Take Your C# Skills to the Next Level

Jeremy Clark
Developer Betterer,
GitHub: jeremybytes

Level: Intermediate

Session Survey

- Your feedback is very important to us
- Please take a moment to complete the session survey found in the mobile app
- Use the QR code or search for “Converge360 Events” in your app store
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LIVE! 360
TECH EVENTS WITH PERSPECTIVE

Take Your C# Skills to the Next Level

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Ignore the number of slides in this deck. These are primarily for your reference.

Most of our time will be spent in code.

Schedule

- Class Hours 9:00 a.m. – 6:00 p.m.
- Break 11:00 a.m. – 11:15 a.m.
- Lunch 1:00 p.m. – 2:00 p.m.
- Break 3:30 p.m. – 3:45 p.m.

Additional breaks and Q&A throughout the day

All Times are Eastern Standard Time

Overview

- What we want from software
- Principles that help
- Tools to get there
  - Interfaces
  - Delegates
  - Dependency Injection
  - Unit Tests

Workshop Materials

https://github.com/jeremybytes/vslive2025-orlando

Topics (in no particular order)

- What & Why?
  - Interfaces
  - Delegates
  - Dependency Injection (DI)
  - Unit Tests
- Explicit Interface Implementation
- Interface Inheritance
- Interface Granularity
- Func<T, TResult>
- Constructor Injection
- Lambda Expressions
- Using a DI Container
- Adding a Cache
- Injecting Behavior
- Testing DateTime.Now
- Test Fakes and Mocks
- SOLID Principles

What We Want from Software

As Developers and Users

As a user, I want software…

- That works
- That is delivered quickly
- That does what I need it to do
- That can be fixed quickly
- That can change as my needs change

As a developer, I want software…

- With no bugs
- Easy to write
- Fulfills the use cases
- Easy to fix when there are bugs
- Easy to change when the use cases change

We want the same things

What users want

- That works
- That is delivered quickly
- That does what I need it to do
- That can be fixed quickly
- That can change as my needs change

What developers want

- With no bugs
- Easy to write
- Fulfills the use cases
- Easy to fix when there are bugs
- Easy to change when the use cases change

Helpful Practice

- **S** • Single Responsibility Principle
- **O** • Open/Closed Principle
- **L** • Liskov Substitution Principle
- **I** • Interface Segregation Principle
- **D** • Dependency Inversion Principle

“Best” Practices

No “Best” Practices

Helpful practices are a good place to start, but don’t use them if they don’t fit your situation.

Tools

- Interfaces
  - Add “seams” to code
  - Modification points
  - Interception points
  - Testing points
- Delegates
  - Inject custom behavior
- Dependency Injection
  - Assemble the pieces
  - Containers automate assembly
- Unit Tests
  - Proof code works
  - Proof that I didn’t break something

Interfaces

Adding seams to code

An interface contains definitions for a group of related functionalities that a non-abstract class or struct must implement.

https://learn.microsoft.com/en-us/dotnet/csharp/fundamentals/types/interfaces

An interface describes
a set of capabilities
on an object.

“I have these functions.”

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

Recommendation

Program to an abstraction rather than a concrete type.

Recommendation

Program to an interface rather than a concrete class.

Various Data Sources

Microsoft SQL Server

MongoDB

CSV

WebAPI

Amazon RDS

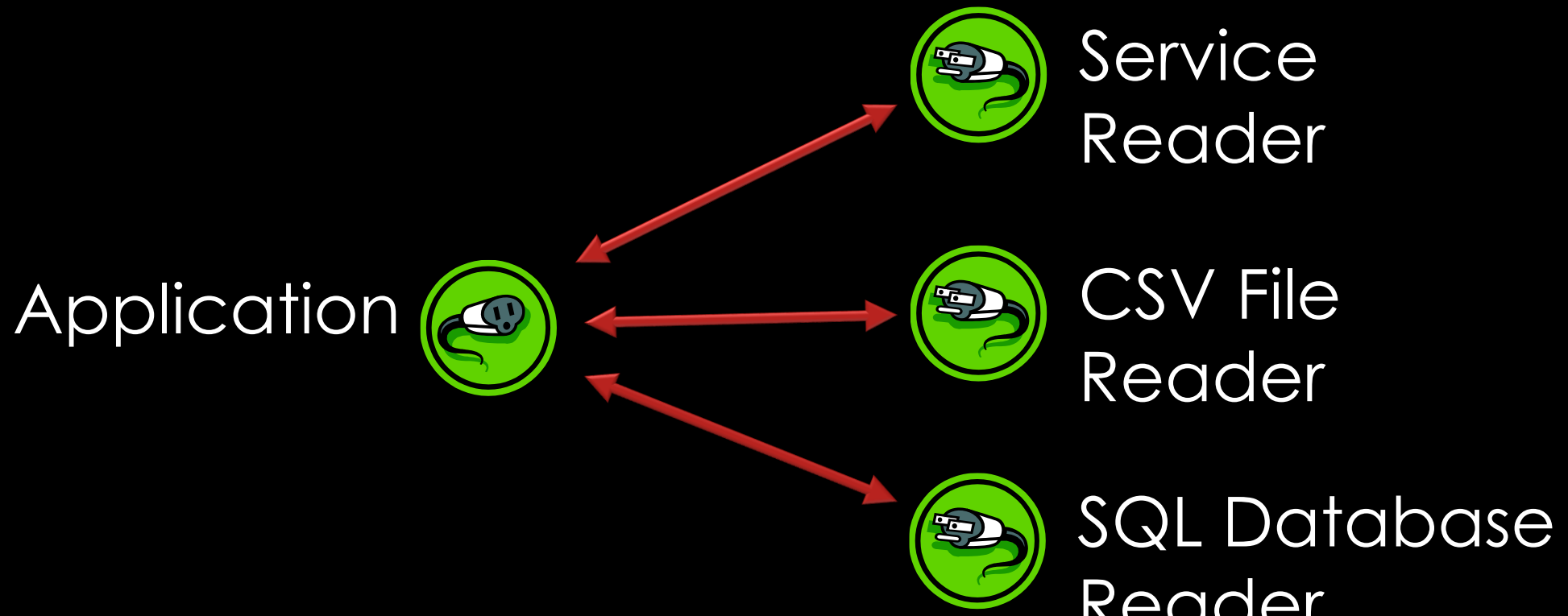
Oracle

JSON

Hadoop

Azure Cosmos DB

Pluggable Data Readers



Data Reader Interface

```
public interface IPersonReader
{
    Task<IReadOnlyCollection<Person>> GetPeople();
    Task<Person?> GetPerson(int id);
}
```

Interfaces and Flexible Code

Resilience in the face of change

Insulation from implementation details

Dynamic Factory

- Check configuration
- Create an assembly load context
- Load the assembly
- Look for the type
- Create the data reader
- Return the data reader

Other Benefits

Interfaces help us isolate code for easier unit testing.

Other Benefits

Interfaces can make dependency injection easier.

Interfaces: What & Why?

- An interface describes a set of capabilities of an object.
- Program to an abstraction (interface) rather than a concrete type (class).
- Resilience in the face of change.
- Insulation from implementation details.
- Easier unit testing.
- Easier dependency injection.

Explicit Implementation

An explicitly implemented member belongs to the interface rather than the class.

Class with No Interface

Declaration

```
public class Catalog
{
  public string Save()
  {
    return "Catalog Save";
  }
}
```

Usage

```
Catalog catalog = new();
string result = catalog.Save();
// result = "Catalog Save"
```

Standard Interface Implementation

Declaration

```
public interface ISaveable
{
  public string Save();
}

public class Catalog : ISaveable
{
  public string Save()
  {
    return "Catalog Save";
  }
}
```

Usage

```
Catalog catalog = new();
string result = catalog.Save();
// result = "Catalog Save"

ISaveable saveable = new Catalog();
result = saveable.Save();
// result = "Catalog Save"
```

Explicit Implementation

Declaration

```
public interface ISaveable
{
    public string Save()
}
public class Catalog : ISaveable
{
    public string Save()
    {
        return "Catalog Save";
    }
    string ISaveable.Save()
    {
        return "Interface Save";
    }
}
```

Usage

```
Catalog catalog = new();
string result = catalog.Save();
// result = "Catalog Save"

ISaveable saveable = new Catalog();
result = saveable.Save();
// result = "Interface Save"

result = ((ISaveable)catalog).Save();
// result = "Interface Save"
```

Explicit Implementation

Declaration

```
public interface ISaveable
{
    public string Save()
}
public class Catalog : ISaveable
{
    // Save() method deleted
    string ISaveable.Save()
    {
        return "Interface Save";
    }
}
```

Usage

```
Catalog catalog = new();
string result = catalog.Save();
// **COMPLIER ERROR**

ISaveable saveable = new Catalog();
result = saveable.Save();
// result = "Interface Save"

saveable = (ISaveable)catalog;
result = saveable.Save();
// result = "Interface Save"
```

Interface Inheritance

```
public interface IEnumerable<T> : IEnumerable
```

- IEnumerable<T> inherits IEnumerable
- When a class implements IEnumerable<T>, it must also implement IEnumerable

IEnumerable<T> / IEnumerable

```
public interface IEnumerable<T> : IEnumerable
{
    IEnumerator<T> GetEnumerator();
}
public interface IEnumerable
{
    IEnumerator GetEnumerator();
}
```

When a class implements IEnumerable<T>,
it must also implement IEnumerable

IEnumerable<T> / IEnumerable

```
public class FibonacciSequence : IEnumerable<double>
{
  public IEnumerator<double> GetEnumerator()
  { // implementation }

  public IEnumerator GetEnumerator()
  { // implementation }
}
```

NOT ALLOWED

Methods cannot be overloaded
only on different return types.

IEnumerable<T> / IEnumerable

```
public class FibonacciSequence : IEnumerable<double>
{
  public IEnumerator<double> GetEnumerator()
  { // implementation }

  IEnumerator IEnumerable.GetEnumerator()
  {
    return this.GetEnumerator();
  }
}
```

SOLUTION: Explicit Implementation.

Interface Segregation Principle

```
public class List<T> : IList<T>, IList,
  ICollection<T>, ICollection,
  IEnumerable<T>, IEnumerable,
  IReadOnlyCollection<T>, IReadOnlyList<T>
```

Clients should not be forced to depend upon methods that they do not use.
Interfaces belong to clients,
not hierarchies.

Interface Segregation Principle

```
public class List<T> : IList<T>, IList,
  ICollection<T>, ICollection,
  IEnumerable<T>, IEnumerable,
  IReadOnlyCollection<T>, IReadOnlyList<T>
```

We should have granular interfaces that only include the members that a particular function needs.

List<T> Interfaces

```
public class List<T> : IList<T>, IList,
  ICollection<T>, ICollection,
  IEnumerable<T>, IEnumerable,
  IReadOnlyCollection<T>, IReadOnlyList<T>
```

IEnumerable<T>

GetEnumerator()

IEnumerable

GetEnumerator()

List<T> Interfaces

```
public class List<T> : IList<T>, IList,
  ICollection<T>, ICollection,
  IEnumerable<T>, IEnumerable,
  IReadOnlyCollection<T>, IReadOnlyList<T>
```

ICollection<T>

Count
IsReadOnly
Add()
Clear()
Contains()
CopyTo()
Remove()

Plus
Everything in
IEnumerable<T>
and
IEnumerable

List<T> Interfaces

```
public class List<T> : IList<T>, IList,
  ICollection<T>, ICollection,
  IEnumerable<T>, IEnumerable,
  IReadOnlyCollection<T>, IReadOnlyList<T>
```

IList<T>

Item / Indexer
IndexOf()
Insert()
RemoveAt()

Plus
Everything in
ICollection<T>,
IEnumerable<T>,
and
IEnumerable

Granular Interfaces

- **If We Need to**
  - Iterate over a Collection / Sequence
  - Data Bind to a List Control
  - Use LINQ functions

IEnumerable<T>

- **If We Need To**
  - Add/Remove Items in a Collection
  - Count Items in a Collection
  - Clear a Collection

ICollection<T>

- **If We Need To**
  - Control the Order Items in a Collection
  - Get an Item by the Index

IList<T>

Single Responsibility Principle

A class should have only one reason to change.

Gather together the things that change for the same reasons. Separate those things that change for different reasons.

Open-Closed Principle

Software entities should be open for extension, but closed for modification.

Ex. Injecting behavior through a delegate or other entity.

Liskov Substitution Principle

Substitutability: an object (such as a class) may be replaced by a sub-object without breaking the program.

Violation example: Rectangle vs. Square

Interface Segregation Principle

Clients should not be forced to depend upon methods that they do not use. Interfaces belong to clients, not hierarchies.

Dependency Inversion Principle

High-level modules should not import anything from low-level modules; both should depend on abstractions.

Abstractions should not depend on details. Details (concrete implementations) should depend on abstractions.

Delegates

Inserting behavior

What Is A Delegate?

Definition

A type that defines a method signature

Why Delegates?

- Decoupling Code
- Methods as Parameters
- Multicasting Support
- Callbacks and Event Handlers
- LINQ
- ASP.NET Core Minimal APIs

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Dependency Injection

Assembling the pieces

Dependency Injection

The fine art of making things someone else's problem.

Typical Introduction

```
private void BuildMainWindow()
{
    var builder = new ContainerBuilder();
    builder.RegisterType<SQLReader>().As<IPersonReader>()
        .SingleInstance();
    builder.RegisterSource(
        new AnyConcreteTypeNotAlreadyRegisteredSource());
    IContainer Container = builder.Build();
    Application.Current.MainWindow =
        Container.Resolve<PeopleViewerWindow>();
}
```

What Is Dependency Injection?

- Dependency Injection is a software design pattern that allows a choice of component to be made at run-time rather than compile time.
  - Wikipedia 2012

What Is Dependency Injection?

- Dependency injection is a software design pattern that allows the removal of hard-coded dependencies and makes it possible to change them, whether at run-time or compile-time.
  - Wikipedia 2013

What Is Dependency Injection?

- Dependency injection is a software design pattern that implements inversion of control and allows a program design to follow the dependency inversion principle. The term was coined by Martin Fowler.
  - Wikipedia 2014

What Is Dependency Injection?

- In software engineering, dependency injection is a software design pattern that implements inversion of control for software libraries, where the caller delegates to an external framework the control flow of discovering and importing a service or software module. Dependency injection allows a program design to follow the dependency inversion principle where modules are loosely coupled. With dependency injection, the client part of a program which uses a module or service doesn't need to know all its details, and typically the module can be replaced by another one of similar characteristics without altering the client.
  - Wikipedia 2015

What Is Dependency Injection?

- In software engineering, dependency injection is a software design pattern that implements inversion of control for resolving dependencies. A dependency is an object that can be used (a service). An injection is the passing of a dependency to a dependent object (a client) that would use it. The service is made part of the client's state.[1] Passing the service to the client, rather than allowing a client to build or find the service, is the fundamental requirement of the pattern.
  - Wikipedia 2016

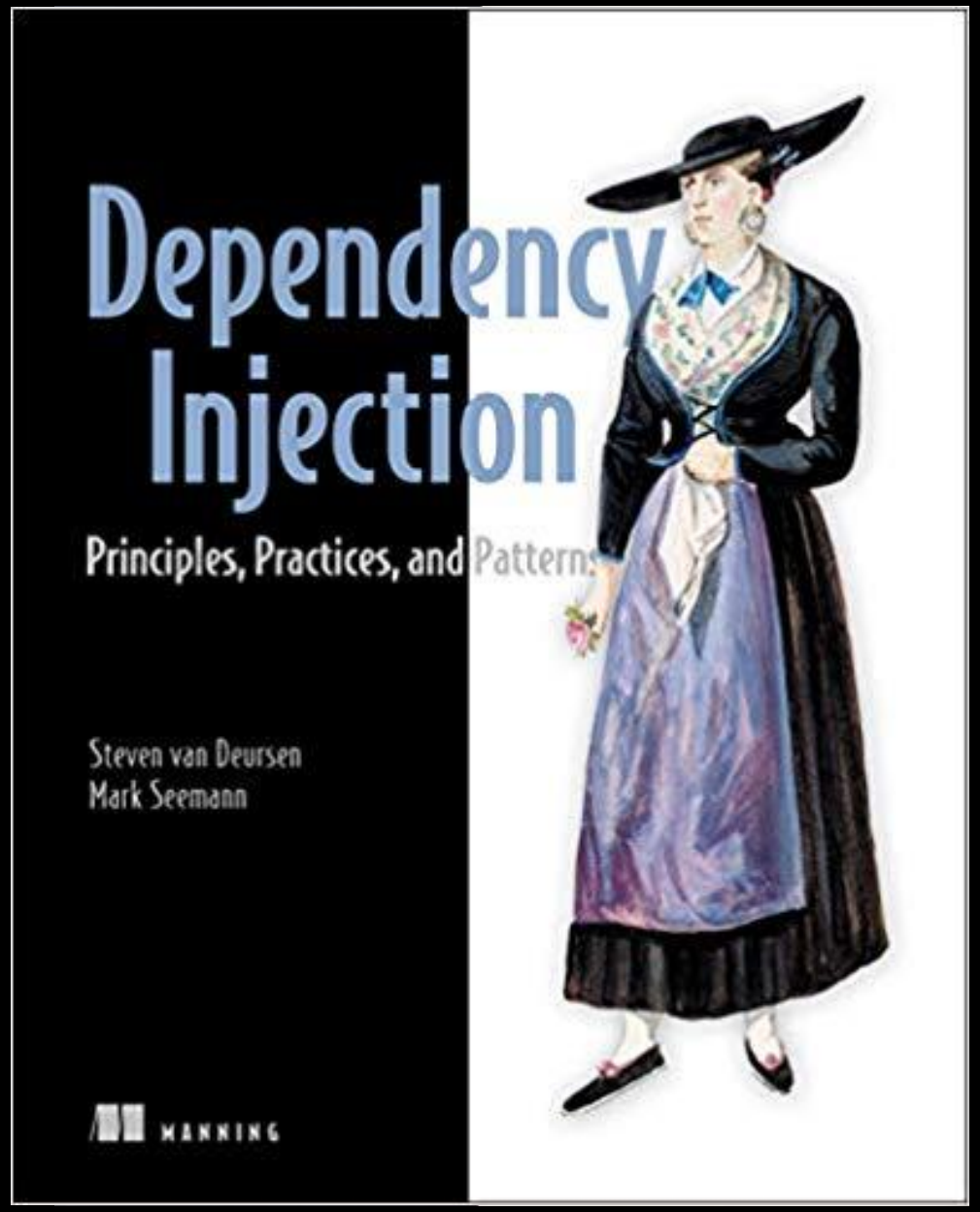
What Is Dependency Injection?

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

Dependency Injection

Principles, Practices, and Patterns

- Mark Seemann
- Steven van Deursen



Primary Benefits

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

- Adherence to S.O.L.I.D. Design Principles.

Benefits – Extensibility

Code can be extended in ways not explicitly planned for.

Benefits – Parallel Development

Code can be developed in parallel with less chance of merge conflicts.

Benefits – Maintainability

Classes with clearly defined responsibilities are easier to maintain.

Benefits – Testability

Classes can be unit tested,
i.e., easily isolated from other classes
and components for testing.

Benefits – Late Binding

Services can be swapped with other services without recompiling code.

Dependency Injection Concepts

- DI Design Patterns
  - Constructor Injection
  - Property Injection
  - Method Injection
  - Ambient Context
  - Service Locator
- Dimensions of DI
  - Object Composition
  - Interception
  - Lifetime Management

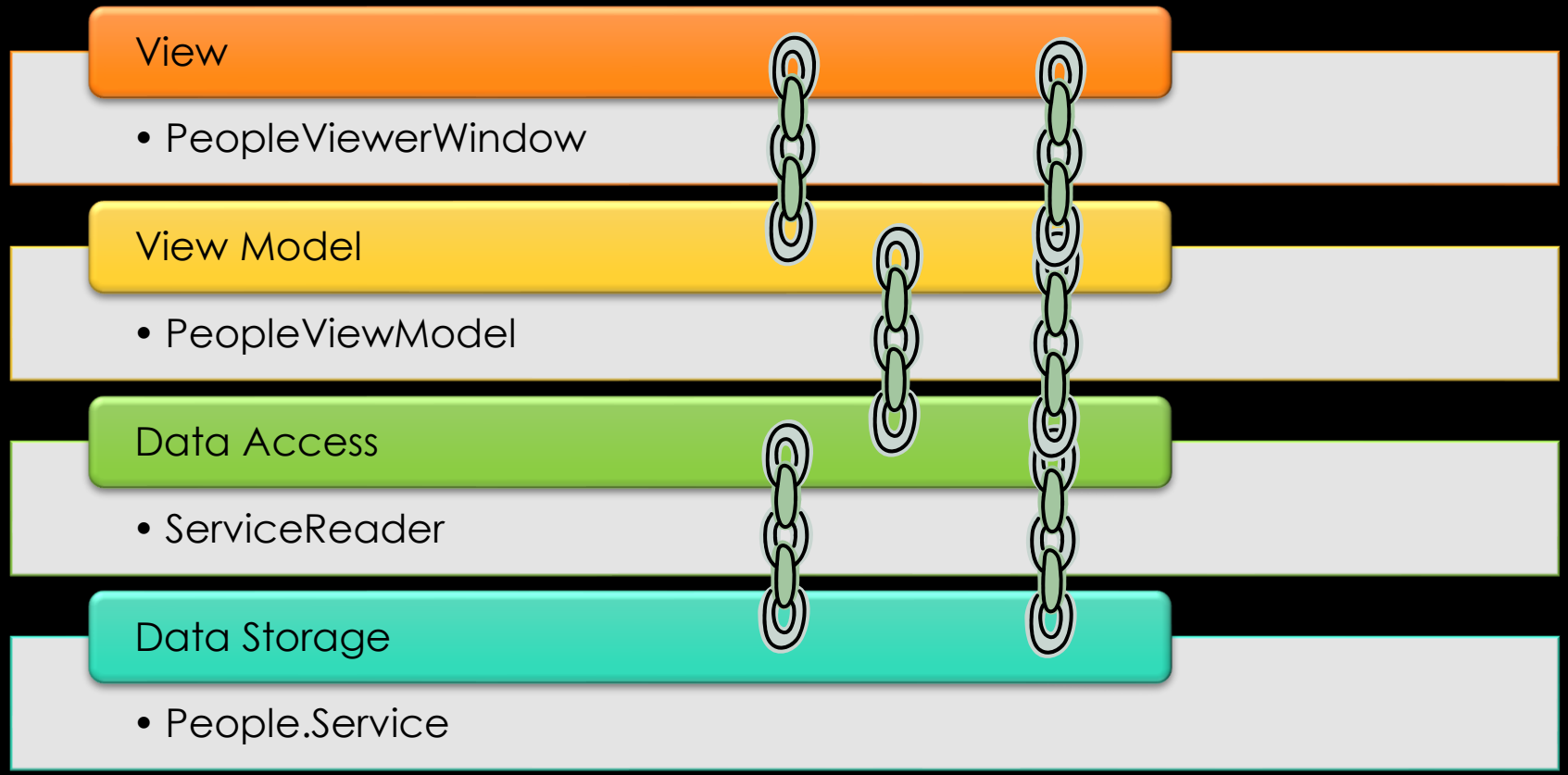
Dependency Injection Containers

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

and many others

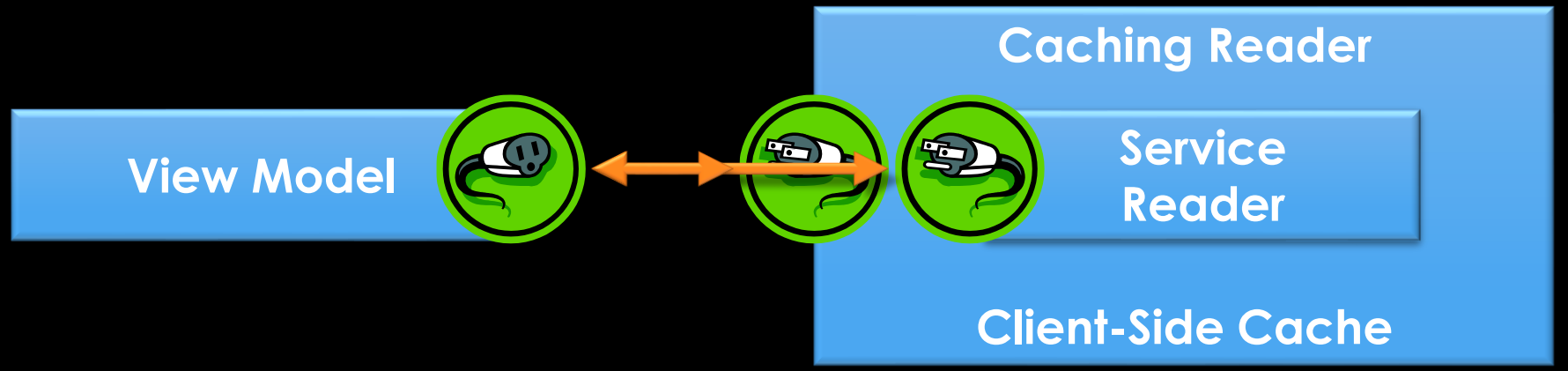
Application Layers

Tight Coupling

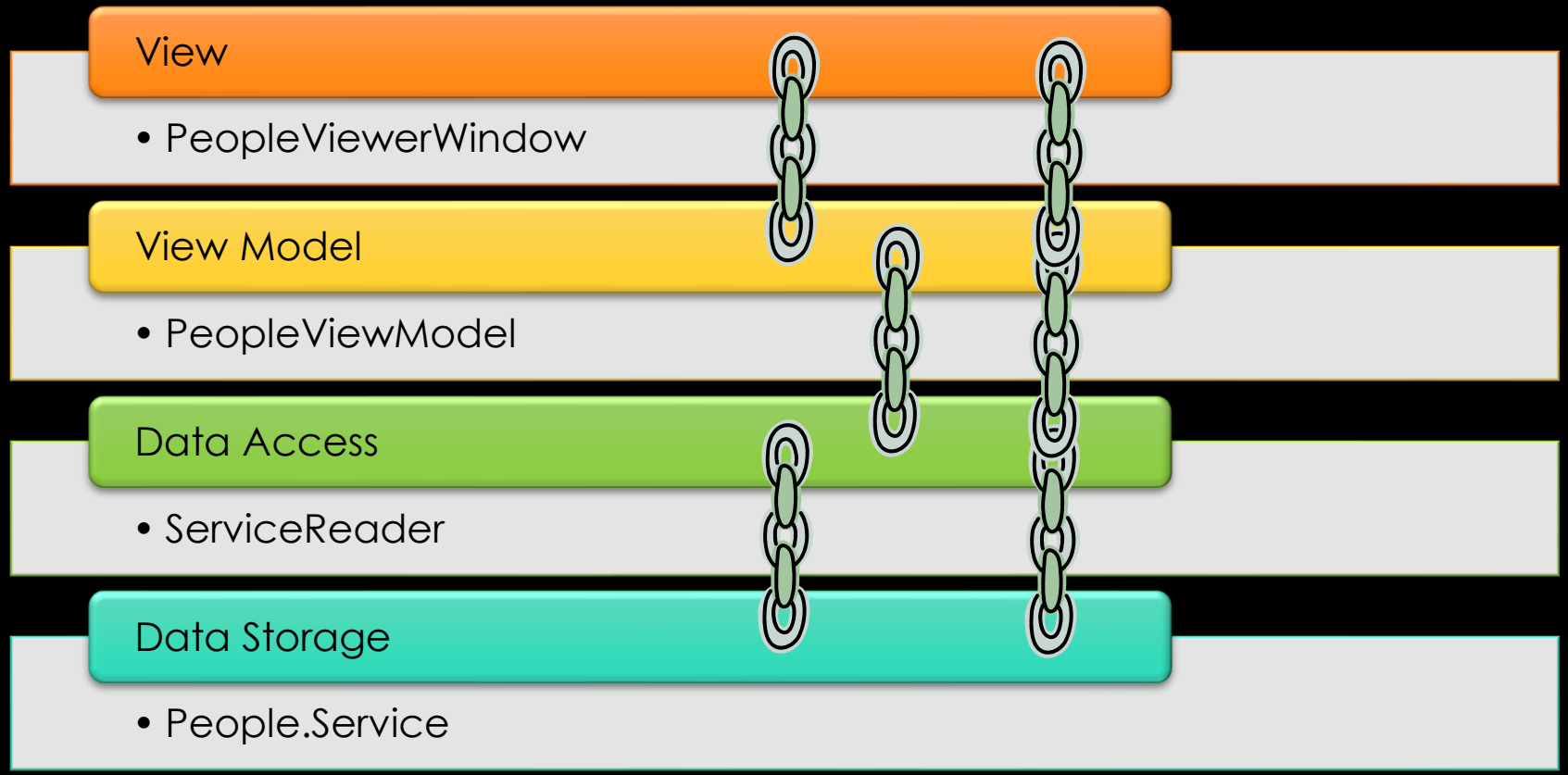


Creating a Caching Reader

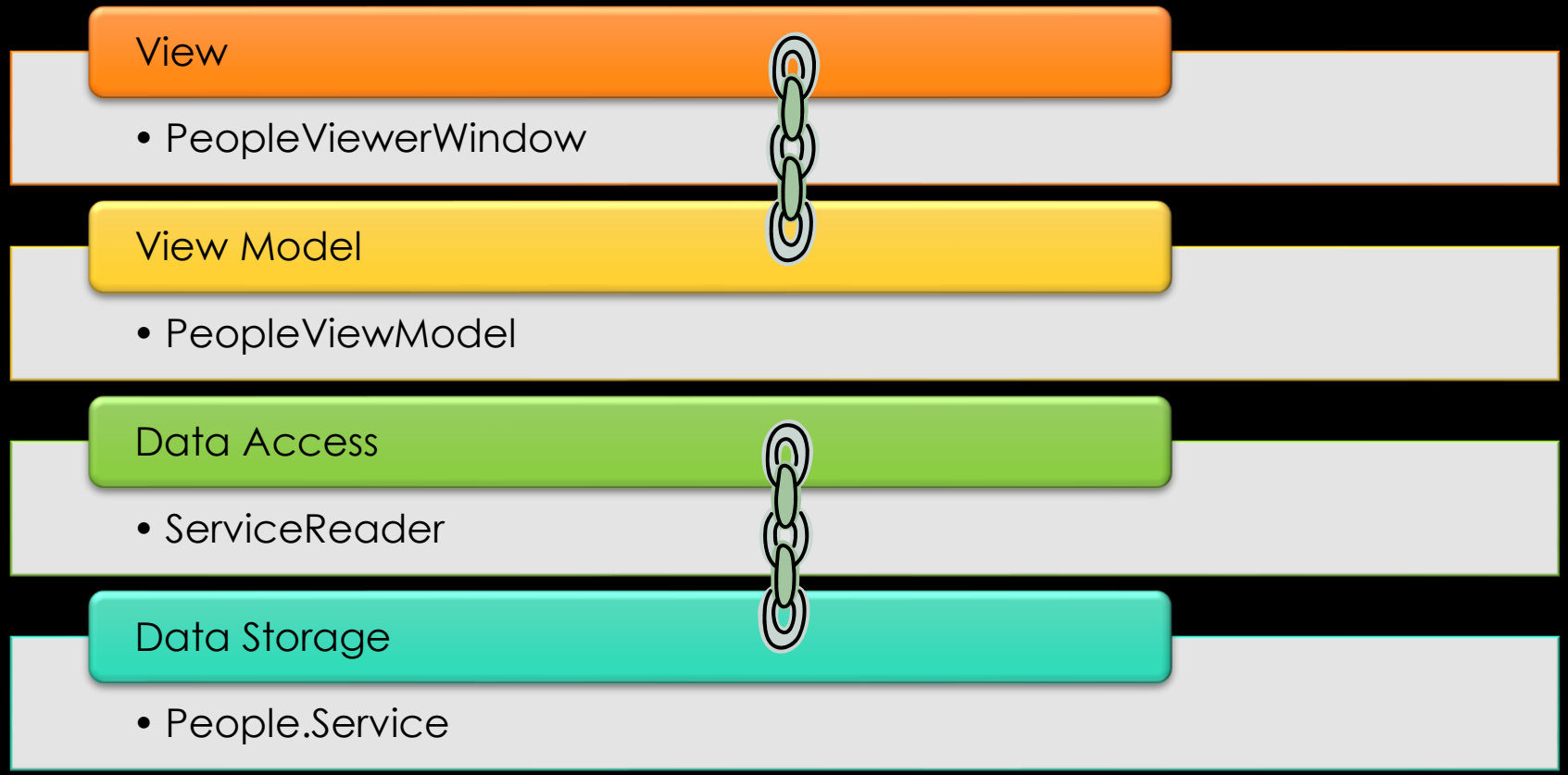
The Decorator Pattern



Loose(r) Coupling



Loose(r) Coupling



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  - Property Injection
  - Method Injection
  - Ambient Context
  - Service Locator
- 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

Primary Constructors

- When using a primary constructor, the constructor parameter can either initialize a field (or property) or be used directly.
- When initializing a property, the parameter is given an “unspeakable” name (like a field for an automatic property).
- When used directly, the parameter is class-level and modifiable.

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, network calls
- 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 / init-Only Properties (for Constructor Injection)
- Guard Clauses (prevent unintended nulls)

Read-Only / init-Only Properties

- Properties marked as “readonly” or with “init” for a setter are settable only during object construction. 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.

Unit Testing

Code faster

Different Kinds of Tests

- Unit Testing
- Integration Testing
- Performance Testing
- Exploratory Test
- Penetration Testing
- User Acceptance Testing (UAT)

What are Unit Tests?

A unit test is an automated piece of code that invokes a unit of work in the system and then checks a single assumption about the behavior of that unit of work.

The Art of Unit Testing by Roy Osherove

Non-Threatening Text Here

Threatening Text Here

What are Unit Tests?

A unit test is an automated piece of code that invokes a unit of work in the system and then checks a single assumption about the behavior of that unit of work.

The Art of Unit Testing by Roy Osherove

automated piece of code

a unit of work

checks a single assumption

Assertions

- The Assert class throws exceptions when the assertion fails
  - https://learn.microsoft.com/en-us/dotnet/api/microsoft.visualstudio.testtools.unittesting.assert?view=visualstudiosdk-2022
- xUnit provides a custom Assert class with similar functionality
  - https://xunit.net/docs/comparisons

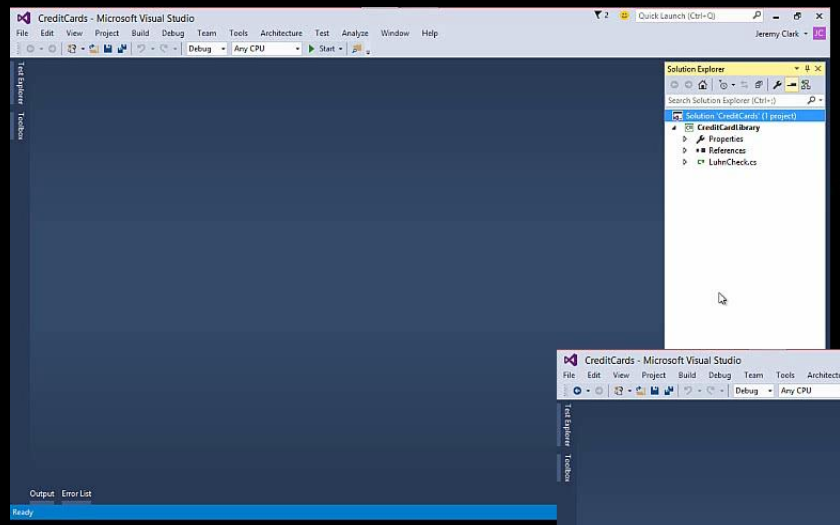
Benefits

- Confirming Functionality
- Checking Regression
- Pinpointing Bugs
- Documenting Functionality

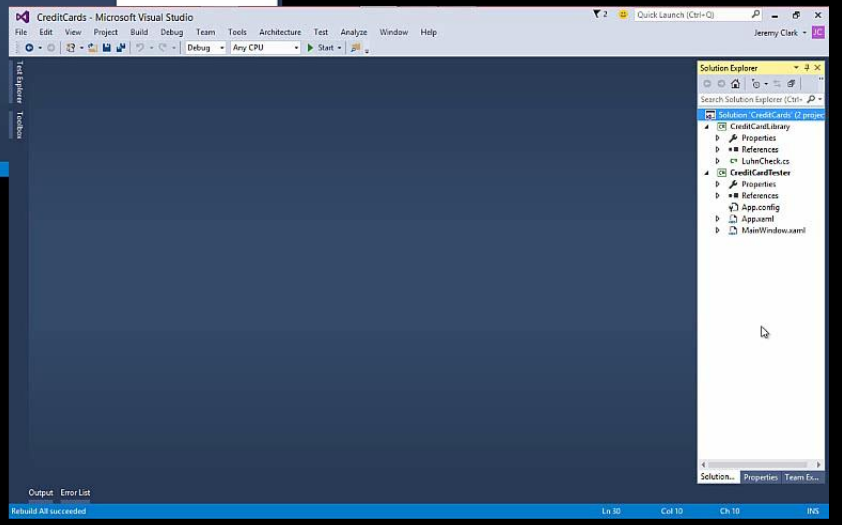
Confirming Functionality

Unit Tests are ***proof*** that my code does what I ***think*** it does

Build Time Comparison



Test Application

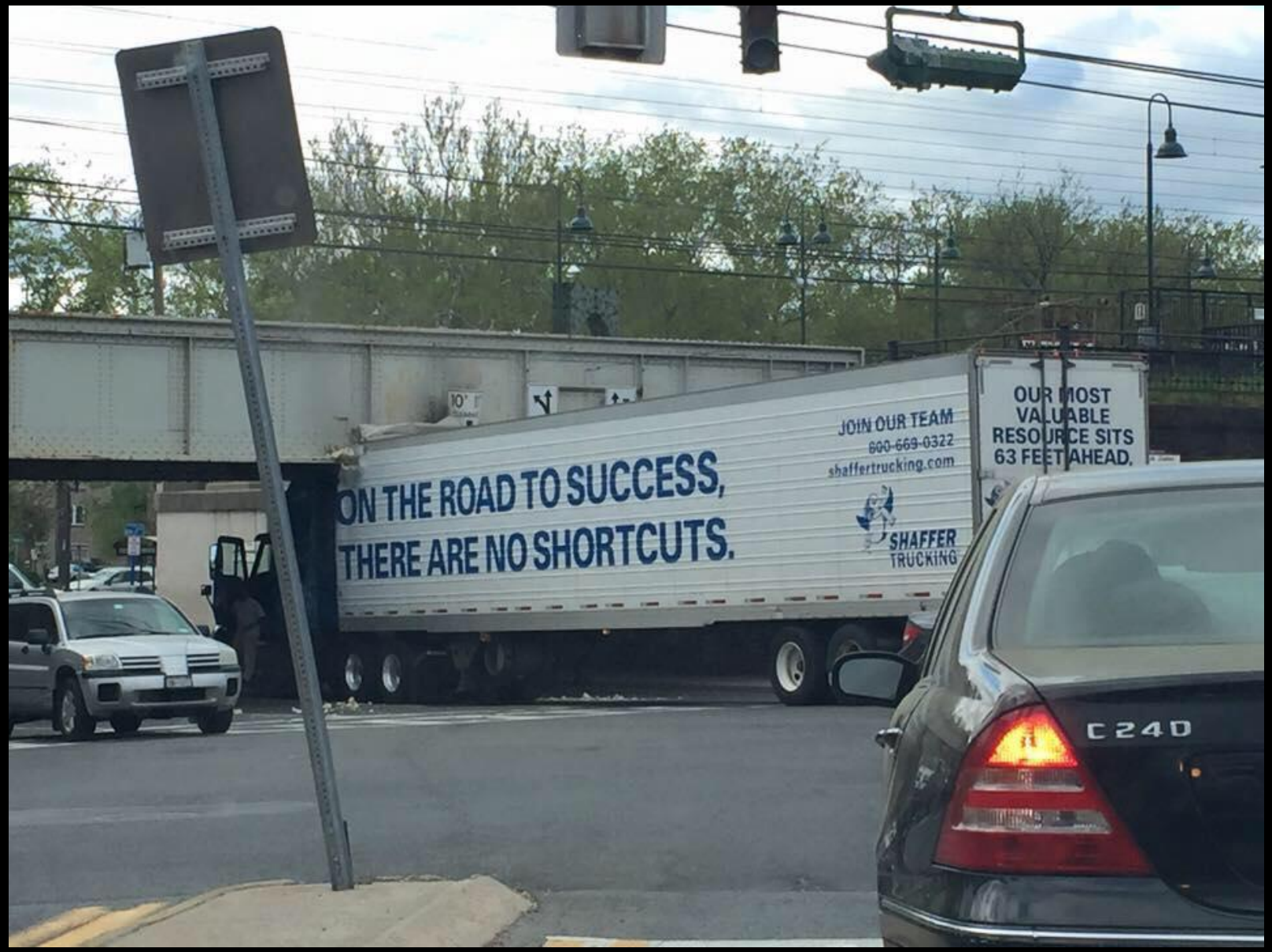


Unit Testing

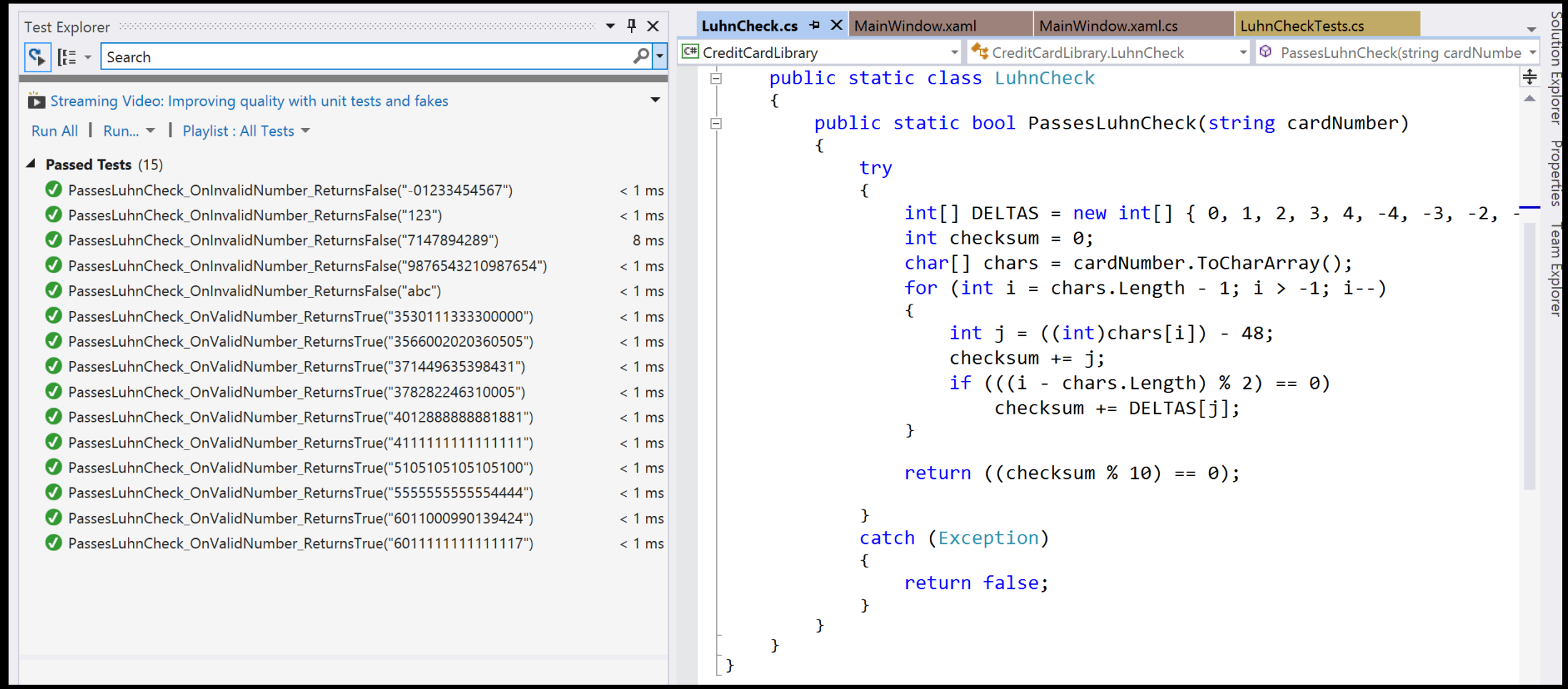
Disclaimer

We get these advantages when we are ***comfortable*** writing ***good*** tests.

Realistic Expectations

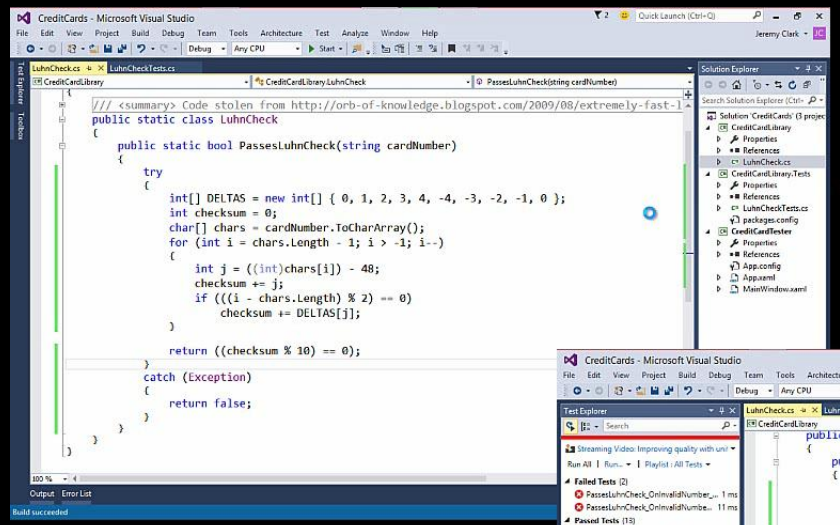


Checking Regression

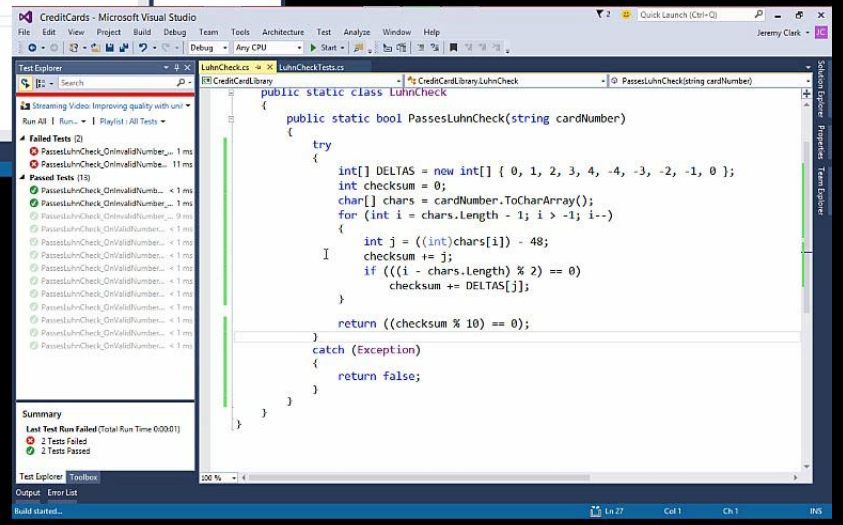



```
public static class LuhnCheck
{
    public static bool PassesLuhnCheck(string cardNumber)
    {
        try
        {
            int[] DELTAS = new int[] { 0, 1, 2, 3, 4, -4, -3, -2, -
            int checksum = 0;
            char[] chars = cardNumber.ToCharArray();
            for (int i = chars.Length - 1; i > -1; i--)
            {
                int j = ((int)chars[i]) - 48;
                checksum += j;
                if (((i - chars.Length) % 2) == 0)
                    checksum += DELTAS[j];
            }

            return ((checksum % 10) == 0);

        }
        catch (Exception)
        {
            return false;
        }
    }
}
```

Regression Comparison

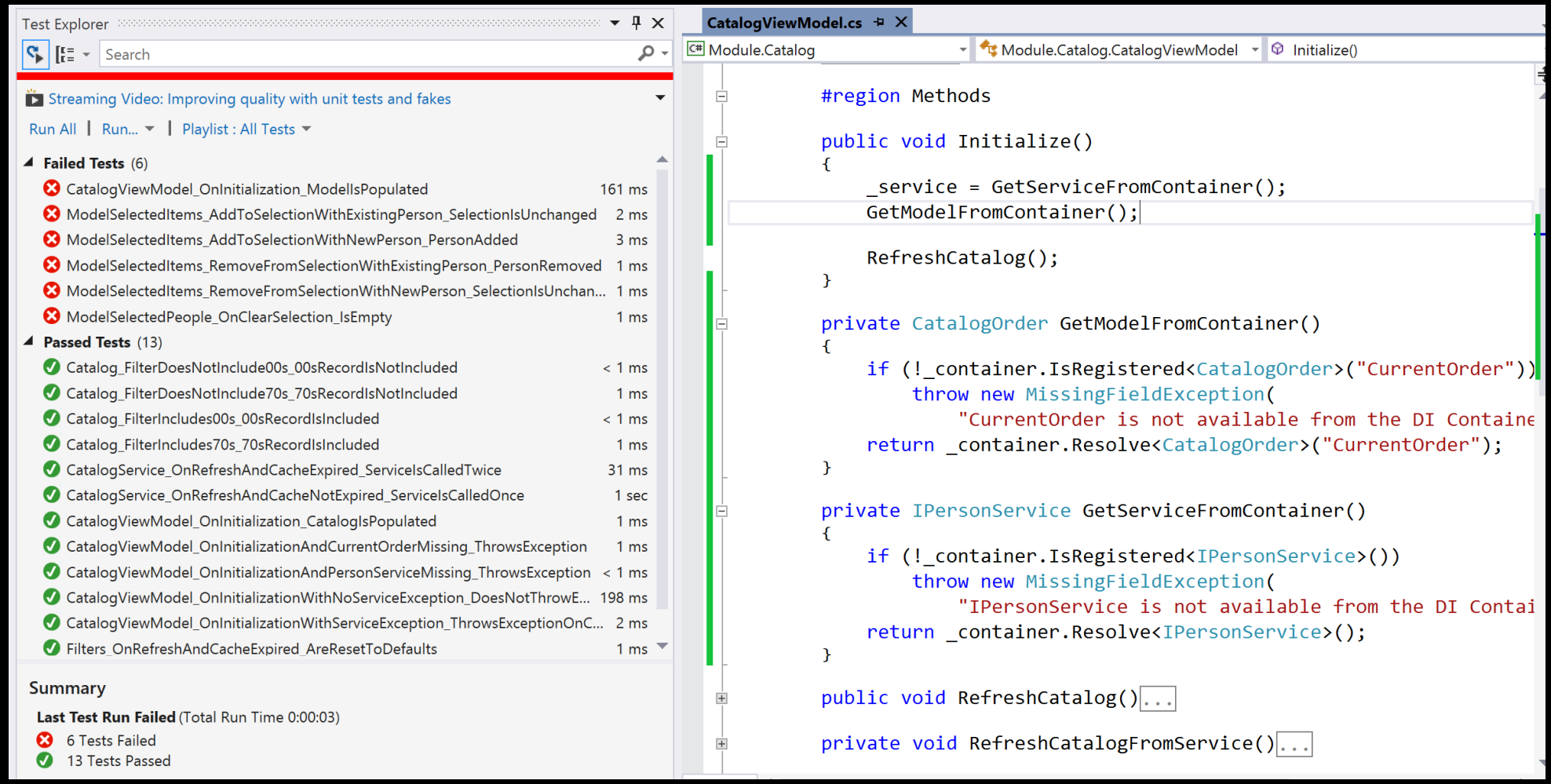


Test Application



Unit Testing

Pinpointing Bugs



Documenting Functionality

- Catalog_FilterDoesNotInclude00s_00sRecordIsNotIncluded
- Catalog_FilterDoesNotInclude70s_70sRecordIsNotIncluded
- Catalog_FilterIncludes00s_00sRecordIsIncluded
- Catalog_FilterIncludes70s_70sRecordIsIncluded
- CatalogService_OnRefreshAndCacheExpired_ServiceIsCalledTwice
- CatalogService_OnRefreshAndCacheNotExpired_ServiceIsCalledOnce
- CatalogViewModel_OnInitialization_CatalogIsPopulated
- CatalogViewModel_OnInitialization_ModelIsPopulated
- CatalogViewModel_OnInitializationAndCurrentOrderMissing_ThrowsException
- CatalogViewModel_OnInitializationAndPersonServiceMissing_ThrowsException

eption

urrentThread

- Filters_OnRefreshAndCacheExpired_AreResetToDefaults
- Filters_OnRefreshAndCacheNotExpired_AreResetToDefaults

- ModelSelectedItems_AddToSelectionWithExistingPerson_SelectionIsUnchanged
- ModelSelectedItems_AddToSelectionWithNewPerson_PersonAdded

Disclaimer

We get these advantages when we are ***comfortable*** writing ***good*** tests.

Good Unit Tests

- Maintainable
- Dependable
- Runnable

Qualities of a Good Test

Maintainable

- Not Tricky
- Easy to Read
- Easy to Write
- Well-Named

Dependable

- Consistent Results
- Isolated
- Continued Relevance
- Tests the Right Things

Runnable

- FAST

Michael C. Feathers on Speed

"A unit test that takes 1/10th of a second to run is a slow unit test."

"Unit tests run fast. If they don't run fast, they aren't unit tests."

Working Effectively with Legacy Code by Michael C. Feathers

Qualities of a Good Test

Maintainable

- Not Tricky
- Easy to Read
- Easy to Write
- Well-Named

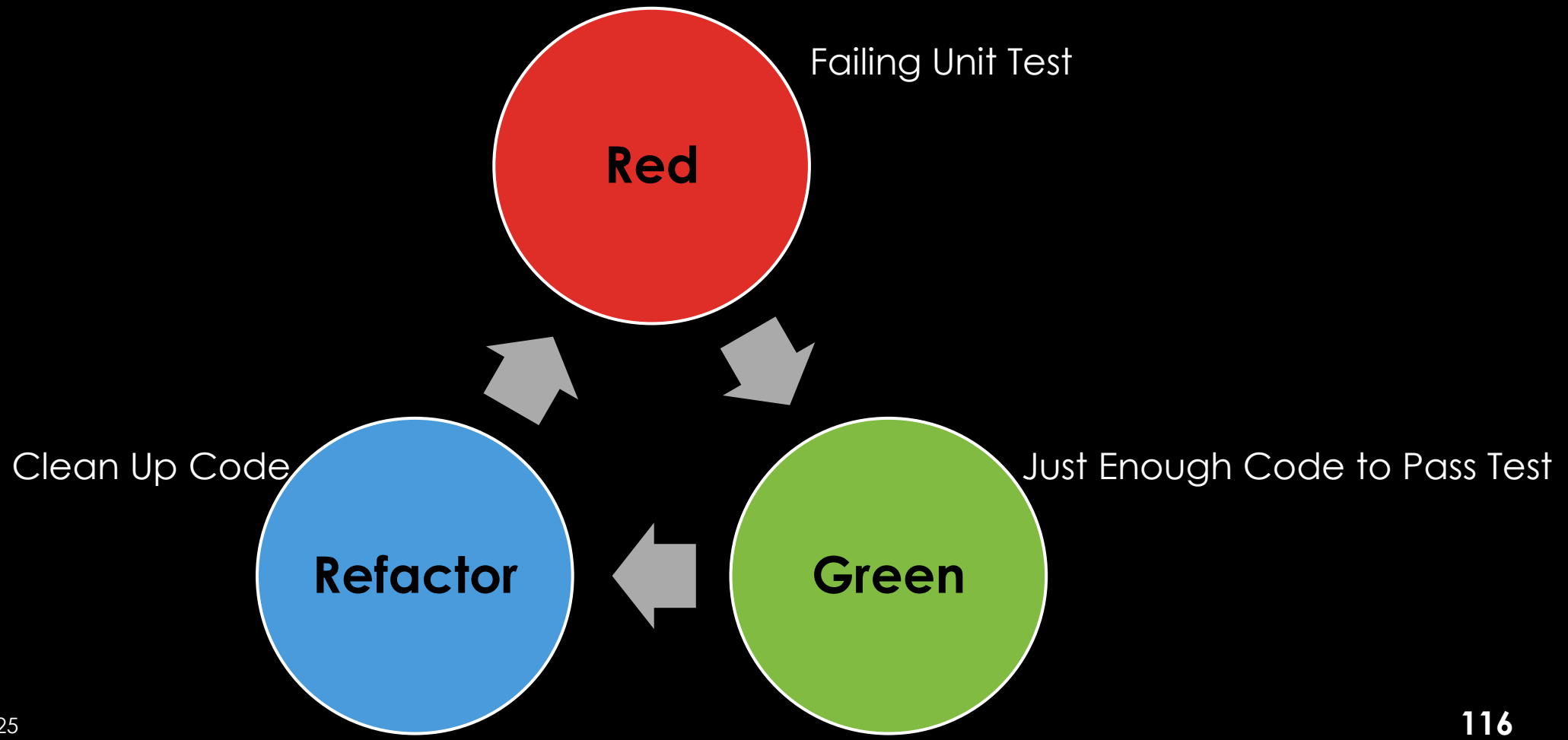
Dependable

- Consistent Results
- Isolated
- Continued Relevance
- Tests the Right Things

Runnable

- FAST
- Single Click
- Repeatable
- Failure Points to the Problem

Test Driven Development



Fizz Buzz

- Print Numbers 1 to 100
- If divisible by 3 replace with “Fizz”
- If divisible by 5 replace with “Buzz”
- If divisible by 3 and 5 replace with “FizzBuzz”

- 1
- 2
- Fizz
- 4
- Buzz
- Fizz
- 7
- 8
- Fizz

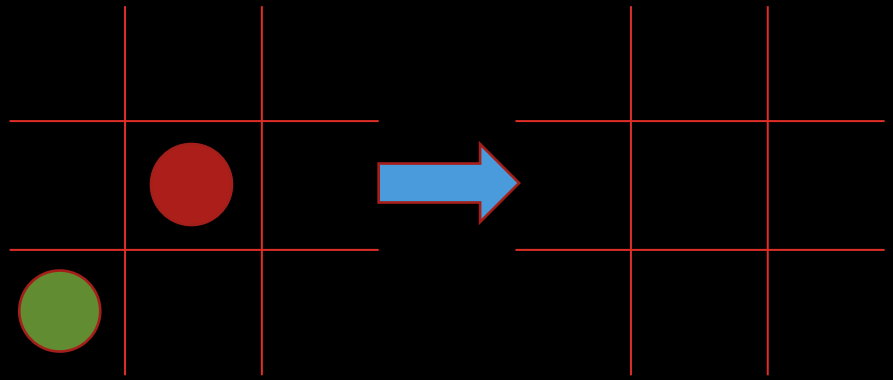
- Buzz
- 11
- Fizz
- 13
- 14
- FizzBuzz
- 16
- 17
- Fizz

Conway's Game of Life

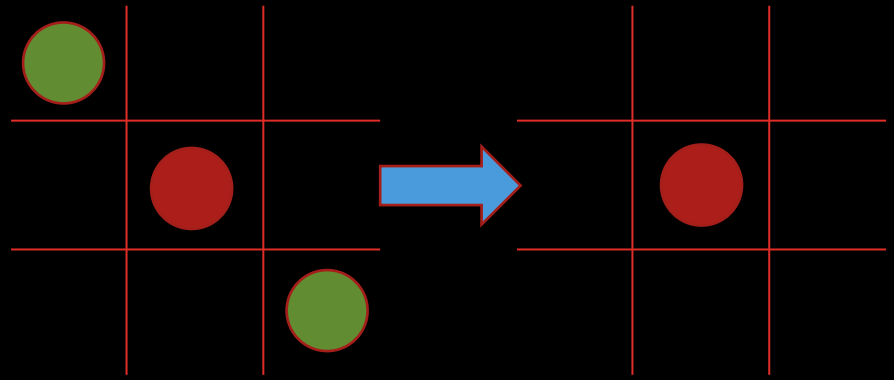
- Any live cell with fewer than two live neighbours dies.
- Any live cell with two or three live neighbours lives.
- Any live cell with more than three live neighbours dies.
- Any dead cell with exactly three live neighbours becomes a live cell.

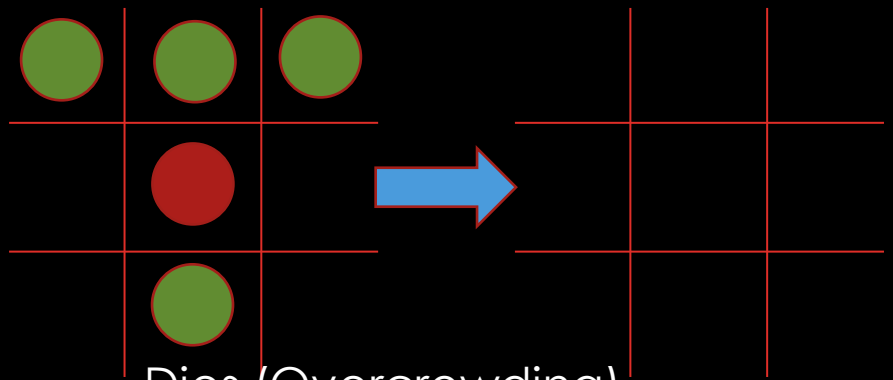
Conway's Game of Life

Dies (Loneliness)

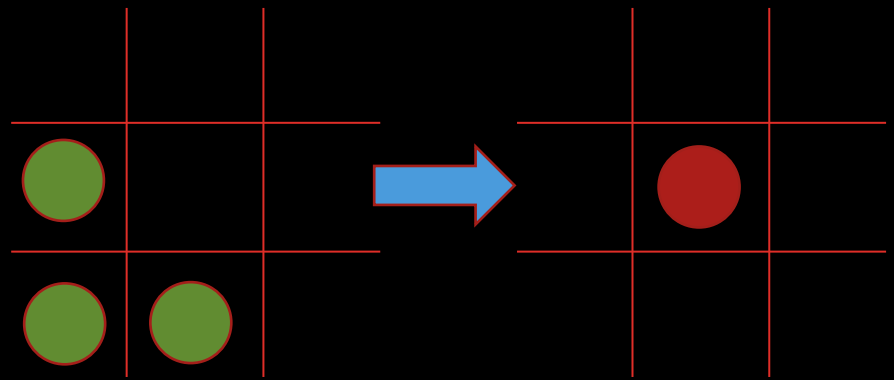


Lives (Happy)





Dies (Overcrowding)



Lives (Reproduction)

Code Coverage

100% Code Coverage is not a guarantee

Conversations about Code Coverage

"What parts of your application are okay ***not*** to test?"

The Stahl Standard

"What parts of your application do your users ***not*** care about?"

-Barry Stahl

Twitter: @bsstahl http://www.cognitiveinheritance.com/

Know the Goals

- Don't do the right thing for the wrong reason.
- Unit testing will not fix bad development practices.

http://www.jenders.com/2012/01/08/thief-almost-caught-on-camera-stealing-thin-lg-television/

Martin Fowler on Fear

"Don't let the fear that testing
can't catch ***all*** bugs
stop you from writing the tests
that will catch ***most*** bugs."

Refactoring by Martin Fowler et al.

Handling Dependencies

- Create Interfaces to add “seams” to our code
- Use Dependency Injection for loose-coupling
- Use Mocking to inject dependencies for testing

Mocking

- Create “Placeholder” Objects
  - In-Memory
  - Only Implement Behavior We Care About
- Mocking Frameworks
  - NSubstitute
  - Moq

Moq

- Available in NuGet
- Documentation
  - https://github.com/Moq/moq4/wiki/Quickstart

Simple Setup

```
public IPersonReader GetTestReader()
{
    List<Person> testData = [ new Person... ];
    var result = Task.FromResult(testData);
    var mockReader = new Mock<IPersonReader>();
    mockReader.Setup(r => r.GetPeople()).Returns(result);
    return mockReader.Object;
}
```

Setup with Parameters

```
public IPersonReader GetTestReader()
{
    List<Person> testData = [ new Person... ];
    var result = Task.FromResult(testData);
    var mockReader = new Mock<IPersonReader>();
    mockReader.Setup(r => r.GetPeople()).Returns(result);
    mockReader.Setup(r => r.GetPerson(It.IsAny<int>()))
        .Returns((int id) => testData.First(p => p.Id == id));
    return mockReader.Object;
}
```

Setup vs. Factory Methods

- Setup Methods in unit tests are run automatically before any test is invoked.
- Setup Methods can be used for object initialization.

HOWEVER

- Factory Methods are not automatically run.
- Factory Methods are explicitly called within the test.
- Readability of tests can be increased by using Factory Methods instead of Setup Methods.

Sample with Setup Method

```
IPersonReader _reader;


[Initialize]
public IPersonReader GetTestReader()
{
    List<Person> testData = [ new Person... ];
    var result = Task.FromResult(testData);
    var mockReader = new Mock<IPersonReader>();
    mockReader.Setup(r => r.GetPeople())
        .Returns(result);
    _reader = mockReader.Object;
}
```

```
[Fact]
public async Task People_OnRefresh_IsPopulated()
{
    var viewModel = new PeopleViewModel(_reader)
    await viewModel.RefreshPeople();
    Assert.NotNull(viewModel.People);
    Assert.Equal(2, viewModel.People.Count());

}
```

Sample with Factory Method

```
public IPersonReader GetTestReader()
{
    List<Person> testData = [ new Person... ];
    var result = Task.FromResult(testData);
    var mockReader = new Mock<IPersonReader>();
    mockReader.Setup(r => r.GetPeople()).Returns(result);

    return mockReader.Object;
}
```

```
[Fact]
public async Task People_OnRefresh_IsPopulated()
{
    var reader = GetTestReader();
    var viewModel = new PeopleViewModel(reader);
    await viewModel.RefreshPeople();
    Assert.NotNull(viewModel.People);
    Assert.Equal(2, viewModel.People.Count());
}
```

xUnit Parameterization

[Theory]
[InlineData(…)]

- Marking a test as "Theory" allows you to include data that is used as test parameters.
  - https://xunit.net/docs/getting-started/v2/netfx/visual-studio#write-first-theory

[Theory] & [InlineData] Attributes

```
[Theory]
[InlineData(2)]
[InlineData(3)]
public void LiveCell_2or3LiveNeighbors_Lives(int neighbors)
{
    CellState currentState = CellState.Alive;
    var newState = LifeRules.GetState(currentState, neighbors);
    Assert.Equal(CellState.Alive, newState);
}
```

xUnit Parameterization

[ClassData] & [MemberData]

These options can be used instead of [InlineData] when data is more complex, needs to be calculated, or comes from a database or file.

Testing for Exceptions

- Manual Testing:
  - Create method with try/catch block.
  - “Assert.Fail()” if no exception is thrown.
  - Catch block can check exception for specific type/properties.

Testing for Exceptions

- xUnit Testing
  - Use “Assert.Throws()” method to check a block of code.
  - Return value is the exception and can be checked for specific properties.
  - Other testing frameworks offer similar assertions.

xUnit Exception Assertion

```
[Fact]
public void InvalidCellState_ThrowsException()
{
    CellState currentState = (CellState)2;
    int neighbors = 3;

    Assert.Throws<ArgumentOutOfRangeException>(
        "currentState",
        () => LifeRules.GetNewState(currentState, neighbors));
}
```

Session Survey

- Your feedback is very important to us
- Please take a moment to complete the session survey found in the mobile app
- Use the QR code or search for “Converge360 Events” in your app store
- Find this session on the Agenda tab
- Click “Session Evaluation”
- Thank you!

LIVE! 360
TECH EVENTS WITH PERSPECTIVE

Thank You!

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- @jeremybytes

https://github.com/jeremybytes/vslive2025-orlando