



TECH EVENTS WITH PERSPECTIVE

*The Ultimate Education Destination*  
**ORLANDO 2024**

# Take Your C# Skills to the Next Level

**Jeremy Clark**  
**Developer Betterer**  
**[jeremybytes.com](https://jeremybytes.com)**

**Level: Intermediate**



Visual Studio **LIVE!**  
EXPERT SOLUTIONS FOR ENTERPRISE DEVELOPERS

Data Platform **LIVE!**  
INSIGHTS FOR MANAGING YOUR DATA ESTATE

**TECHMENTOR**  
IN-DEPTH TRAINING FOR IT PROS

Artificial  
Intelligence **LIVE!**  
AI FOR DEVELOPERS AND DATA SCIENTISTS

Cloud &  
Containers **LIVE!**  
CLOUD-NATIVE, PaaS & SERVERLESS COMPUTING

Cybersecurity  
& Ransomware **LIVE!**  
DEFENDING AGAINST RANSOMWARE AND OTHER ATTACKS

# Session Survey

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- Click “Session Evaluation”
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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 08:00 – 17:00
- Break TBA
- Lunch TBA
- Break TBA

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/vslive2024-orlando>



# Topics (in no particular order)

- What & Why?
  - Interfaces
  - Delegates
  - Dependency Injection (DI)
  - Unit Tests
- Explicit Interface Implementation
- Interface Inheritance
- Interface Granularity
- DI Patterns
- Stable vs. Volatile Dependencies
- Read-only/init-only Properties
- Using a DI Container
- Injecting Primitives
- Adding a Cache
- Injecting Behavior
- Testing `DateTime.Now`
- Test Fakes and Mocks



# 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	Fields
Methods	Constructors
Events	Destructors
Indexers	



## 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

Oracle

Amazon RDS

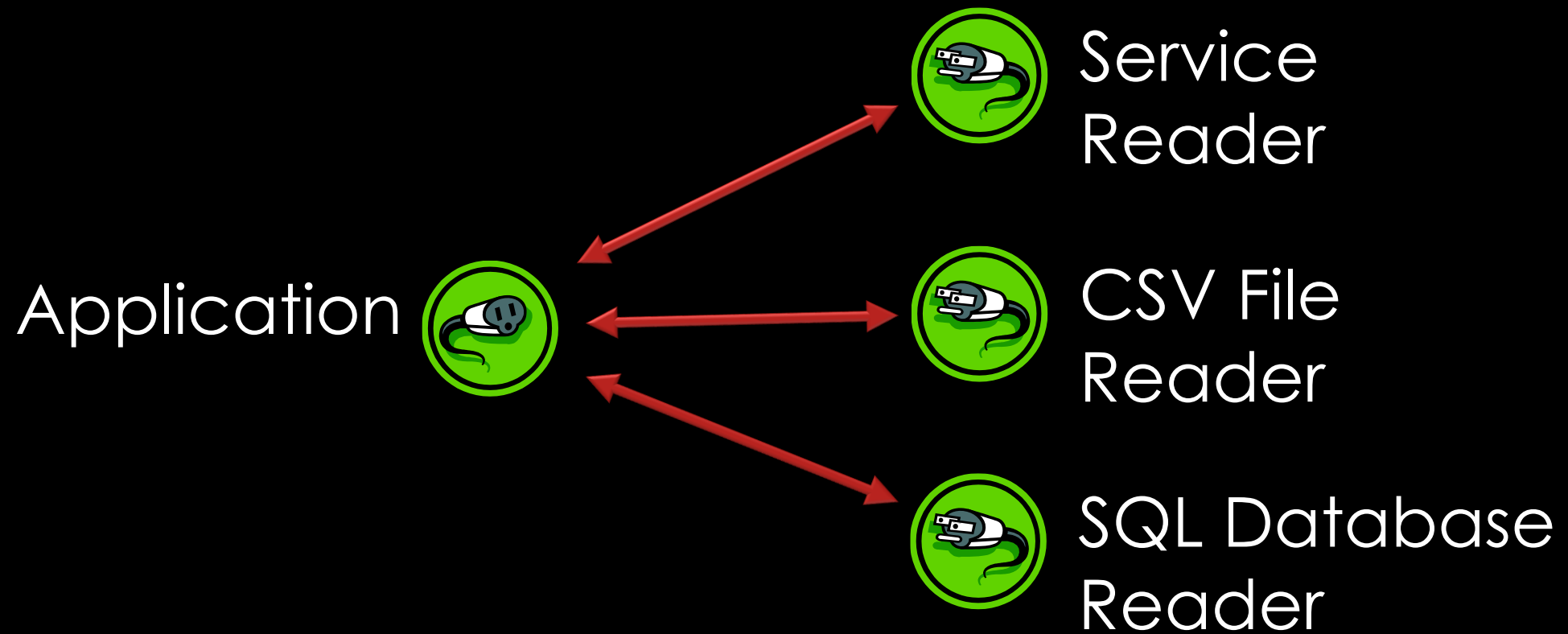
JSON

Azure Cosmos DB

Hadoop



# 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

# Single Responsibility Principle

A class should have only **one reason to change**.

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# Open-Closed Principle

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

Ex. Injecting behavior through a delegate or other entity.

# Dependency Injection

## Assembling the pieces

An abstract graphic at the top of the slide featuring a series of overlapping, wavy bands of color. From left to right, the colors transition from a bright yellow-orange to a deep red, then to a dark green, and finally to a light blue/cyan on the far right. The waves are fluid and organic in shape.

# 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?

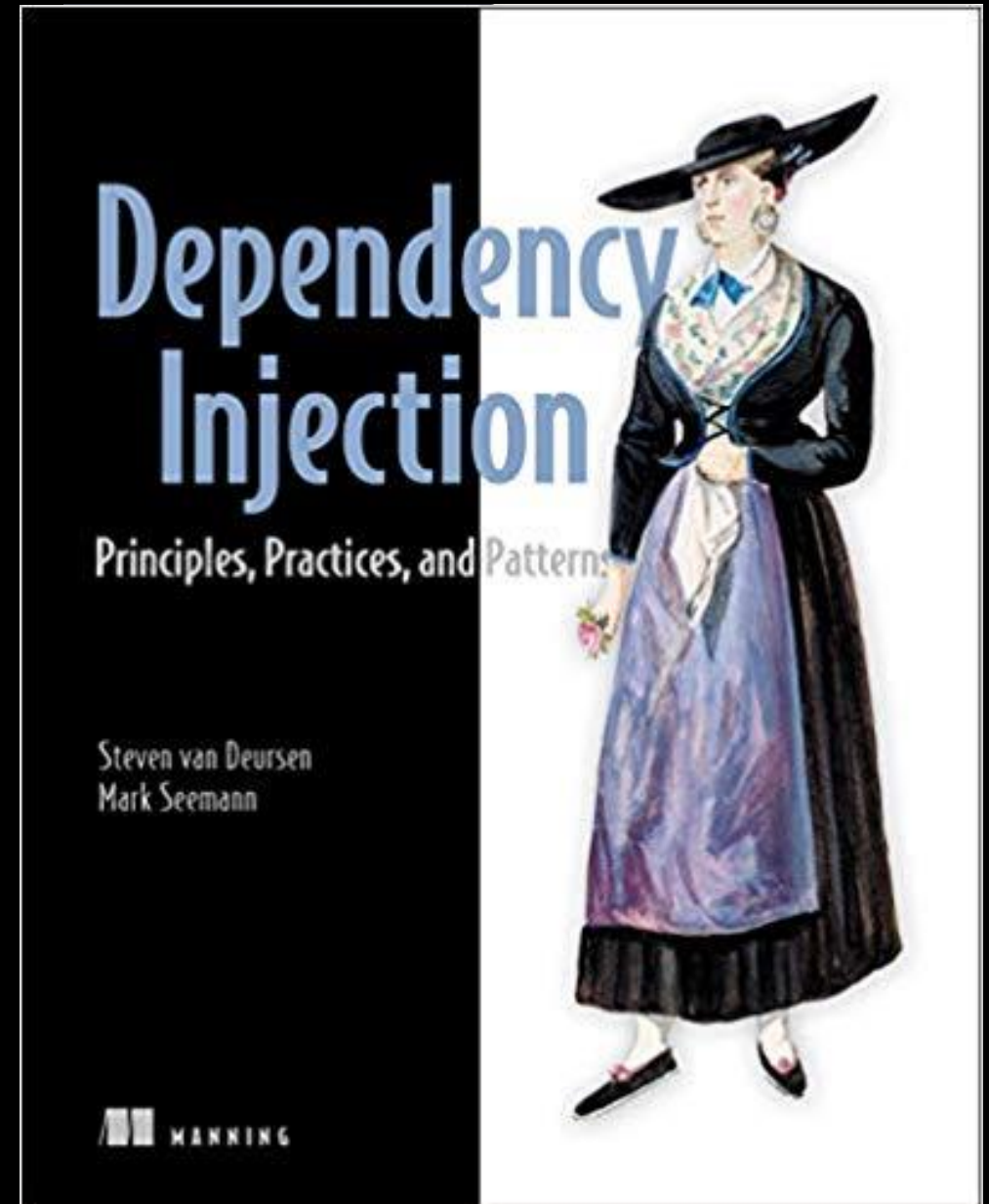
- Dependency Injection is a set of software design principles and patterns that enable us to develop **loosely coupled code**.

- 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

## View

- PeopleViewerWindow

## View Model

- PeopleViewModel

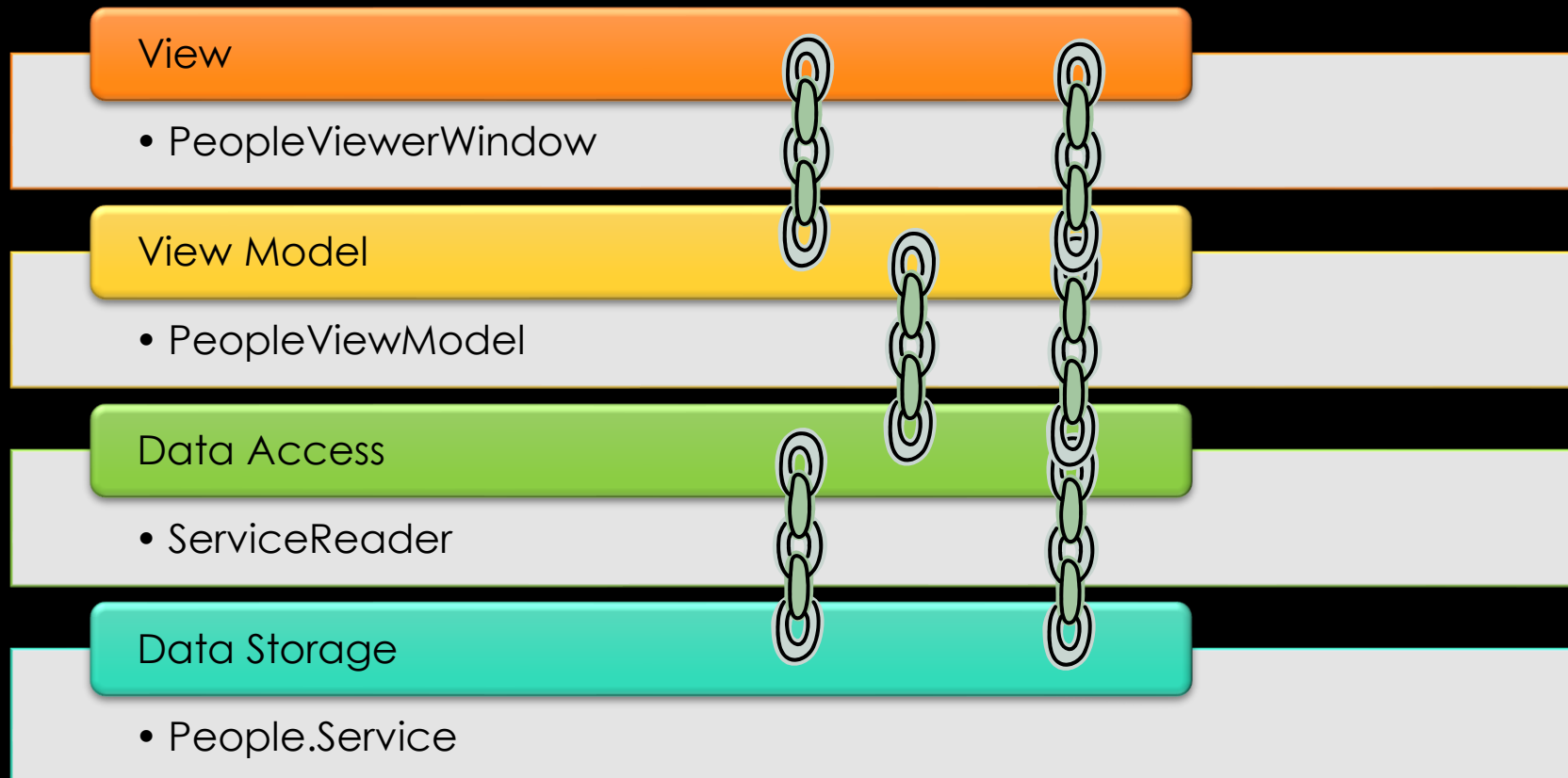
## Data Access

- ServiceReader

## Data Storage

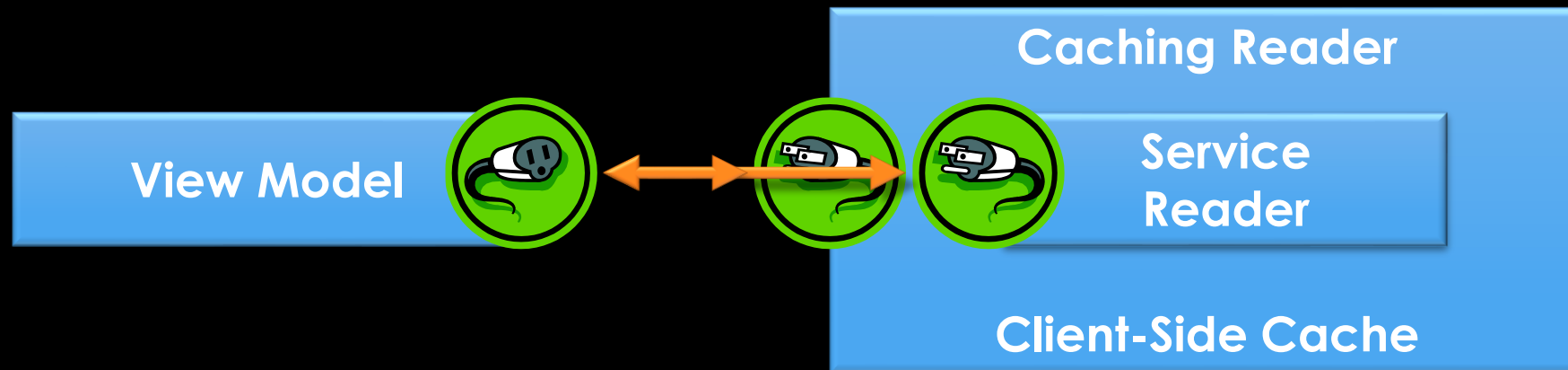
- People.Service

# Tight Coupling

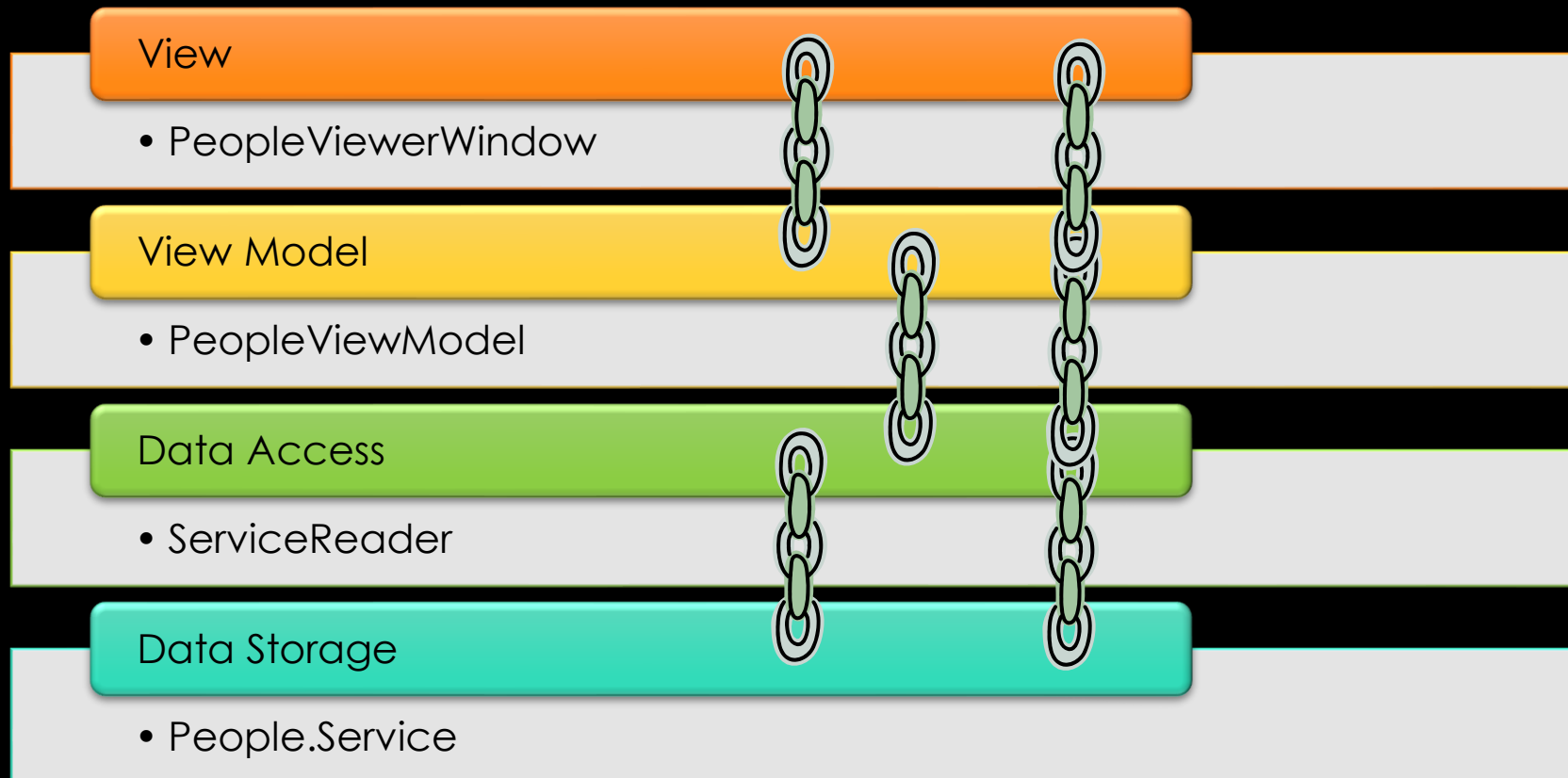


# Creating a Caching Reader

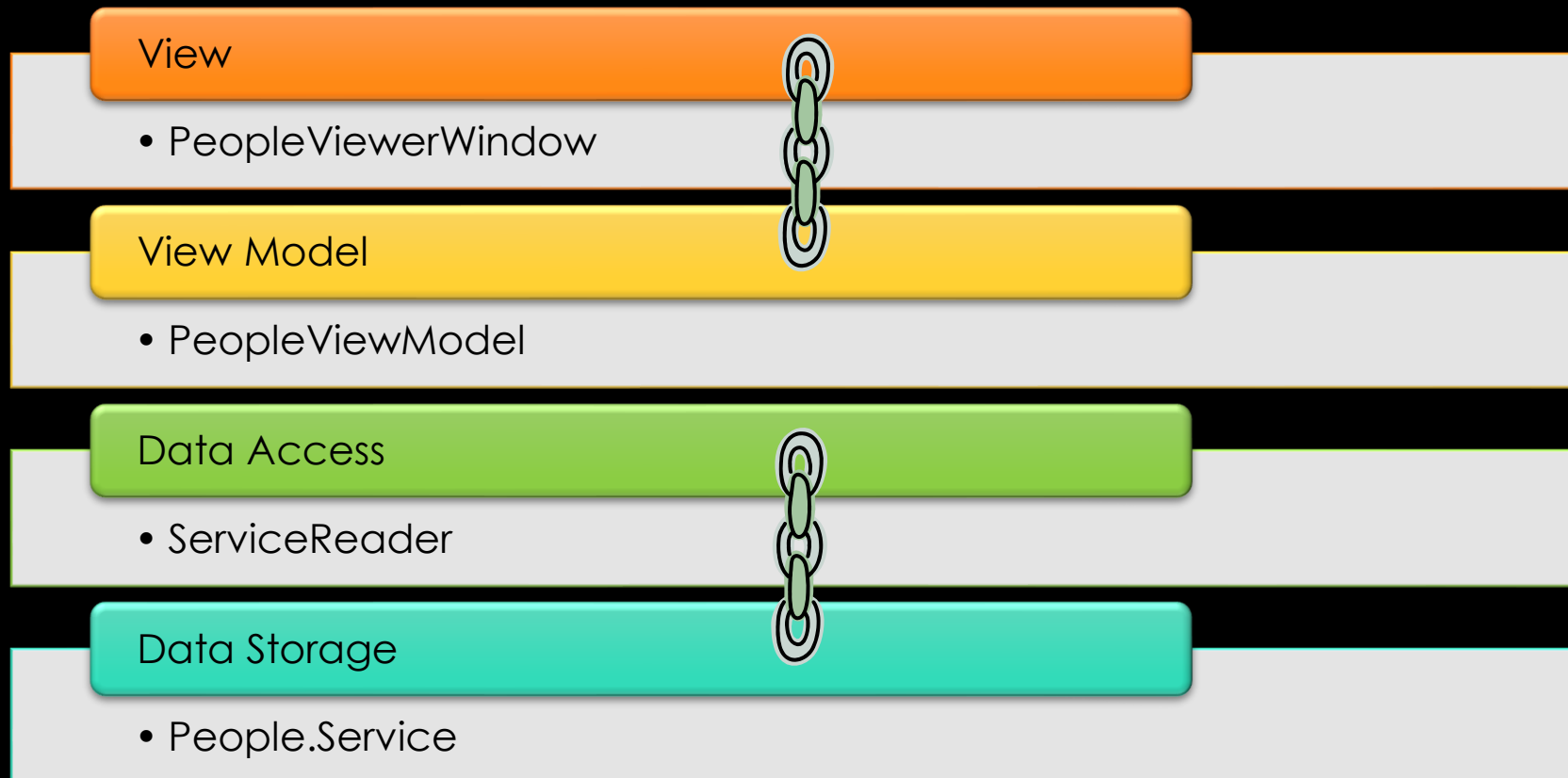
## The Decorator Pattern



# Loose(r) Coupling



# Loose(r) Coupling



# Primary Benefits

- Extensibility
  - Parallel Development
  - Maintainability
  - Testability
  - Late Binding
- 
- Adherence to S.O.L.I.D. Design Principles.

# Dependency Injection Concepts

- DI Design Patterns
  - Constructor Injection
  - 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 3<sup>rd</sup> 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 Oshero

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.

**automated piece of code**

**a unit of work**

**checks a single  
assumption**

*The Art of Unit Testing* by Roy Osherove

# 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>
- NUnit provides a custom Assert class that contains additional functionality
  - <https://docs.nunit.org/articles/nunit/writing-tests/assertions/assertions.html>





# Benefits

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

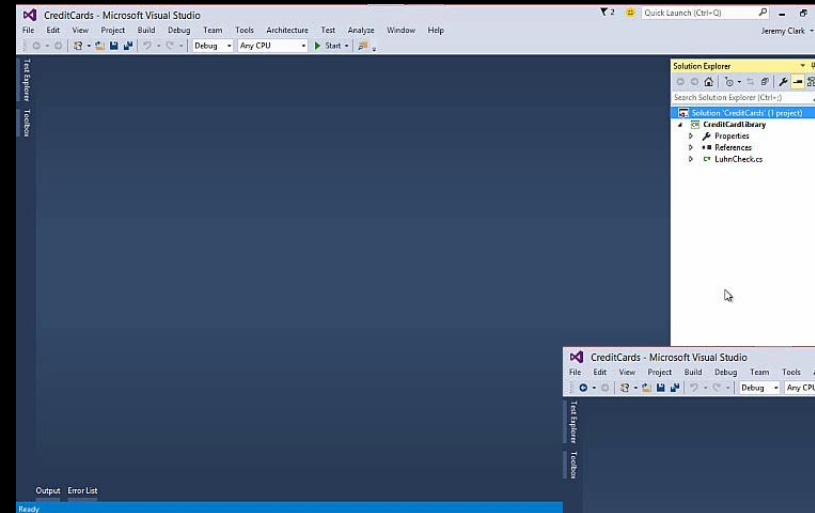


# Confirming Functionality

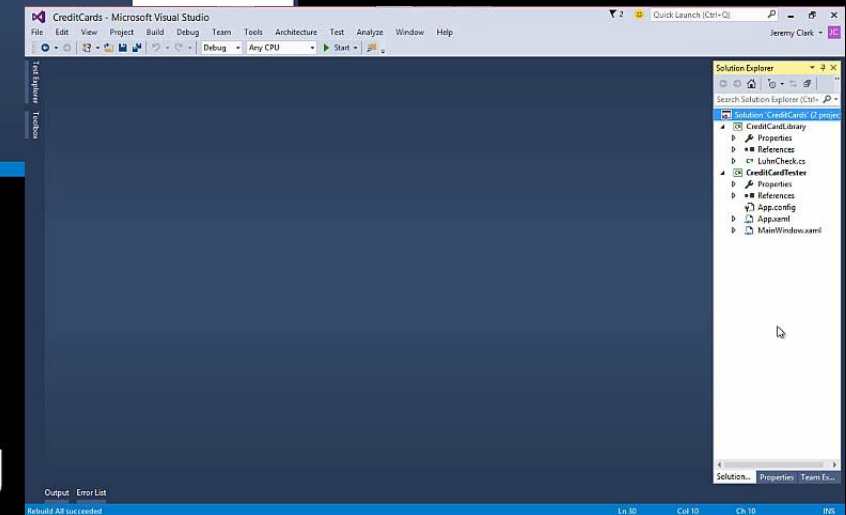
Unit Tests are ***proof*** that my code  
does what I ***think*** it does

# Build Time Comparison

# Test Application



# Unit Testing

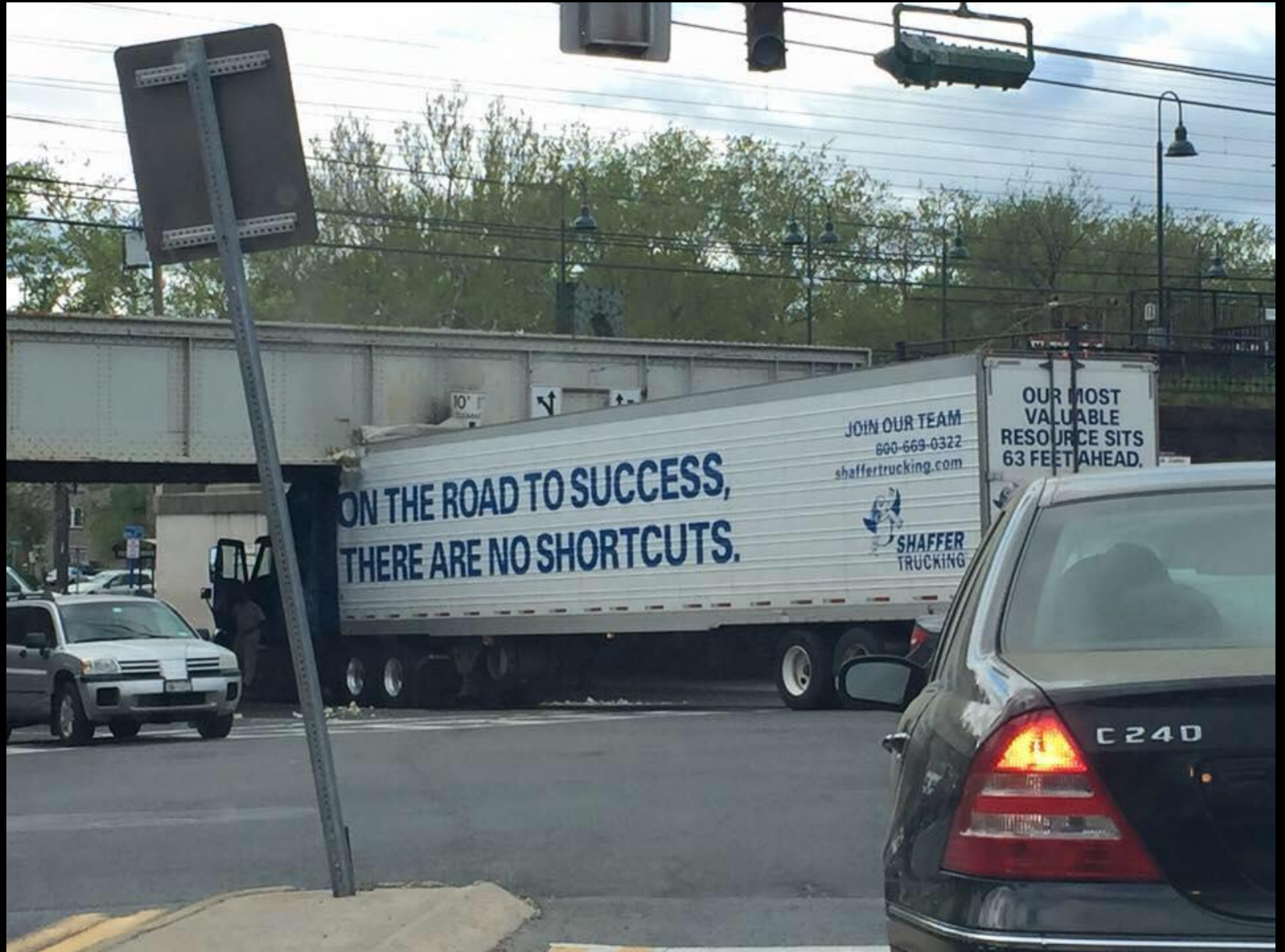


An abstract graphic at the top of the slide featuring a series of overlapping, wavy bands in shades of orange, red, yellow, and green, set against a black background.

# Disclaimer

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

# Realistic Expectations





# Checking Regression

The screenshot displays the Visual Studio IDE with the Test Explorer on the left and the LuhnCheckTests.cs file open in the editor on the right.

**Test Explorer (Left):**

- Search bar: [Search]
- Buttons: Run All | Run... | Playlist: All Tests
- Section: **Passed Tests (15)**
- Test Results (all passed):
  - PassesLuhnCheck\_OnInvalidNumber\_ReturnsFalse("-01233454567") < 1 ms
  - PassesLuhnCheck\_OnInvalidNumber\_ReturnsFalse("123") < 1 ms
  - PassesLuhnCheck\_OnInvalidNumber\_ReturnsFalse("7147894289") 8 ms
  - PassesLuhnCheck\_OnInvalidNumber\_ReturnsFalse("9876543210987654") < 1 ms
  - PassesLuhnCheck\_OnInvalidNumber\_ReturnsFalse("abc") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("3530111333300000") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("3566002020360505") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("371449635398431") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("378282246310005") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("401288888881881") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("411111111111111") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("5105105105105100") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("555555555554444") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("6011000990139424") < 1 ms
  - PassesLuhnCheck\_OnValidNumber\_ReturnsTrue("601111111111117") < 1 ms

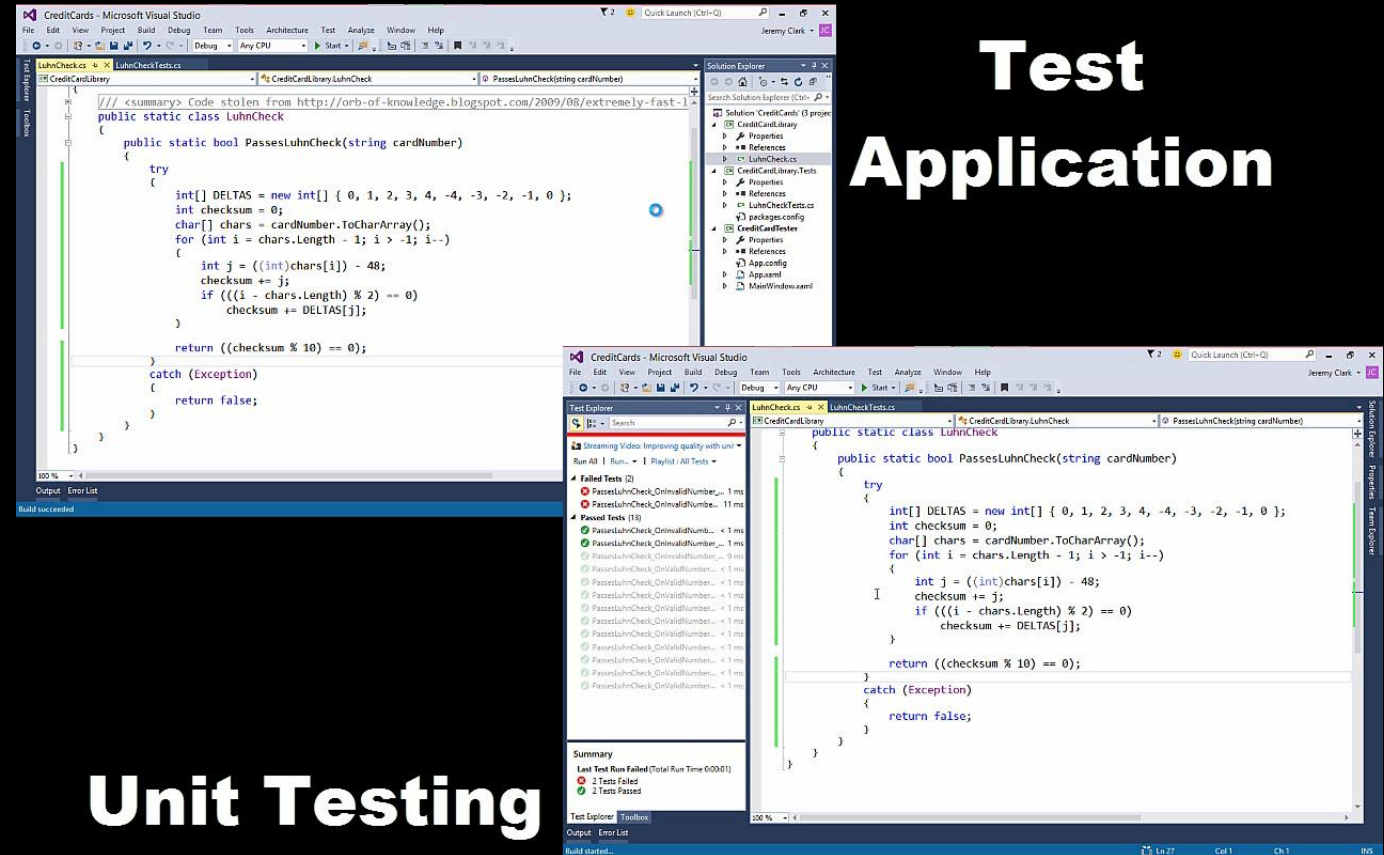
**Source Code (Right):**

```
LuhnCheckTests.cs
public static class LuhnCheck
{
    public static bool PassesLuhnCheck(string cardNumber)
    {
        try
        {
            int[] DELTAS = new int[] { 0, 1, 2, 3, 4, -4, -3, -2, -1 };
            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

**Test Explorer**

Streaming Video: Improving quality with unit tests and fakes

Run All | Run... | Playlist: All Tests

**Failed Tests (6)**

- ✗ CatalogViewModel\_OnInitialization\_ModelIsPopulated 161 ms
- ✗ ModelSelectedItems\_AddToSelectionWithExistingPerson\_SelectionIsUnchanged 2 ms
- ✗ ModelSelectedItems\_AddToSelectionWithNewPerson\_PersonAdded 3 ms
- ✗ ModelSelectedItems\_RemoveFromSelectionWithExistingPerson\_PersonRemoved 1 ms
- ✗ ModelSelectedItems\_RemoveFromSelectionWithNewPerson\_SelectionIsUnchan... 1 ms
- ✗ ModelSelectedPeople\_OnClearSelection\_IsEmpty 1 ms

**Passed Tests (13)**

- ✓ Catalog\_FilterDoesNotInclude00s\_00sRecordsIsNotIncluded < 1 ms
- ✓ Catalog\_FilterDoesNotInclude70s\_70sRecordsIsNotIncluded 1 ms
- ✓ Catalog\_FilterIncludes00s\_00sRecordsIsIncluded < 1 ms
- ✓ Catalog\_FilterIncludes70s\_70sRecordsIsIncluded 1 ms
- ✓ CatalogService\_OnRefreshAndCacheExpired\_ServicesCalledTwice 31 ms
- ✓ CatalogService\_OnRefreshAndCacheNotExpired\_ServicesCalledOnce 1 sec
- ✓ CatalogViewModel\_OnInitialization\_CatalogIsPopulated 1 ms
- ✓ CatalogViewModel\_OnInitializationAndCurrentOrderMissing\_ThrowsException 1 ms
- ✓ CatalogViewModel\_OnInitializationAndPersonServiceMissing\_ThrowsException < 1 ms
- ✓ CatalogViewModel\_OnInitializationWithNoServiceException\_DoesNotThrowE... 198 ms
- ✓ CatalogViewModel\_OnInitializationWithServiceException\_ThrowsExceptionOnC... 2 ms
- ✓ Filters\_OnRefreshAndCacheExpired\_AreResetToDefaults 1 ms

**Summary**

Last Test Run Failed (Total Run Time 0:00:03)

- ✗ 6 Tests Failed
- ✓ 13 Tests Passed

**CatalogViewModel.cs**

```
#region Methods

public void Initialize()
{
    _service = GetServiceFromContainer();
    GetModelFromContainer();

    RefreshCatalog();
}

private CatalogOrder GetModelFromContainer()
{
    if (!_container.IsRegistered<CatalogOrder>("CurrentOrder"))
        throw new MissingFieldException(
            "CurrentOrder is not available from the DI Containe");
    return _container.Resolve<CatalogOrder>("CurrentOrder");
}

private IPersonService GetServiceFromContainer()
{
    if (!_container.IsRegistered<IPersonService>())
        throw new MissingFieldException(
            "IPersonService is not available from the DI Contai");
    return _container.Resolve<IPersonService>();
}

public void RefreshCatalog()...

private void RefreshCatalogFromService()...
```

# Documenting Functionality

- ✓ Catalog\_FilterDoesNotInclude00s\_00sRecordsIsNotIncluded
- ✓ Catalog\_FilterDoesNotInclude70s\_70sRecordsIsNotIncluded
- ✓ Catalog\_FilterIncludes00s\_00sRecordsIsIncluded
- ✓ Catalog\_FilterIncludes70s\_70sRecordsIsIncluded
- ✓ CatalogService\_OnRefreshAndCacheExpired\_ServicesCalledTwice
- ✓ CatalogService\_OnRefreshAndCacheNotExpired\_ServicesCalledOnce
- ✓ CatalogViewModel\_OnInitialization\_CatalogsPopulated
- ✓ CatalogViewModel\_OnInitialization\_ModelsPopulated
- ✓ CatalogViewModel\_OnInitializationAndCurrentOrderMissing\_ThrowsException
- ✓ CatalogViewModel\_OnInitializationAndPersonServiceMissing\_ThrowsException

- ✓ Filters\_OnRefreshAndCacheExpired\_AreResetToDefaults
- ✓ Filters\_OnRefreshAndCacheNotExpired\_AreResetToDefaults

- ✓ ModelSelectedItem\_AddToSelectionWithExistingPerson\_SelectionIsUnchanged
- ✓ ModelSelectedItem\_AddToSelectionWithNewPerson\_PersonAdded

An abstract graphic at the top of the slide featuring a series of overlapping, wavy bands in shades of orange, red, yellow, and green, set against a black background.

# 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  $1/10^{\text{th}}$  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

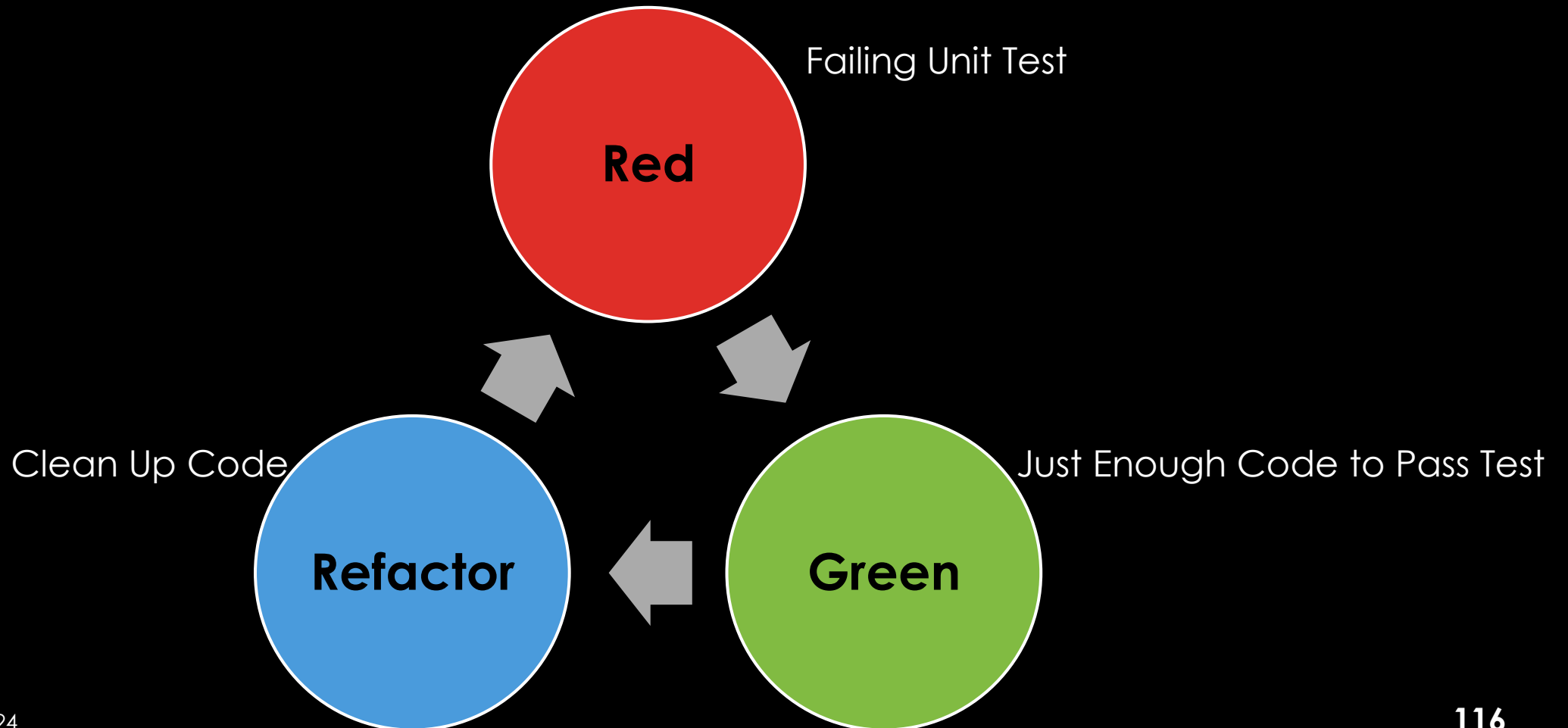
- Consistent Results
- Isolated
- Continued Relevance
- Tests the Right Things

## 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”

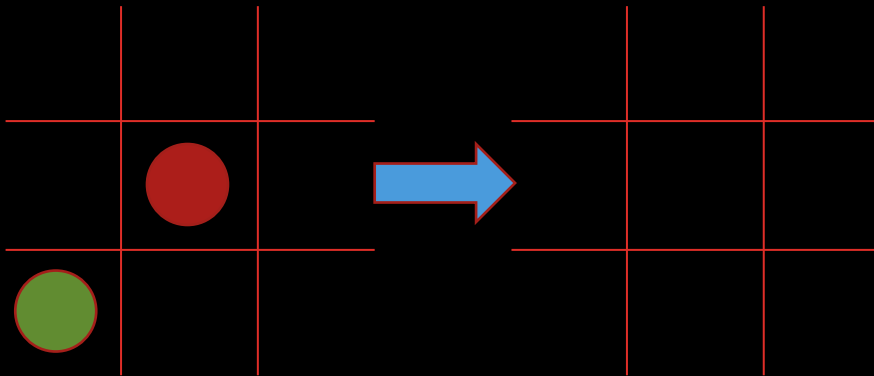
- |        |            |
|--------|------------|
| • 1    | • BUZZ     |
| • 2    | • 11       |
| • Fizz | • Fizz     |
| • 4    | • 13       |
| • BUZZ | • 14       |
| • Fizz | • FizzBUZZ |
| • 7    | • 16       |
| • 8    | • 17       |
| • Fizz | • Fizz     |

# Conway's Game of Life

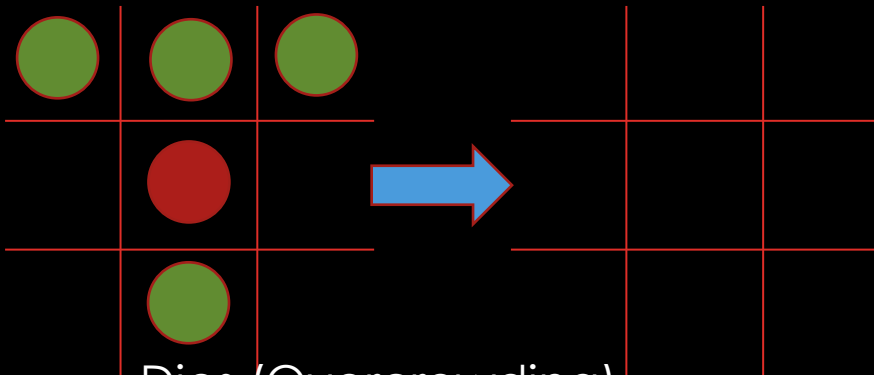
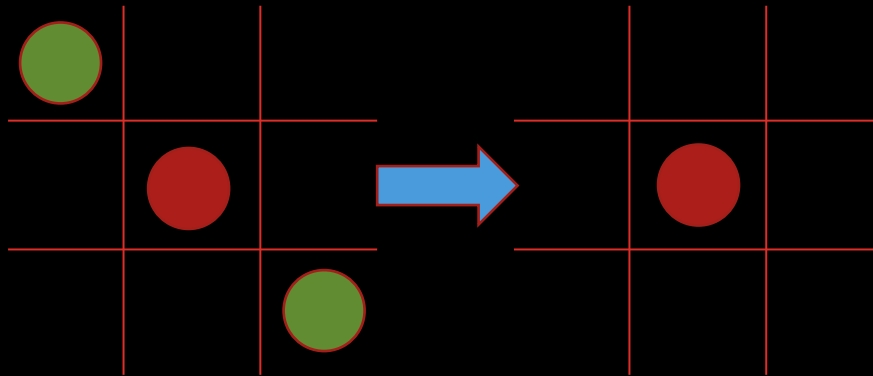
- Any live cell with fewer than two live neighbours dies.
- Any live cell with two or three live neighbours lives.
- Any live cell with more than three live neighbours dies.
- Any dead cell with exactly three live neighbours becomes a live cell.

# Conway's Game of Life

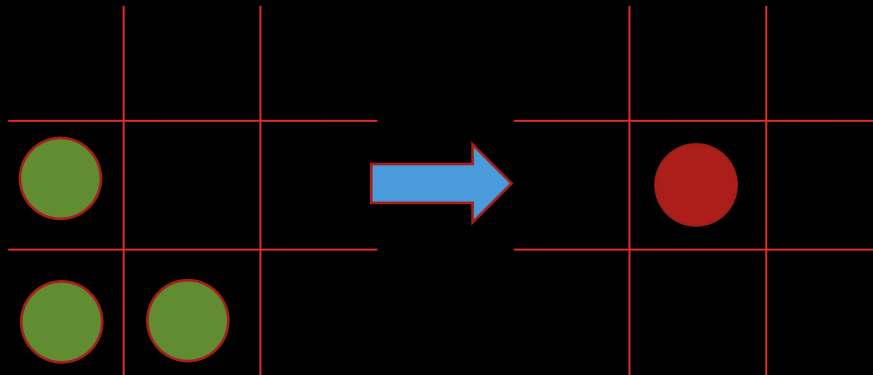
Dies (Loneliness)



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 IPersonRepository GetTestRepository()
{
    var people = new List<Person>()
    {
        new Person() {FirstName = "John", LastName = "Smith",
            Rating = 7, StartDate = new DateTime(2000, 10, 1)},
        new Person() {FirstName = "Mary", LastName = "Thomas",
            Rating = 9, StartDate = new DateTime(1971, 7, 23)},
    };

    var repoMock = new Mock<IPersonRepository>();
    repoMock.Setup(r => r.GetPeople()).Returns(people);
    return repoMock.Object;
}
```

# Setup with Parameters

```
public IPersonService GetTestService()
{
    var people = new List<Person>()
    {
        new Person() {FirstName = "John", LastName = "Smith",
            Rating = 7, StartDate = new DateTime(2000, 10, 1)},
        new Person() {FirstName = "Mary", LastName = "Thomas",
            Rating = 9, StartDate = new DateTime(1971, 7, 23)},
    };

    var svcMock = new Mock<IPersonService>();
    svcMock.Setup(s => s.GetPeople()).Returns(people.ToArray());
    svcMock.Setup(s => s.GetPerson(It.IsAny<string>()))
        .Returns((string n) => people.FirstOrDefault(p => p.LastName == n));
    return svcMock.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

```
IPersonRepository _repository;

[TestInitialize]
public void Setup()
{
    var people = new List<Person>()
    {
        new Person() {FirstName = "John", LastName = "Smith",
            Rating = 7, StartDate = DateTime.Parse("10/01/2000")},
        new Person() {FirstName = "Mary", LastName = "Thomas",
            Rating = 9, StartDate = DateTime.Parse("07/23/1971")},
    };

    var repoMock = new Mock<IPersonRepository>();
    repoMock.Setup(r => r.GetPeople()).Returns(people);
    _repository = repoMock.Object;
}
```

```
[TestMethod]
public void People_OnRefreshCommand_IsPopulated()
{
    // Arrange
    var vm = new MainWindowViewModel(_repository);

    // Act
    vm.RefreshPeopleCommand.Execute(null);

    // Assert
    Assert.IsNotNull(vm.People);
    Assert.AreEqual(2, vm.People.Count());
}
```

# Sample with Factory Method

```
public IPersonRepository GetRepositoryStub()
{
    var people = new List<Person>()
    {
        new Person() {FirstName = "John", LastName = "Smith",
            Rating = 7, StartDate = DateTime.Parse("10/01/2000")},
        new Person() {FirstName = "Mary", LastName = "Thomas",
            Rating = 9, StartDate = DateTime.Parse("07/23/1971")},
    };

    var repoMock = new Mock<IPersonRepository>();
    repoMock.Setup(r => r.GetPeople()).Returns(people);
    return repoMock.Object;
}
```

```
[TestMethod]
public void People_OnRefreshCommand_IsPopulated()
{
    // Arrange
    IPersonRepository repository = GetRepositoryStub();
    var vm = new MainWindowViewModel(repository);

    // Act
    vm.RefreshPeopleCommand.Execute(null);

    // Assert
    Assert.IsNotNull(vm.People);
    Assert.AreEqual(2, vm.People.Count());
}
```

# NUnit Parameterization

[Values()]

- The Values Attribute can be applied to parameters directly for individual values.
  - <https://docs.nunit.org/articles/nunit/writing-tests/attributes/values.html>

# [Values()] Attribute

```
[Test]
public void FizzBuzzWhenDivisibleBy3_ReturnsFizz(
    [Values(3, 6, 9, 12, 18)] int input)...
```

# NUnit Parameterization

## [Range()]

- The Range Attribute can be applied to parameters directly to test for a range of values.
  - <https://docs.nunit.org/articles/nunit/writing-tests/attributes/range.html>

# [Range()] Attribute

```
[Test]  
public void LiveCell_MoreThan3LiveNeighbors_Dies(  
    [Range(4, 8)] int liveNeighbors)...
```

# NUnit Parameterization

## [TestCase()]

- The [TestCase()] attribute can be applied to a test method to submit values for parameters.
  - <https://docs.nunit.org/articles/nunit/writing-tests/attributes/testcase.html>



# [TestCase()] Attribute

```
[TestCase("6011000990139424")]  
[TestCase("3530111333300000")]  
[TestCase("3566002020360505")]  
public void PassesLuhnCheck_OnValidNumber_ReturnsTrue(string cardNumber)...
```

# 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

- NUnit Testing
  - Use “Assert.Throws()” method to check a block of code.
  - Return value is the exception and can be checked for specific properties.
  - Alternately, use the “IResolveConstraint” specific to NUnit.
- <https://docs.nunit.org/articles/nunit/writing-tests/assertions/classic-assertions/Assert.Throws.html>

# 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!





Thank You!

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<https://github.com/jeremybytes/vslive2024-orlando>