Leveling Up Dependency Injection in C#

2: Deeper Dive

Jeremy Clark
www.jeremybytes.com
@jeremybytes

What Is Dependency Injection?

- Dependency Injection is a set of software design principles and patterns that enable us to develop loosely coupled code.
  - Mark Seemann

Primary Benefits

- Extensibility
- Parallel Development
- Maintainability
- Testability
- Late Binding

Dependency Injection Concepts

- DI Design Patterns
  - Constructor Injection
  - Property Injection
  - Method Injection
- Dimensions of DI
  - Object Composition
  - Interception
  - Lifetime Management

Constructor Injection

The dependency is injected into the class through a constructor parameter.

Where to use Constructor Injection

- A dependency will be used/re-used at the class level.
- A non-optional dependency must be provided.

- Advantage: it keeps dependencies obvious. Code will not compile if the dependency is not provided

Property Injection

The dependency is injected into the class by setting a property on that class.

Where to use Property Injection

- A dependency will be used/re-used at the class level.
- A dependency is optional.
- A dependency has a good default value that can be used if a separate implementation is not provided.
- Advantage: we do not need to supply a dependency if we want to use the default behavior
- Disadvantage: the dependency is hidden. It may not be obvious to developers that a separate behavior can be provided.

Method Injection

The dependency is injected into a method through a method parameter.

Where to use Method Injection

- A dependency will only be used by a specific method – i.e., it will not be stored by the class and used in other methods.
- A dependency varies for each call of a method.

Stable and Volatile Dependencies

- A stable dependency is one that is not likely to change over the life of the application. For example, classes in the .NET Base Class Library (BCL)
- A volatile dependency is one that is likely to change or needs to be swapped out for fake behavior in unit tests.

Criteria for Stable Dependencies

- The class or module already exists
- You expect that new versions won't contain breaking changes
- The types in question contain deterministic algorithms
- You never expect to have to replace, wrap, decorate, or intercept the class or module with another

Criteria for Volatile Dependencies

- The dependency introduces a requirement to set up or configure a runtime environment for the application
  - Web services, databases, cloud services
- The dependency doesn't yet exist or is still in development

Criteria for Volatile Dependencies

- The dependency isn't installed on all machines in the development organization
  - Expensive 3rd party library
- The dependency contains non-deterministic behavior
  - Random number generator
  - DateTime.Now

Tips / Techniques

- Read-Only Properties (for Constructor Injection)
- Guard Clauses (prevent unintended nulls)

Read-Only Properties

- Properties marked as “readonly” are settable only in the constructor. This prevents the property from being inadvertently changed during the lifetime of the object.
- This is applicable to Constructor Injection; for obvious reasons, this would be a problem for Property Injection.

Guard Clauses

- Guard clauses (null checks) should be used in constructors, methods, and property setters to ensure that dependencies are not set to null.
- If a “null behavior” is required, consider using the Null Object pattern. This provides a valid implementation with no actual behavior.

Useful Design Patterns

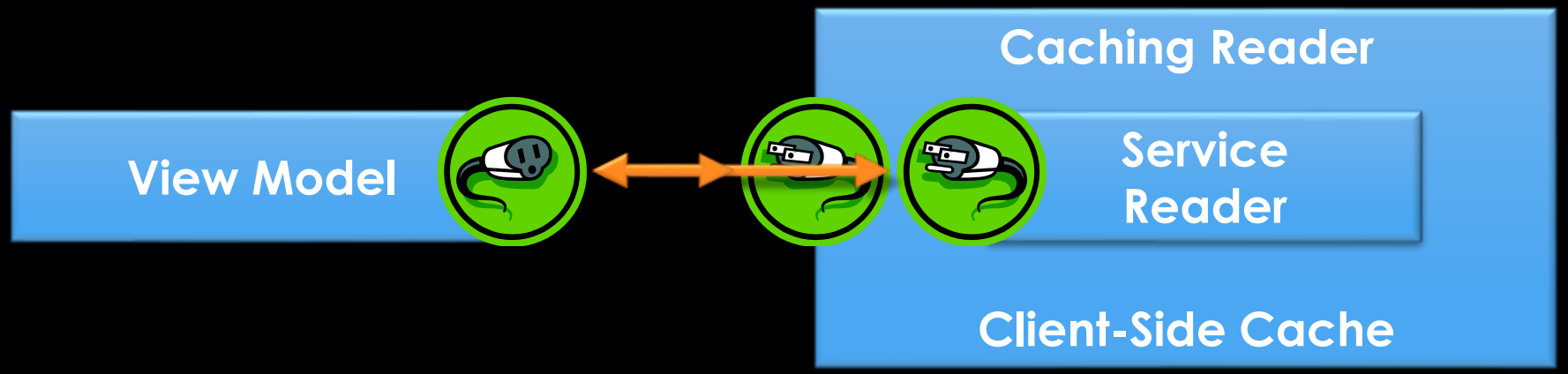
- Decorator
- Proxy
- Null Object

Decorator

Attach additional responsibilities to an object dynamically. Decorators provide a flexible alternative to subclassing for extending functionality.

Decorator

Caching Decorator



Where to use the Decorator Pattern

- Cross-cutting concerns
- Interception

Proxy

Provide a surrogate or placeholder
for another object to control access to it.

Where to use the Proxy Pattern

- Can be used to encapsulate IDisposable classes.

```
public async Task<IReadOnlyCollection<Person>> GetPeople()
{
    using var reader = new SQLReader(sqlFileName);
    return await reader.GetPeople();
}
```

*Note: we must “await” the proxied reader here. This will ensure that the “GetPeople” method completes before the reader is disposed.

Null Object

Instead of using a null reference
to convey absence of an object,
one uses an object which implements
the expected interface, but whose
method body is empty.

Null Object

The advantage of this approach over a working default implementation is that a null object is very predictable and has no side effects: it does nothing.

Where to use the Null Object Pattern

- Can be used for optional dependencies (which are truly optional).
- Rather than having null checks. A null object can provide empty functionality without the risk of null reference exceptions.

Null Object Example

```
public class NullLogger : ILogger
{
    public Log(string message)
    {
        // Does nothing (also no NullReferenceException)
    }
}
```

Common Stumbling Blocks

- Constructor Over-Injection
- Static Dependencies
- Dealing with IDisposable (and other lifetime concerns)
- Using Factory Methods
- Configuration Strings

Constructor Over-Injection

- Symptom: a constructor contains a large number of parameters.
- Code Smell: this often indicates that a class is trying to do too much.

Constructor Over-Injection

- Possible Solution:
  Break up the class along the functionality lines. This generally results in object groupings and dependencies that are more manageable in size.

Constructor Over-Injection

- Possible Solution:
  Create Parameter Objects.
- A parameter object can combine multiple dependencies into a single parameter. This allows grouping of parameters along functional lines.

Static Dependencies

- Symptom: A class relies on a static object as a dependency.
- Problem: This makes it difficult to swap out functionality for testing.
- Example: DateTime.Now()

Static Dependencies

- Possible Solution:
  Instead of relying on the static object directly, a class can wrap that dependency in a property. By default, the static dependency will be used, but it's possible to provide a different implementation for testing or other purposes.

Dealing with IDisposable

- Symptom: a dependency implements IDisposable.
- Code Smell: This is a leaky abstraction. The requirement to dispose of the object "leaks" out; the consuming class needs to know this about the dependency.

Dealing with IDisposable

- Possible Solution:
  Create a proxy class to wrap the functionality.
- Each method call creates the underlying object inside a “using”, the makes the call.
- The object is disposed and resources released.

- Example: SQL Repository

Factory Methods

- Symptom: A class uses a factory method and has a private constructor.
- Problem: This breaks auto-wiring in DI containers.

- Solution: We'll take a closer look after exploring DI containers further.

Configuration Strings

- Symptom: A class constructor needs a string as a parameter, such as a connection string.
- Problem: This breaks auto-wiring in DI containers.

- Solution: We'll take a closer look after exploring DI containers further.

Dimensions of Dependency Injection

- Object Composition
  - Snapping loosely coupled pieces together
- Lifetime Management
  - Managing creation and re-use of objects.
  - Transient, Singleton, Scoped, Thread
- Interception
  - Adding or replacing functionality in method calls

Dependency Injection Containers

- C# Containers
  - Ninject
  - Autofac
- Frameworks w/ Containers
  - ASP.NET Core
  - Angular
  - Prism

and many others

Object Composition

- Composing objects should happen as close to the application entry point as possible.
- In a desktop application, this means application startup.
- In an ASP.NET MVC application, this means the start of the request (generally creation of the controller).
- For other web applications, the entry point may be framework specific.

Object Composition

- The composition root should be the ONLY place a DI container is used. If the container is used in other areas, this is a code smell that the code violates DI principles.
- This often happens when the Service Locator (anti-)pattern is used.

Interception

- Interception is used for cross-cutting concerns.
- By using a Decorator, an object can intercept calls to the underlying object and add its own behavior.
- Examples:
  - Auditing
  - Logging
  - Authorization
  - Caching

Lifetime Management

- Transient
- Singleton
- Scoped
- Thread (not as relevant as it used to be)

Transient Lifetime

- A new instance of a dependency is used whenever there is a request for that dependency.
- Each instance is independent and will get cleaned up / garbage collected as it goes out of scope.

Singleton Lifetime

- A single instance of a dependency is used whenever there is a request for that dependency.
- The lifetime is managed by the DI container. It may or may not be released when all references have been released.

Scoped Lifetime

- A new instance is used for each “scope” of an application.
- If a dependency is needed multiple times within the same scope, a single instance of that dependency is used.
- Scope example: In a web application, the scope generally refers to the current request.
- Container scopes can be explicitly defined.

Thread Lifetime

- A new instance is used for each thread of an application.
- This lifetime is less common due to an increase in asynchronous programming.
- Scoped lifetime is preferred over thread lifetime.

Factory Methods

- Symptom: A class uses a factory method and has a private constructor.
- Problem: This breaks auto-wiring in DI containers.

Factory Methods

- Possible Solution:
  Most DI containers have a way to bind to a factory method.

- Ninject Example:

```
Container
    .Bind<ConcreteType>()
    .ToMethod(c => FactoryForConcreteType());
```

Factory Methods

- Possible Solution:
  Most DI containers have a way to bind to a factory method.

- ASP.NET Core Example:

```
builder.Services
    .AddSingleton<ConcreteType>(s => FactoryForType());
```

Configuration Strings

- Symptom: A class constructor needs a string as a parameter, such as a connection string.
- Problem: This breaks auto-wiring in DI containers.

Configuration Strings

- Possible Solution:
  Create a parameter object to hold the string. This gives a strongly-typed object that can be configured and resolved by the container.

- This is a preferred method since it gives additional type safety.

Configuration Strings

- Sample (strong-typed parameter):

```
builder.Services
    .AddSingleton<ServiceReaderUri>(s =>
        new ServiceReaderUri("http://localhost:9874"));
builder.Services
    .AddSingleton<IPersonReader, ServiceReader>();
```

Configuration Strings

- Alternate Solution:
  Use the factory method syntax to inject the string manually.

- Ninject Example:

```
Container
    .Bind<ConcreteType>()
    .ToMethod(c => new ConcreteType(paramString))
```

Resources

Code Samples & Resources

https://github.com/jeremybytes/di-dotnet-workshop-2022

Thank You!

Jeremy Clark

- http://www.jeremybytes.com
- jeremy@jeremybytes.com
- @jeremybytes