerServices.InterceptsLocation(
    @"C:\projects\sources\SamplesInPractice\InterceptorSamples\InterceptorPlayground\Program.cs",
    4,
    24
    )]
public static string InstanceMethodInterceptor(this Test test, int age)
{
    return $"Intercepted: {test.Hello(age)}";
}
```

```
var test = new Test();
Console.WriteLine(test.Hello(10));

public class Test
{
    public string Hello(int age)
      => $"Hello, I'm {age} years old";
}
```

# Intercepts extension method

```
[System.Runtime.CompilerServices.InterceptsLocation(
    @"C:\projects\sources\SamplesInPractice\InterceptorSamples\InterceptorPlayground\Program.cs",
    5,
    24
    )]
public static int ExtensionMethodInterceptor(this Test test, int age)
{
    return ++age;
}
```

```
var test = new Test();
Console.WriteLine(test.AgePlusPlus(10));

public class Test
{
}
public static class Extensions
{
    public static int AgePlusPlus(this Test test, int age)
      => age++;
}
```

# Multiple Interception

```
Console.WriteLine("Amazing Interceptor");
Console.WriteLine("Amazing .NET Conf China 2023");

[System.Runtime.CompilerServices.InterceptsLocation(
    @"C:\projects\sources\SamplesInPractice\InterceptorSamples\InterceptorPlayground\Program.cs",
    8,
    9
    )]
[System.Runtime.CompilerServices.InterceptsLocation(
    @"C:\projects\sources\SamplesInPractice\InterceptorSamples\InterceptorPlayground\Program.cs",
    7,
    9
    )]
public static void AmazingConsoleWriteLineInterceptor(string? text)
{
    Console.WriteLine($"Amazing .NET, {text}");
}
```

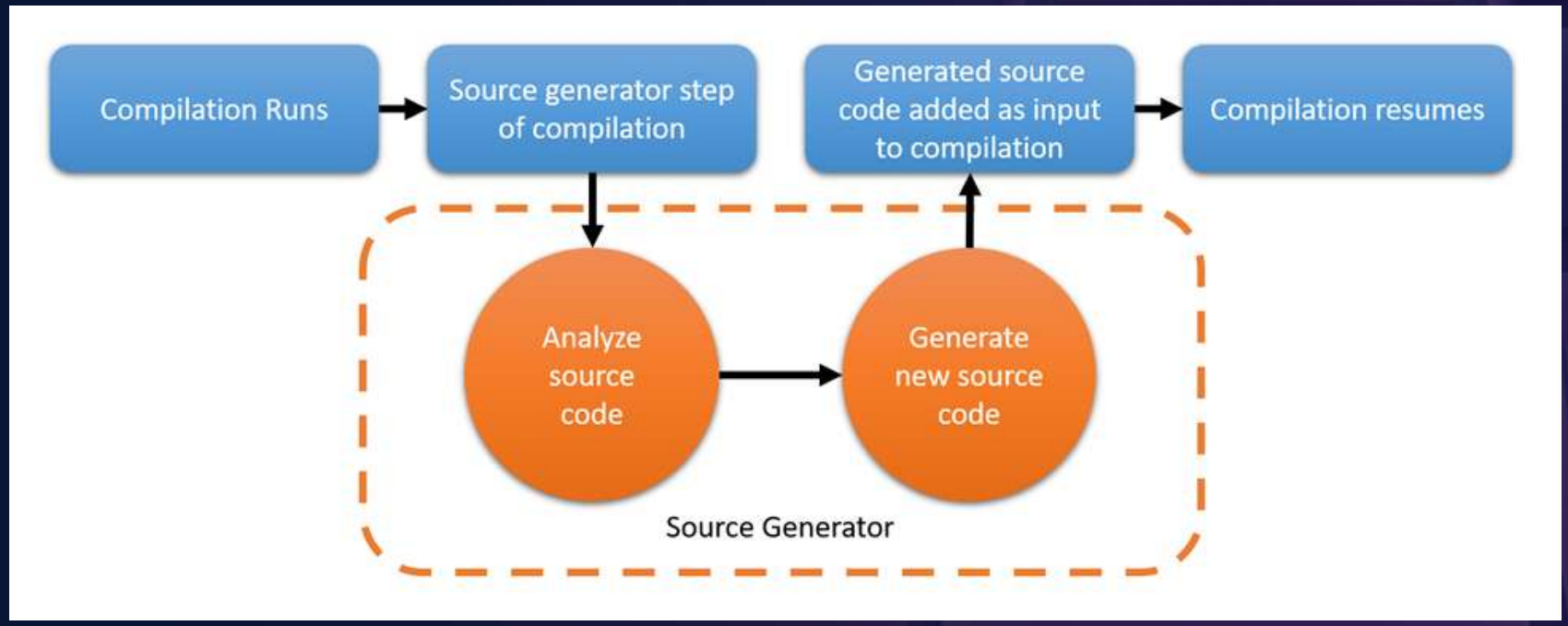
```
Amazing .NET, Amazing Interceptor
Amazing .NET, Amazing .NET Conf China 2023
```

# Source Generator Integration

```
C# Program.cs ×
1 ⟨⟩    Console.WriteLine("Hello, World!");
2
```

```
C:\projects\sources\SamplesInPractice\InterceptorSamples\InterceptorPlayground\Program.cs(28,10): error CS9141: The pro
vided line and character number does not refer to an interceptable method name, but rather to token 'Console'. [C:\proj
ects\sources\SamplesInPractice\InterceptorSamples\InterceptorPlayground\InterceptorPlayground.csproj]

The build failed. Fix the build errors and run again.
```




# Source Generator Integration

```
private static (string, int, int) GetLocation(IInvocationOperation operation)
{
    // The invocation expression consists of two properties:
    // - Expression: which is a `MemberAccessExpressionSyntax` that represents the method being invoked.
    // - ArgumentList: the list of arguments being invoked.
    // Here, we resolve the `MemberAccessExpressionSyntax` to get the location of the method being invoked.
    var memberAccessorExpression = ((MemberAccessExpressionSyntax)((InvocationExpressionSyntax)operation.Syntax).Expression);
    // The `MemberAccessExpressionSyntax` in turn includes three properties:
    // - Expression: the expression that is being accessed.
    // - OperatorToken: the operator token, typically the dot separate.
    // - Name: the name of the member being accessed, typically `MapGet` or `MapPost`, etc.
    // Here, we resolve the `Name` to extract the location of the method being invoked.
    var invocationNameSpan = memberAccessorExpression.Name.Span;
    // Resolve LineSpan associated with the name span so we can resolve the line and character number.
    var lineSpan = operation.Syntax.SyntaxTree.GetLineSpan(invocationNameSpan);
    // Resolve the filepath of the invocation while accounting for source mapped paths.
    var filePath = operation.Syntax.SyntaxTree.GetInterceptorFilePath(operation.SemanticModel?.Compilation.Options.SourceReferenceResolver);
    // LineSpan.LinePosition is 0-indexed, but we want to display 1-indexed line and character numbers in the interceptor attribute.
    return (filePath, lineSpan.StartLinePosition.Line + 1, lineSpan.StartLinePosition.Character + 1);
}
```

```
file static class Extensions
{
    // https://github.com/dotnet/roslyn/blob/main/docs/features/interceptors.md
    // Utilize the same logic used by the interceptors API for resolving the source mapped
    internal static string GetInterceptorFilePath(this SyntaxTree tree, SourceReferenceResolver? resolver) =>
        resolver?.NormalizePath(tree.FilePath, baseFilePath: null) ?? tree.FilePath;
}
```

# Source Generator Integration

```
[Generator(LanguageNames.CSharp)]
public sealed class LoggingGenerator : IIncrementalGenerator
{
    public void Initialize(IncrementalGeneratorInitializationContext context)
    {
        var methodCalls = context.SyntaxProvider.CreateSyntaxProvider(
            predicate: static (node, _) => node is
                InvocationExpressionSyntax
                {
                    Expression: MemberAccessExpressionSyntax
                    {
                        Name:
                        {
                            Identifier:
                            {
                                ValueText: "InterceptableMethod"
                            }
                        }
                    }
                }
            ,
            transform: static (context, token) =>
            {
                var operation = context.SemanticModel.GetOperation(context.Node, token);
                if (operation is IInvocationOperation targetOperation
                    )
                {
                    return new InterceptInvocation(targetOperation);
                }
                return null;
            })
            .Where(static invocation => invocation != null);
            // ...
    }
}
```

# Source Generator Integration

```
var interceptors = methodCalls.Collect()
    .Select((invocations, _) =>
    {
        var stringBuilder = new StringBuilder();
        foreach (var invocation in invocations)
        {
            Debug.Assert(invocation != null);
            var definition = $$"""
[System.Runtime.CompilerServices.InterceptsLocationAttribute(@"{{invocation.Location.FilePath}}", {{invocation.Location.Line}}, {{invocation.Location.Column}})]
public static void LoggingInterceptorMethod(this CSharp12Sample.C c)
{
    System.Console.WriteLine("logging before...");
    c.InterceptableMethod();
    System.Console.WriteLine("logging after...");
}
""";
            stringBuilder.Append(definition);
            stringBuilder.AppendLine();
        }
        return stringBuilder.ToString();
    });
```

```
context.RegisterSourceOutput(interceptors, (ctx, sources) =>
{
    var code = $$"""
//------------------------------------------------------------------------------
// <auto-generated>
//     This code was generated by a tool.
//
//     Changes to this file may cause incorrect behavior and will be lost if
//     the code is regenerated.
// </auto-generated>
//------------------------------------------------------------------------------

namespace System.Runtime.CompilerServices
{
    [AttributeUsage(AttributeTargets.Method, AllowMultiple = true)]
    file sealed class InterceptsLocationAttribute(string filePath, int line, int character) : Attribute;
}

namespace CSharp12Sample.Generated
{
    public static partial class GeneratedLogging
    {
{{sources}}
    }
}
""";
    ctx.AddSource("GeneratedLoggingInterceptor.g.cs", code);
});
```

# Source Generator Integration

```
public InterceptInvocation(IInvocationOperation invocationOperation)
{
    _invocationOperation = invocationOperation;
    _memberAccessExpressionSyntax =
        (MemberAccessExpressionSyntax)((InvocationExpressionSyntax)_invocationOperation.Syntax)
        .Expression;
    MethodName = _memberAccessExpressionSyntax.Name.Identifier.Text;
    AssemblyName = _invocationOperation.TargetMethod.ContainingAssembly.MetadataName;
    ContainingNamespace = _invocationOperation.TargetMethod.ContainingNamespace.GetFullNamespace();
    ContainingTypeName = string.IsNullOrEmpty(ContainingNamespace)
            ? _invocationOperation.TargetMethod.ContainingType.Name
            : $"{ContainingNamespace}.{_invocationOperation.TargetMethod.ContainingType.Name}"
        ;
    IsStaticMethod = _invocationOperation.TargetMethod.IsStatic;
    IsExtensionMethod = _invocationOperation.TargetMethod.IsExtensionMethod;

    Location = GetLocation();
}
```

# Source Generator Integration

```
var interceptors:IncrementalValueProvider<string> = methodCalls.Collect() // IncrementalValueProvider<ImmutableArray<...>>
    .Select((invocations:ImmutableArray<InterceptInvocation?>, _) =>
    {
        var stringBuilder = new StringBuilder();
        foreach (var invocationGroup:IGrouping<{MethodName,ContainingTypeName},...>? in invocations.GroupBy(i:InterceptInvocation? => new
                {
                    i!.MethodName,
                    i.ContainingTypeName
                }))
        {
            foreach (var invocation in invocationGroup)
            {
                Debug.Assert(invocation != null);
                stringBuilder.AppendLine(
$$"""        [System.Runtime.CompilerServices.InterceptsLocationAttribute(@"{{invocation!.Location.FilePath}}", {{invocation.Location.Line}}, {{invocation.Location.Column}})]""");
            }

            var interceptorCode:string =
                (invocationGroup.Key.ContainingTypeName, invocationGroup.Key.MethodName) switch
                {
                    (ContainingTypeName: "Microsoft.Extensions.DependencyInjection.IServiceScopeFactory", MethodName: "CreateScope")
                        => ScopeActivityGeneratedSource.ServiceScopeFactoryCreateScopeInterceptorCode,
                    (ContainingTypeName: "Microsoft.Extensions.DependencyInjection.ServiceProviderServiceExtensions", MethodName: "CreateScope")
                        => ScopeActivityGeneratedSource.ServiceProviderCreateScopeInterceptorCode,
                    (ContainingTypeName: "Microsoft.Extensions.DependencyInjection.ServiceProviderServiceExtensions", MethodName: "CreateAsyncScope")
                        => ScopeActivityGeneratedSource.ServiceProviderCreateScopeAsyncInterceptorCode,
                    _ => throw new ArgumentOutOfRangeException(paramName: $"{invocationGroup.Key.MethodName}")
                };
            stringBuilder.AppendLine(interceptorCode);
            stringBuilder.AppendLine();
        }
        return stringBuilder.ToString().TrimEnd();
```

# Minimal API AOT

```
9
10  [CompilerGenerated]
11  internal class Program
12  {
13      private static void <Main>$(string[] args)
14      {
15          WebApplicationBuilder builder = WebApplication.CreateEmptyBuilder(new WebApplicationOptions());
16          builder.Services.AddRoutingCore();
17          builder.WebHost.UseKestrelCore();
18          WebApplication app = builder.Build();
19          app.UseRouting();
20          app.UseEndpoints(delegate(IEndpointRouteBuilder endpoints)
21          {
22              endpoints.MapGet("/", (Func<string>)(() => "Hello World"));
```

```
public static Microsoft.AspNetCore.Builder.RouteHandlerBuilder Microsoft.AspNetCore.Builder.EndpointRouteBuilderExtensions.MapGet(this Microsoft.AspNetCore.Routing.IEndpointRouteBuilder endpoints, string pattern, System.Delegate handler)
```

```
dotnet build -p PublishAot=false # without AOT
```

```
11  [CompilerGenerated]
12  internal class Program
13  {
14      private static void <Main>$(string[] args)
15      {
16          WebApplicationBuilder builder = WebApplication.CreateEmptyBuilder(new WebApplicationOptions());
17          builder.Services.AddRoutingCore();
18          builder.WebHost.UseKestrelCore();
19          WebApplication app = builder.Build();
20          app.UseRouting();
21          app.UseEndpoints(delegate(IEndpointRouteBuilder endpoints)
22          {
23              endpoints.MapGet0("/", (Func<string>)(() => "Hello World"));
```

```
internal static Microsoft.AspNetCore.Builder.RouteHandlerBuilder Microsoft.AspNetCore.Http.Generated.<GeneratedRouteBuilderExtensions_g>F69328E0708B4B584C5AACA22FE2C51A1CF192D6622828F613FC57C583CA77B63__GeneratedRouteBuilderExtensionsCore.MapGet0(this
Microsoft.AspNetCore.Routing.IEndpointRouteBuilder endpoints, string pattern, System.Delegate handler)
```

```
dotnet build -p PublishAot=true # with AOT
```

# Minimal API AOT

```
namespace System.Runtime.CompilerServices
{
    [System.CodeDom.Compiler.GeneratedCodeAttribute("Microsoft.AspNetCore.Http.RequestDelegateGenerator, Version=8.0.0.0, Culture=neutral, PublicKeyToken=adb9793829ddae
    [AttributeUsage(AttributeTargets.Method, AllowMultiple = true)]
    2 references
    file sealed class InterceptsLocationAttribute : Attribute
    {
        1 reference
        public InterceptsLocationAttribute(string filePath, int line, int colum
        {
        }
    }
}

namespace Microsoft.AspNetCore.Http.Generated
{
    using System;

    [System.CodeDom.Compiler.GeneratedCodeAttribute("Microsoft.AspNetCore.Http.RequestDelegateGenerator, Version=8.0.0.0, Culture=neutral, PublicKeyToken=adb9793829ddae
    2 references
    file static class GeneratedRouteBuilderExtensionsCore
    {
        1 reference
        private static readonly JsonOptions FallbackJsonOptions = new();
        1 reference
        private static readonly string[] GetVerb = new[] { global::Microsoft.AspNetCore.Http.HttpMethods.Get };

        [InterceptsLocation(@"C:\projects\sources\SamplesInPractice\AotTest\AplAotSample\Program.cs", 11, 15)]
        0 references
        internal static RouteHandlerBuilder MapGet0(
            this IEndpointRouteBuilder endpoints,
            [StringSyntax("Route")] string pattern,
            Delegate handler)
        {
            MetadataPopulator populateMetadata = (methodInfo, options) =>
            {
                Debug.Assert(options != null, "RequestDelegateFactoryOptions not found.");
                Debug.Assert(options.EndpointBuilder != null, "EndpointBuilder not found.");
                options.EndpointBuilder.Metadata.Add(new System.CodeDom.Compiler.GeneratedCodeAttribute("Microsoft.AspNetCore.Http.RequestDelegateGenerator, Version=8.
                options.EndpointBuilder.Metadata.Add(new ProducesResponseTypeMetadata(statusCode: StatusCodes.Status200OK, contentTypes: GeneratedMetadataConstants.Plai
                return new RequestDelegateMetadataResult { EndpointMetadata = options.EndpointBuilder.Metadata.AsReadOnly() };
            };
            RequestDelegateFactoryFunc createRequestDelegate = (del, options, inferredMetadataResult) =>
            return MapCore(
                endpoints,
                pattern,
                handler,
                GetVerb,
```

```
# aot and emit generated files
dotnet build -p PublishAot=true -p EmitCompilerGeneratedFiles=true
```

# Minimal API AOT

```
var app = WebApplication.CreateSlimBuilder().Build();

app.Map("/", () => "Hello world").ShortCircuit();
app.MapRuntimeInfo().ShortCircuit();

app.Run();
```

```
app.Map0("/", (Func<string>)(() => "Hello world")).ShortCircuit();
app.MapRuntimeInfo().ShortCircuit();
```

```
8   public static IEndpointConventionBuilder MapRuntimeInfo(this IEndpointRouteBuilder endpointRouteBuilder, string path = "/runtime-info")
9   {
10      ArgumentNullException.ThrowIfNull(endpointRouteBuilder, "endpointRouteBuilder");
11      return endpointRouteBuilder.MapGet(path, (Func<RuntimeInfo>)(() => ApplicationHelper.RuntimeInfo));
```

```
public static Microsoft.AspNetCore.Builder.RouteHandlerBuilder Microsoft.AspNetCore.Builder.EndpointRouteBuilderExtensions.MapGet(this Microsoft.AspNetCore.Routing.IEndpointRouteBuilder endpoints, string pattern, System.Delegate handler)
```

# Minimal API AOT

| Name | Date modified | Type | Size |
|---|---|---|---|
| ApiAotSample.exe | 12/10/2023 09:10 | Application | 6,672 KB |
| ApiAotSample.pdb | 12/10/2023 09:10 | Program Debug Database | 59,980 KB |
| appsettings.Development.json | 11/29/2023 10:25 | JSON File | 1 KB |
| appsettings.json | 11/29/2023 10:25 | JSON File | 1 KB |

PowerShell

```
PowerShell 7.4.0
Loading personal and system profiles took 511ms.
PS C:\projects\sources\SamplesInPractice\AotTest\ApiAotSample\out> .\ApiAotSample.exe
```

PowerShell

```
PowerShell 7.4.0
PS C:\projects\sources\SamplesInPractice\AotTest\ApiAotSample> cat .\Program.cs
var builder = WebApplication.CreateEmptyBuilder(new WebApplicationOptions());
builder.Services.AddRoutingCore();
builder.WebHost.UseKestrelCore();
// builder.Logging.AddConsole();

var app = builder.Build();

app.UseRouting();
app.UseEndpoints(endpoints =>
{
    endpoints.MapGet("/", () => "Hello World");
});

app.Run();
PS C:\projects\sources\SamplesInPractice\AotTest\ApiAotSample> dotnet-http :5000/
HTTP/1.1 200 OK
Content-Type: text/plain; charset=utf-8
Date: Sun, 10 Dec 2023 01:14:00 GMT
Server: Kestrel
Transfer-Encoding: chunked
```

# References


- https://github.com/dotnet/roslyn/blob/main/docs/features/interceptors.md
- https://github.com/dotnet/csharplang/issues/7009
- https://github.com/WeihanLi/SamplesInPractice/blob/main/CSharp12Sample/InterceptorSample.cs
- https://github.com/WeihanLi/SamplesInPractice/blob/main/InterceptorSamples
- https://andrewlock.net/exploring-the-dotnet-8-preview-changing-method-calls-with-interceptors/
- https://github.com/dotnet/aspnetcore/blob/main/src/Http/Http.Extensions/gen/RequestDelegateGenerator.cs
- https://github.com/DapperLib/DapperAOT
- https://code-maze.com/how-to-use-interceptors-in-c-12/


# Thank You

*Keep Coding*