Deep Dive into C# Interfaces

Things you might not have thought about

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Features You May Not Have Thought About

- Default Implementation
  - Methods, Properties, Events, and Indexers
- Access Modifiers
  - public, private, protected, internal, etc.
- Static Members
  - Methods, Fields, Constructors
- Abstract Members
- Partial Interfaces
- Static Main
- Static Abstract Members

Here There Be Dragons

You might choose not to use these features, but you may encounter them in the libraries you use.

Default Implementation

```
public interface ILogger
{
    void Log(LogLevel level, string message);

    void LogException(Exception ex)
    {
        Log(LogLevel.Error, ex.ToString());
    }
}
```

Default Implementation

```
public interface ILogger
{
    void Log(LogLevel level, string message);

    void LogException(Exception ex)
    {
        Log(LogLevel.Error, ex.ToString());
    }
}
```

MORE THAN JUST THIS

Interface

Defines a contract

Implement any number of interfaces

Limited implementation code

No automatic properties

- Properties
- Methods
- Events
- Indexers

Abstract Class

Shared Implementation

Inherit from a single base class

Unconstrained implementation code

Can have automatic properties

- Properties
- Methods
- Events
- Indexers
- Fields
- Constructors
- Destructors

What is an Interface?

An interface describes a set of capabilities of an object.

Features

- Default Implementation
  - Methods, Properties, Events, and Indexers
- Access Modifiers
  - public, private, protected, internal, etc.
- Static Members
  - Methods, Fields, Constructors
- Abstract Members
- Partial Interfaces
- Static Main
- Static Abstract Members

Default Method Implementation

```
public interface ILogger
{
    void Log(LogLevel level, string message);

    void LogException(Exception ex)
    {
        Log(LogLevel.Error, ex.ToString());
    }
}
```

/DefaultImplementation/ILogger.cs

Recommendation

When calling interface members, use the interface type.

Calling a Default Method Implementation

- Must be called using the interface type
- The class type will not work
- "var" will not work

```
var ex = new InvalidOperationException();
ILogger logger1 = new InitialLogger();
logger1.LogException(ex); // calls default

InitialLogger logger2 = new InitialLogger();
logger2.LogException(ex); // compiler error

var logger3 = new InitialLogger();
logger3.LogException(ex); // compiler error
```

Replacing a Default Implementation

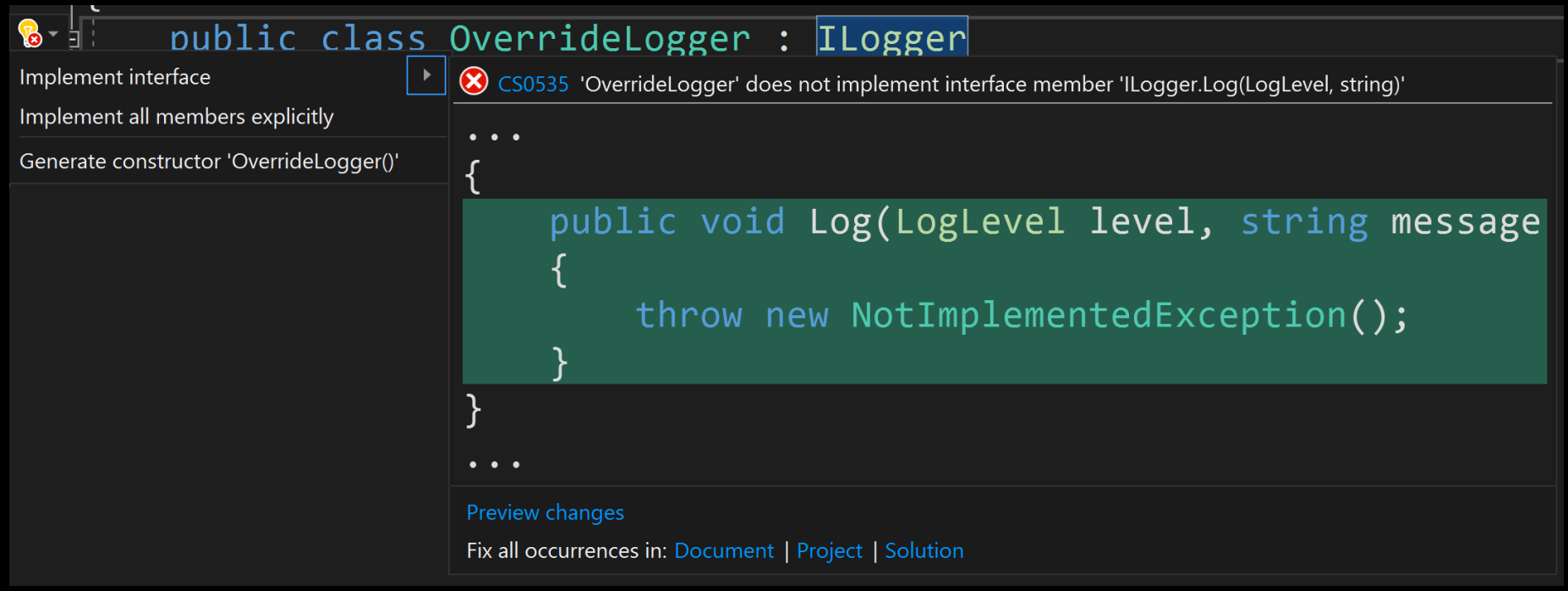
- Implementing class can provide its own implementation

```
public class JeremyLogger : ILogger
{
    public void Log(LogLevel level, string message)
    {
        Console.WriteLine($"JeremyLogger Level - {level:F}: {message}");
    }

    public void LogException(Exception ex)
    {
        Log(LogLevel.Error, $"From JeremyLogger: {ex.Message}");
    }
}
```

Visual Studio Tooling Quirk

- Visual Studio 2022 does not include interface members with default implementation in the "Implement interface" shortcut.



Calling an Implemented Interface Member

- The most specific method is always called (meaning, the default implementation is ignored if a class has a public implementation).

```
ILogger logger1 = new JeremyLogger();
logger1.LogException(ex);

JeremyLogger logger2 = new JeremyLogger();
logger2.LogException(ex);

var logger3 = new JeremyLogger();
logger3.LogException(ex);
```

Explicit Implementation

```
public class ExplicitLogger : ILogger
{
    void ILogger.Log(LogLevel level, string message)
    {
        Console.WriteLine($"Level - {level:F}: {message}");
    }

    void ILogger.LogException(Exception ex)
    {
        Console.WriteLine($"Level - {LogLevel.Error}: {ex.Message}");
    }
}
```

/DefaultImplementation/ExplicitLogger.cs

```
public class ExplicitLogger : ILogger
{
    void ILogger.Log(LogLevel level, string message)
    {
        Console.WriteLine($"Level - {level:F}: {message}");
    }

    void ILogger.LogException(Exception ex)
    {
        Console.WriteLine($"Level - {LogLevel.Error}: {ex.Message}");
    }
}
```

Explicit Implementation

```
ILogger logger1 = new ExplicitLogger();
logger1.Log(LogLevel.Info, "Hello"); // calls method

ExplicitLogger logger2 = new ExplicitLogger();
logger2.Log(LogLevel.Info, "Hello"); // compiler error

var logger3 = new ExplicitLogger();
logger3.Log(LogLevel.Info, "Hello"); // compiler error
```

Default implementation is called the same way as explicit implementation

```
var ex = new InvalidOperationException();
ILogger logger1 = new InitialLogger();
logger1.LogException(ex); // calls default

InitialLogger logger2 = new InitialLogger();
logger2.LogException(ex); // compiler error

var logger3 = new InitialLogger();
logger3.LogException(ex); // compiler error
```

Confused Yet?

If a class does *NOT* provide an implementation…

- Using the interface type, the default is called.
- Using the class type, the code does not compile.
- Using "var", the code does not compile.

If the class *DOES* provide an implementation…

- Using the interface type, the class method is called.
- Using the class type, the class method is called.
- Using "var", the class method is called.

Recommendation

When calling interface members, use the interface type.

What is an Interface?

- An interface describes a set of capabilities of an object.
- The capabilities might not be directly exposed (example: explicitly implemented interface members).
- An object may only have the capabilities if it is referenced the right way (i.e., by the interface type rather than the class type).
- A default implementation is called the same way as an explicit implementation.

Be Careful of Assumptions

- What's wrong with the following interface?

```
public interface IFileHandler
{
    void Delete(string filename);


}
```

- Answer: It makes assumptions about the IFileHandler implementers (specifically that they use System.IO.File objects).

/DangerousAssumptions/BadInterface/IFileHandler.cs

Recommendation

Default implementations should only reference other interface members.

Be Careful of Assumptions

- What's wrong with the following interface?

```
public interface IReader<T>
{
    IReadOnlyCollection<T> GetItems();
    T GetItemAt(int index) => GetItems().ElementAt(index);
}
```

- Answer: It assumes that using an iterator is okay. If "GetItems" returns a large collection, this could cause memory pressure. If the "Get" operation is slow (for example a large calculation), then getting the entire list to pull out a single item is inefficient.

/DangerousAssumptions/SlowPerformance/IReader.cs

Recommendation

Know the capabilities of your mocking framework.

Unit Testing & Mocks

Many mocking frameworks do not support testing default implementation.

- Supported
  - **Moq**
  - **Rocks**
- Not Supported
  - **FakeItEasy**
    (open issue: https://github.com/FakeItEasy/FakeItEasy/issues/1633)
  - **NSubstitute**

```
public interface IRegularPolygon
{
    int NumberOfSides { get; }
    int SideLength { get; set; }

    double GetPerimeter() => NumberOfSides * SideLength;
    double GetArea();
}
```

Example: FakeItEasy

```
[Test]
0 references
public void FakeItEasy_CheckDefaultImplementation()
{
    var mock = A.Fake<IRegularPolygon>();
    A.CallTo(() => mock.NumberOfSides).Returns(3);
    A.CallTo(() => mock.SideLength).Returns(5);

    double result = mock.GetPerimeter();

    Assert.AreEqual(15.0, result);
}
```

- Test Fails: Since "GetPerimeter" is not set up on the mock object, FakeItEasy uses its own default behavior for a mock object (which is to return "0.0" for a method returning a double).

/UnitTests.Tests/IRegularPolygonTests.cs

```
public interface IRegularPolygon
{
    int NumberOfSides { get; }
    int SideLength { get; set; }

    double GetPerimeter() => NumberOfSides * SideLength;
    double GetArea();
}
```

Example: Moq

```
[Test]
public void Moq_CheckDefaultImplementation()
{
    var mock = new Mock<IRegularPolygon>();
    mock.CallBase = true;
    mock.SetupGet(m => m.NumberOfSides).Returns(3);
    mock.SetupGet(m => m.SideLength).Returns(5);

    double result = mock.Object.GetPerimeter();

    Assert.AreEqual(15.0, result);
}
```

- Test Succeeds: “CallBase = true” will call the “GetPerimeter” default implementation from the interface.

/UnitTests.Tests/IRegularPolygonTests.cs

Recommendation

Know the capabilities of your mocking framework.

Observation

Default implementation is good for calculated properties.

(And not much else for properties.)

Default Property Implementation

- Good for calculated properties (getters)

```
public interface IRegularPolygon
{
    int NumberOfSides { get; }
    int SideLength { get; set; }

    double Perimeter { get => NumberOfSides * SideLength; }
```

/InterfaceProperties/Interface/IRegularPolygon.cs

Default Property Implementation

- Read/Write Properties must have default implementation for both "get" and "set"… *

```
int NotAllowed
{
    get => 20;
    set;
}
```

```
int AlsoNotAllowed
{
    get;
    set { }
}
```

*See caveat on next slide

/InterfaceProperties/BadInterface/IBadInterface.cs

Default Property Implementation

- Default implementation doesn't really make sense for "set" (there's no way to have a backing field).
- Things like this cause a StackOverflow:

```
int BadMember
{
    get => 1;
    set { BadMember = value; }
}
```

/InterfaceProperties/BadInterface/IBadInterface.cs

Default Property Implementation

- Default implementation **cannot** be used to specify an automatic property.
- The following interface properties are normal (abstract) interface members:

```
public interface IRegularPolygon
{
    int NumberOfSides { get; }
    int SideLength { get; set; }
```

/InterfaceProperties/Interface/IRegularPolygon.cs

What about the new `field` keyword?

- In C# 14 (now in preview), the `field` keyword refers to an auto-created backing field.

```
public int SideLength
{
    get => field;
    set => field = value;
}
```

- Unfortunately, you **cannot use `field` in an interface** (since fields are part of an instance).

Observation

Default implementation is good for calculated properties.

(And not much else for properties.)

Access Modifiers

All access modifiers are allowed on interface members.

Note: This was not well advertised, and there is still a lot of incorrect information out out there.

Access Modifiers

All access modifiers are (technically) allowed

- `public` is default
- `private` has limited usefulness

DANGER
- `protected` and `internal` are undefined

Access Modifiers - Public

- Default access modifier is `public` for interfaces.
- The following interface members are both `public`:

```
public interface ICustomerReader
{
    IReadOnlyCollection<Customer> GetCustomers();
    public Customer GetCustomer(int Id);
}
```

/AccessModifiers/Public/ICustomerReader.cs

Access Modifiers - Private

- `private` members can only be accessed within the interface.
- `private` members must have a default implementation.

```
private int DirectDistance((int, int) point1, (int, int) point2)
{
    (int x1, int y1) = point1;
    (int x2, int y2) = point2;
    return (x1 - x2) + (y1 - y2);
}
1 reference
private int CubeIt(int x) => x * x * x;
1 reference
private int FlipSign(int x) => x * -1;
```

*Note: This sample is a bit contrived to show that "`private`" members must have implementation

/AccessModifiers/Private/IDistanceCalculator.cs

Access Modifiers - Private

- "private" members can be used to break up larger default implementation methods.
- Example, if a "public" method has a complex default implementation, it can be split up into smaller "private" methods inside the interface.

My Opinion: If code inside an interface is complex enough that it requires this type of factoring, maybe it is not appropriate for it to be part of an interface.

Access Modifiers - Protected

- Behavior of protected / internal members is undefined in the language specification.
- But the compiler does not stop you from using protected / internal access modifiers.

My Opinion: Stick with "public" and "private" members.

Static Methods

- Interface "static" methods are just like "static" methods on a class.
- The following are equivalent:

```
public class ReaderFactory
{
    private static IPeopleReader savedReader;
    public static Type readerType =
        typeof(HardCodedPeopleReader);

    public static IPeopleReader GetReader()
    {
        Implementation details

        return savedReader;
    }
}
```

```
public interface IReaderFactory
{
    private static IPeopleReader savedReader;
    public static Type readerType =
        typeof(HardCodedPeopleReader);

    public static IPeopleReader GetReader()
    {
        Implementation details

        return savedReader;
    }
}
```

/StaticMembers/Factories

Static Main

"static Main()" is the entry point to an application.

- This is a valid console application (just this file):

```
namespace StaticMain;

public interface IHelloWorld
{
    static void Main(string[] args)
    {
        if (args?.Length == 0)
            Console.WriteLine("Hello, World!");
        else
            Console.WriteLine($"Hello, {args![0]}!");
    }
}
```

/StaticMain/IHelloWorld.cs

Static Fields

- "static" fields on an interface are just like "static" fields on a class.
- A static field is a shared value; it is associated with the interface rather than any particular instance.

Static Fields as Parameters

- "static" fields can be used to parameterize a default implementation.

- See Microsoft Learn example: https://learn.microsoft.com/en-us/dotnet/csharp/advanced-topics/interface-implementation/default-interface-methods-versions#provide-parameterization

Abstract Members

- A member can be marked "abstract"
- “abstract” is the default.
- The following properties are both abstract:

```
public interface ICustomerReader
{
    IReadOnlyCollection<Customer> GetCustomers();
    abstract Customer GetCustomer(int Id);
}
```

Partial Interfaces

- Interfaces can be marked "partial" (just like classes).
- This allows them to be extended in a separate file (and at a later time).

```
public partial interface ICustomerReader
{
    IReadOnlyCollection<Customer> GetCustomers();
    Customer GetCustomer(int Id);
}
```

Static Abstract Members

- Interfaces can have static abstract members.

```
public interface IGetNext<T>
    where T : IGetNext<T>
{
    static abstract T operator ++(T other);
}
```

- This means that interface implementations must have that static member with the member implementation.

Static Abstract Members

- Can be used for operator overloads with interfaces.

```
public interface IGetNext<T>
    where T : IGetNext<T>
{
    static abstract T operator ++(T other);
}
```

- Can also be used for static factories.

Operator Overload Example 1

```
public record RepeatSequence : IGetNext<RepeatSequence>
{
    private const char Ch = 'A';
    public string Text = new string(Ch, 1);

    public static RepeatSequence operator ++(RepeatSequence other)
    {
        return other with { Text = other.Text + Ch };
    }

    public override string ToString() => Text;
}
```

https://learn.microsoft.com/en-us/dotnet/csharp/whats-new/tutorials/static-virtual-interface-members

Operator Overload Example 2

```
public record FibonacciNext : IGetNext<FibonacciNext>
{
    public int Previous = 0;
    public int Current = 1;

    public static FibonacciNext operator ++(FibonacciNext other)
    {
        checked
        {
            int next = other.Previous + other.Current;
            return other with { Previous = other.Current, Current = next };
        }
    }

    public override string ToString() => Current.ToString();
}
```

Using the Interface Operator

```
public class Nexter<T> : IEnumerable<T> where T : IGetNext<T>, new()
{
    public IEnumerator<T> GetEnumerator()
    {
        // first value
        T value = new();
        yield return value;

        // subsequent values
        while (true)
        {
            try { value++; }
            catch { break; }
            yield return value;
        }
    }
```

WARNING

- Interfaces with static abstract members cannot be used as generic type parameters.
- This can specifically cause problems with dependency injection.

Observation

Avoid using static abstract members unless you are building a framework that requires operator overloads.

(or in some other edge cases)

Here There Be Dragons

You might choose not to use these features, but you may encounter them in the libraries you use.

Thank You!

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