

Functional Techniques for C#

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You are effective with the imperative, object-oriented core of Java or .NET but you look longingly at the winsome smile of functional languages.

If you play with your language's functional features, you're never quite sure if you're getting it right or taking full advantage of them. This talk is for you.

You'll learn which code to attack with functional ideas and how to do it.

You'll look at code similar to what you write every day, and see it transform from long, difficult-to-follow code to short code that's easy to understand, hard to mess up, and straightforward to debug. Better yet, functional approaches help you apply patterns in a clear and consistent way.

Apply these techniques while leveraging delegates, lambda expressions, base classes and generics.

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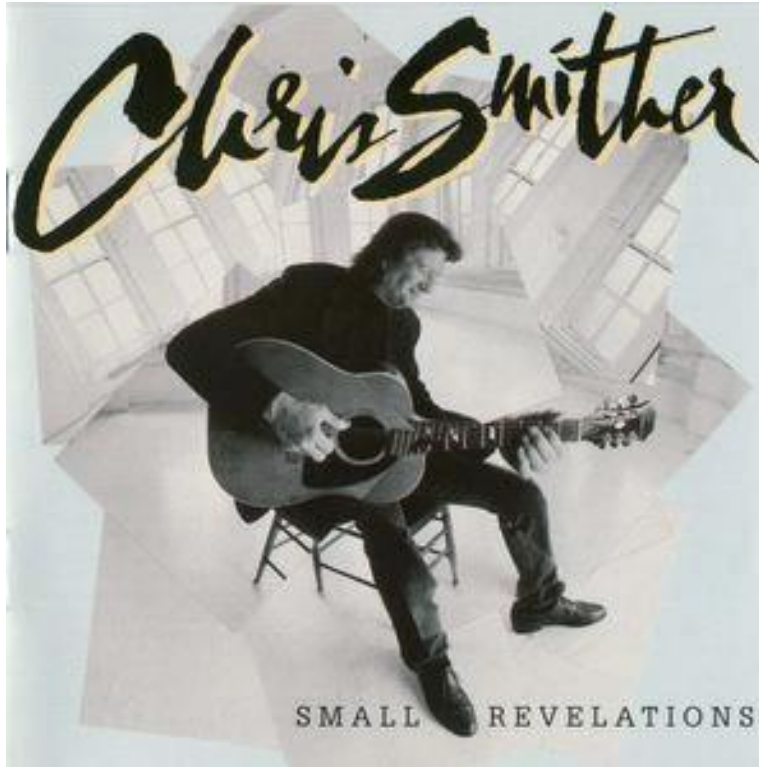
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Winsome Smile

Chris Smither

Small Revelations album



Winsome –

“attractive or appealing in appearance or character.”

- *Defined by Google*

What is a Functional Language?

Functional Language

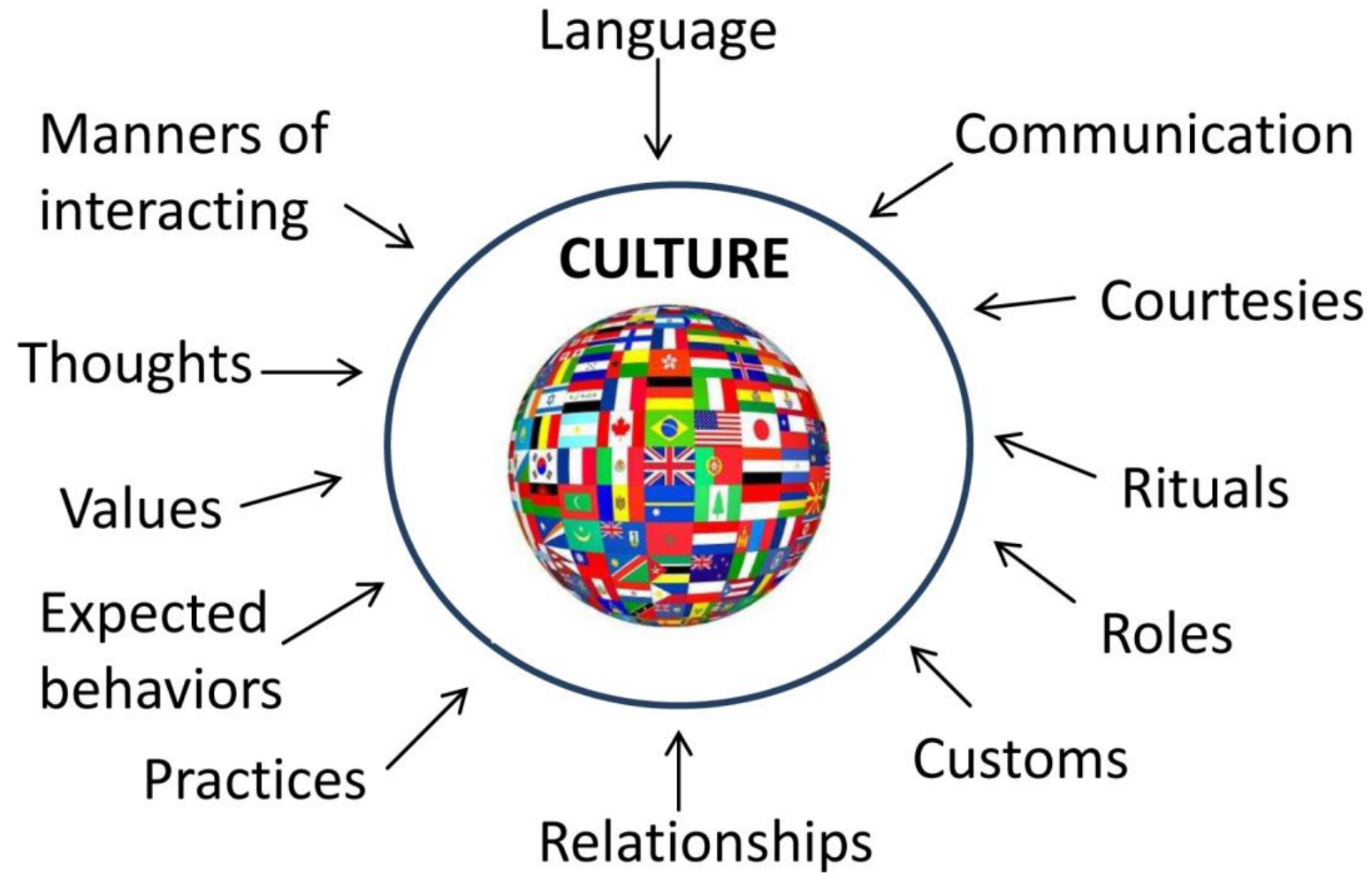
- Central construct is a function
- Functions are first class citizens

Object Oriented Language

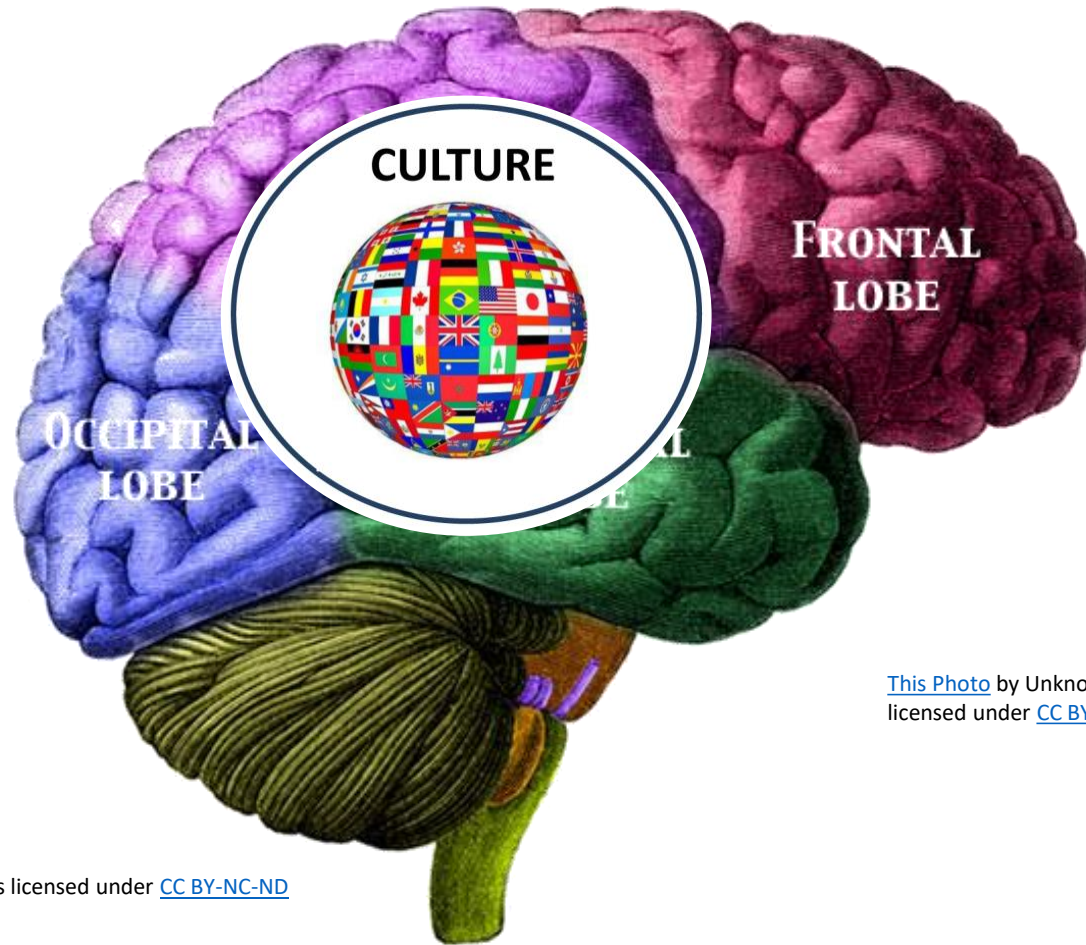
- Central concept is a class
- Functions may be (or may not be) first class citizens

Bigger distinctions

- Dynamic vs Strong/static typing
 - JavaScript vs Haskell
- Compiler intensity (policing)
 - JavaScript vs Haskell
- Compiled vs. interpreted
 - C# vs Visual Basic for Applications (VBA)
- Support for REPL
 - PowerShell or F#



Culture and language have a great impact on how you think



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Why functional?

- Testability
 - Parallel
 - Reuse
 - Expressiveness
 - Reasonableness
- Purity
 - Immutability
 - Inheritance, helper classes
 - Less smelly
 - Craftsmanship (naming, SRP, etc)

Why C# with Functional

- C#, Visual Basic (Java similar)
 - Lots of usage (your team might be using it)
 - Best of strong typing to reduce accidents
 - But that's noise!
 - Inference and implicit operators
 - Generics to reuse types
 - Extension methods to extend types
 - Functions first class citizens (strongly typed delegates)
 - Expressions: a structure to describe delegate contents
- Keep the best of this, add more...

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Purity

- No surprises!
 - Should indicate all possible input/output
 - Same input should **always** result in same output

Demo!

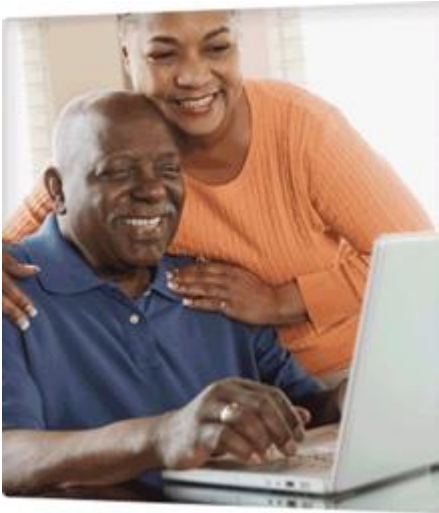
Purity

Purity

- No surprises!
 - Should indicate all possible input/output
 - Same input should *always* result in same output
 - Control flow should be entirely predictable
 - Careful planning for exception
 - Void methods (except those doing absolutely nothing) are not pure
- Pure code is easy to test
 - Be clear within your project what “the world can’t change” means

Purity is rather boring

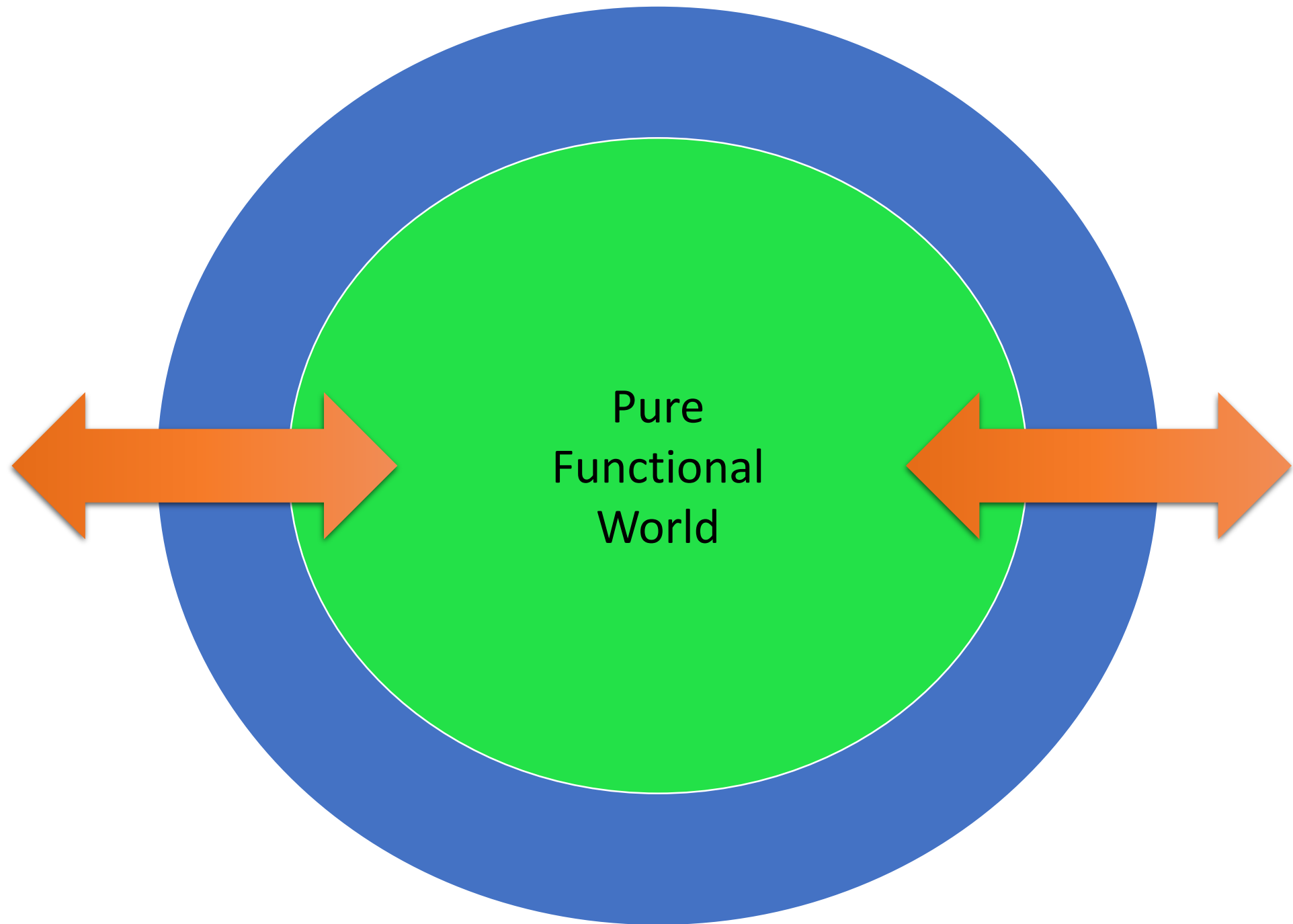
Might look like this in C# (our goal)



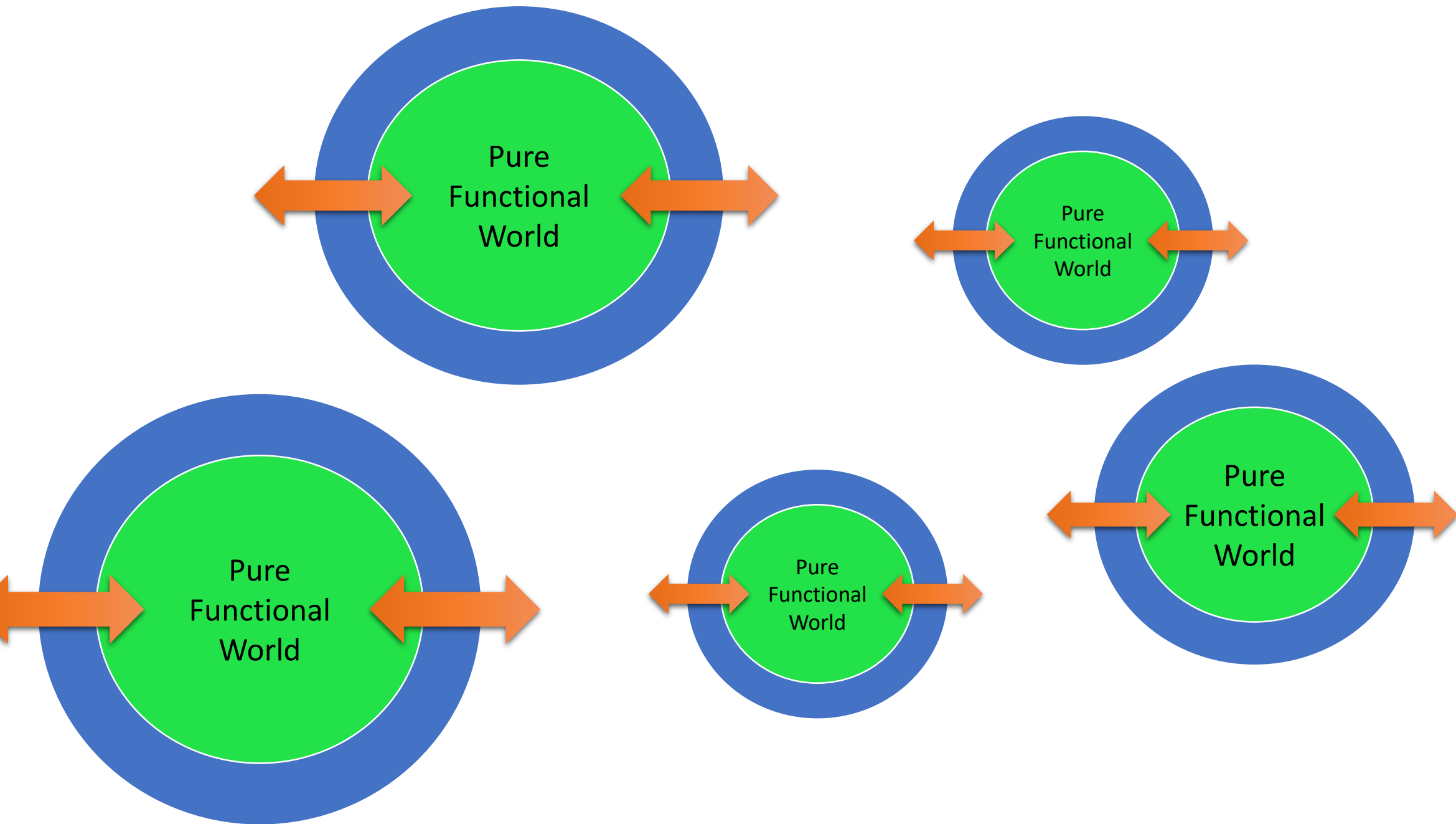
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Separate pure and not pure code

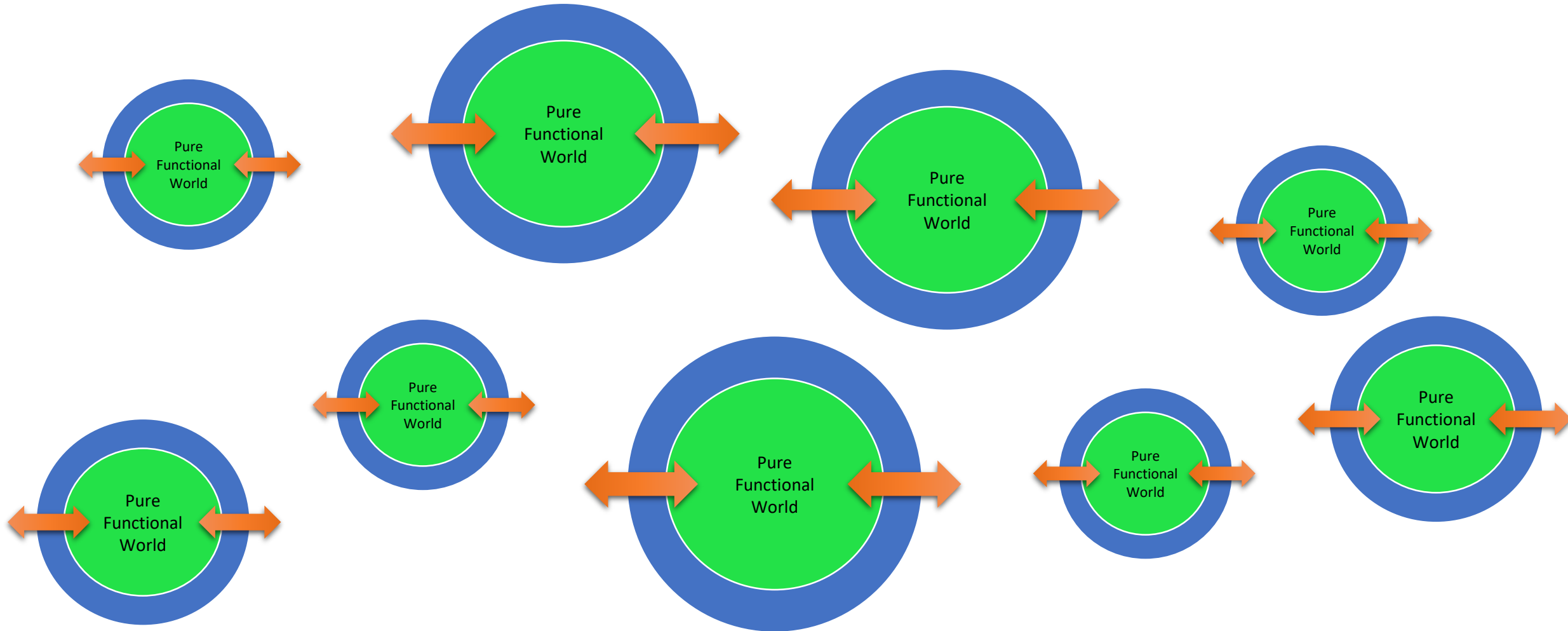


C#



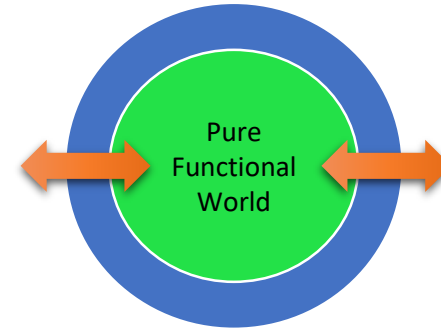
Functional
techniques

C# is statically typed and allows multiple internal functional islands



The ability to test is a measure of architectural sanity

- Unit tests within pure units
- Automated functional tests between units
- Don't mingle pure and impure code
- Don't mingle unit and functional tests



Rather confusing that we call our automated test tools unit test tools

Separate pure and not pure code

Separate pure and not pure code

Separate pure and not pure code

C# 7 and functional constructs (opinion)

First class functions		A-
Purity		D
Immutability		B-
OOP		A
Strong typing		A
Generics		A
Pattern matching		C
Expression Trees		A
Duck typing		F
Records		F

Functions as first-class citizens

- Define functions (like data)
- Pass functions around (like data)
- Support higher order functions
 - Functions with delegate parameters or return delegates
- In C# (and Visual Basic) this means Delegates

Delegates – functions as data

- Generic delegate types (Action, Func)
- Type safe function pointers
 - System.Delegate and inherited types
 - “Named” in docs
 - Anonymous methods
 - delegate()
 - Reference to a method (name without parens)
 - Can be a local method
 - Lambdas

Delegates – functions as data

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- Type safe function pointers
 - ~~• System.Delegate and inherited types~~
 - ~~• “Named” in docs~~
 - ~~• Anonymous methods~~
 - ~~• delegate()~~
 - Reference to a method (name without parens)
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 - Lambdas

f

Delegate

Lambda

func

Are the same in today's context

- Delegates are code fragments that can be stored to execute later
- **Func<T>**
 - **Func<T<T1<T2>>>**
- **Func<T1, T2>**
 - **Func<TParam, T<T1<T2>>>**
 - **Func<int, Task<DataResult<List<Student>>>>**
- **=>**
 - **Func<int, int> f1 = x => x + 2;**
 - **Func<int> f2 = () => 42;**
 - **Func<int, int, int> f3 = (x, y) => x + y;**
- **...Where<T>(Func<T, bool> predicate)**

LINQ

- Select, Where, OrderBy etc. are higher order functions
- They are pure because they return a new list
- Lambdas are not free, especially with closures

```
var x = 42;
```

```
var y = list.Where(z => z.Id == x);
```

- In memory loops are faster in high performance code (like .NET framework)
- Expressions contain code definition
 - Can be understood in different languages
 - Like TSQL

- Action: Delegates that don't return a value
 - **Action<T>**
 - **Action<T<T1<T2>>>**
 - Not pure (unless trivial)
 - Doesn't interchange with Func (not polymorphic)
 - ...RecordTime<T>(Func<T> op)
 - ...RecordTime<T>(Func<T, T2> op)
 - ...
 - ...RecordTime<T>(Action<T> op)
 - ...RecordTime<T>(Action<T, T2> op)
- Arity**

Can convert delegate types to each other

```
public static class ActionExt
{
    public static Func<Unit> ToFunc(this Action action)
        => () => { action(); return VoidType(); };

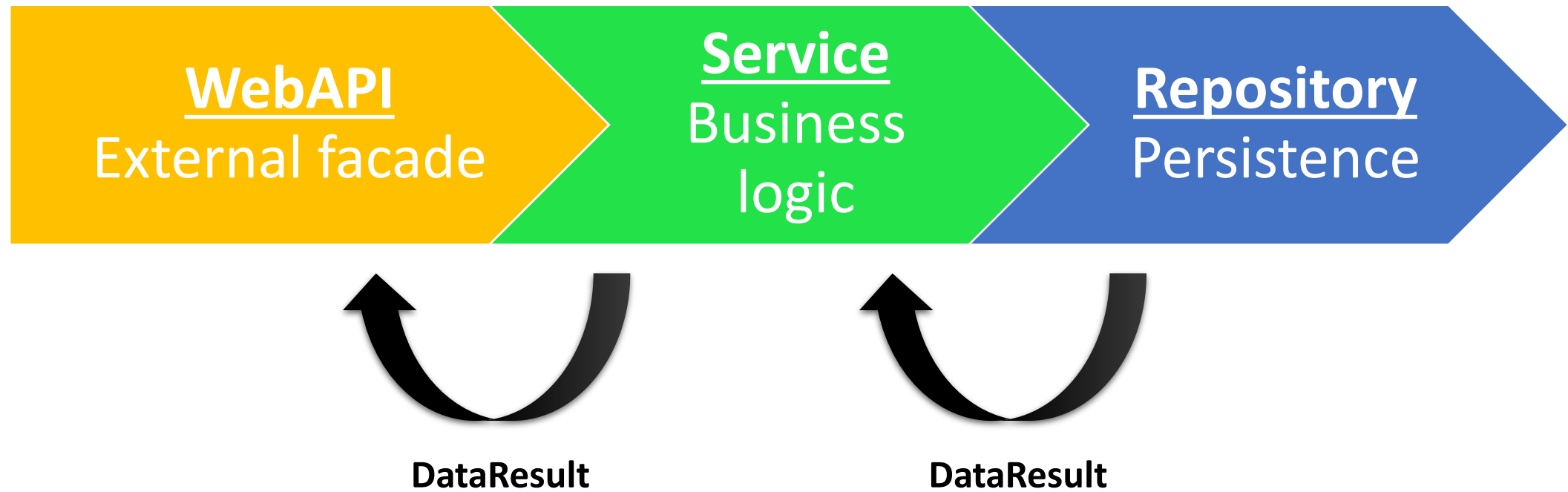
    public static Func<T, Unit> ToFunc<T>(this Action<T> action)
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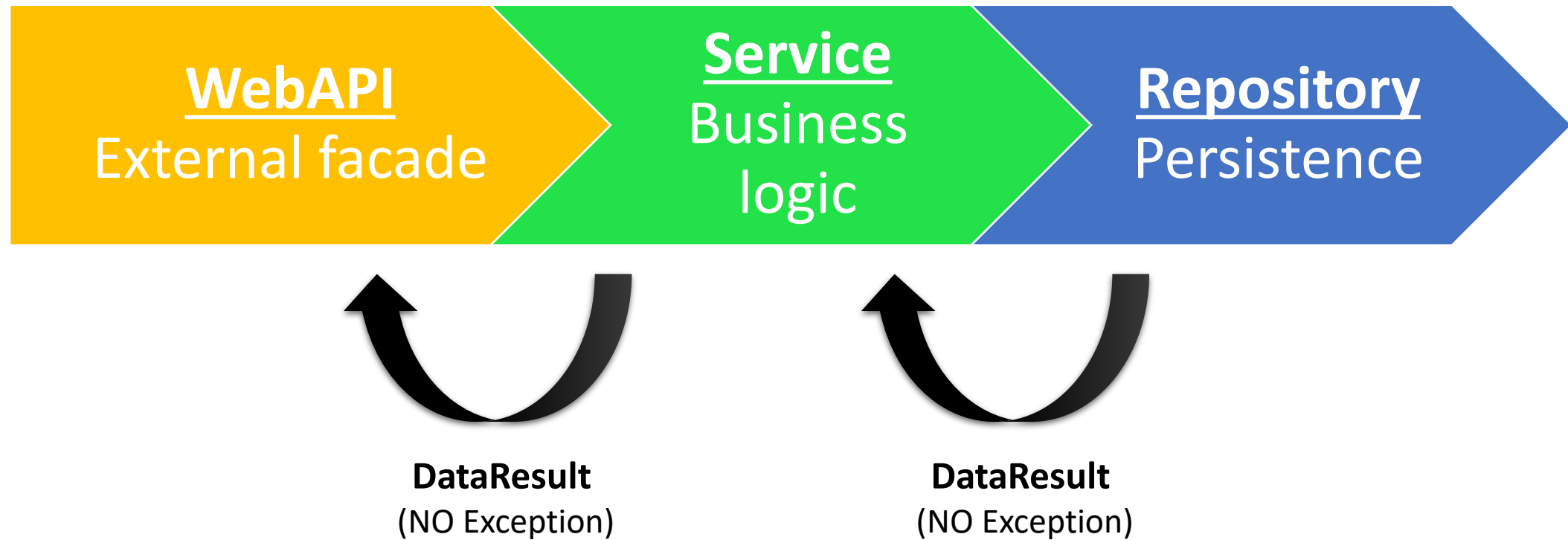
    public static Func<T1, T2, Unit> ToFunc<T1, T2>(
        this Action<T1, T2> action)
        => (T1 x, T2 y) => { action(x, y); return VoidType(); };
}
```

Handling Errors

What could possibly go wrong?

- Protocol failure like routing (one, not seen by app)
- Unpacking behavior like bad JSON format (one, seen by infrastructure)
- Validation like string too long (many)
- Anticipated environment issues like database missing (one, ☞ ops)
- Unexpected app failure like null reference (one, ☞ programmers)
- Batch process, last 3 above for each item
 - All succeed
 - Some succeed
 - None succeed





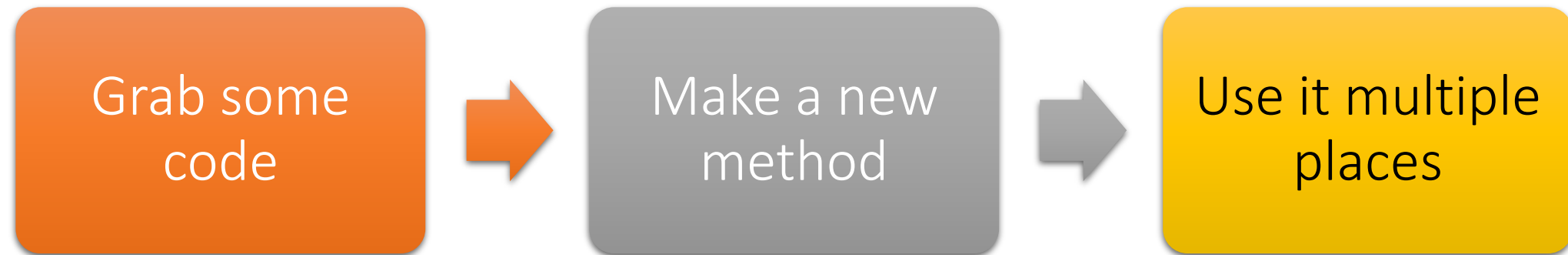
Demo!

`DataResult<TData>`

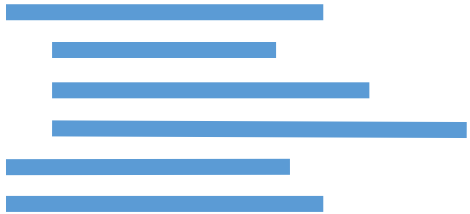
Refactoring to Functional

Imperative (normal) Refactoring

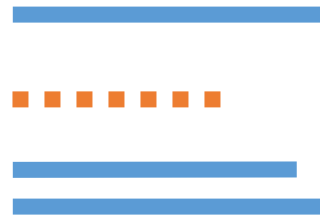
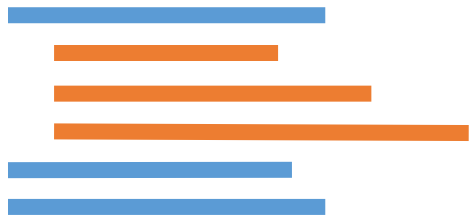
- Inside out refactoring



Imperative Refactoring



Imperative Refactoring

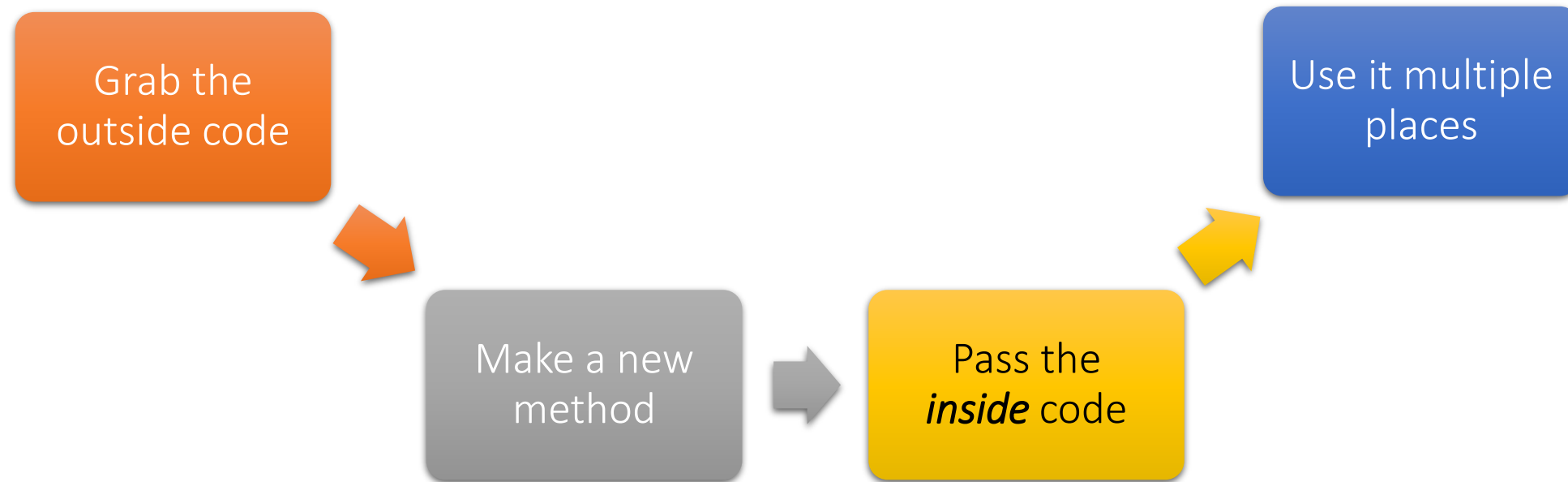


Demo!

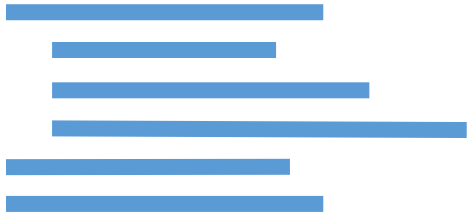
Inside out refactoring (normal)

Functional Refactoring

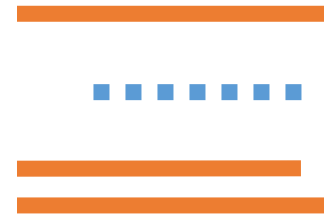
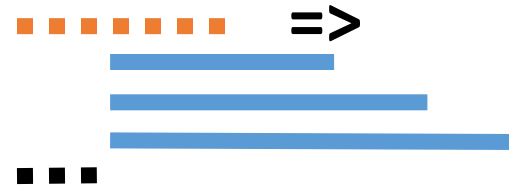
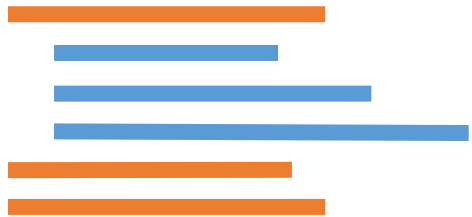
- Outside in refactoring



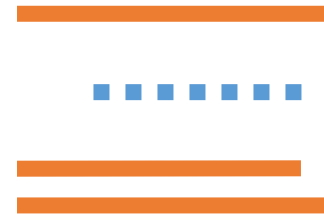
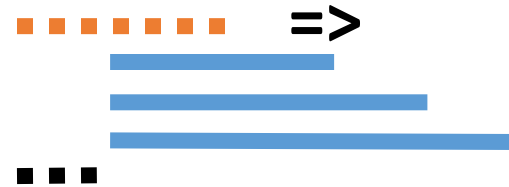
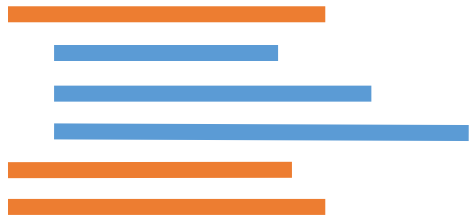
Functional Refactoring



Functional Refactoring



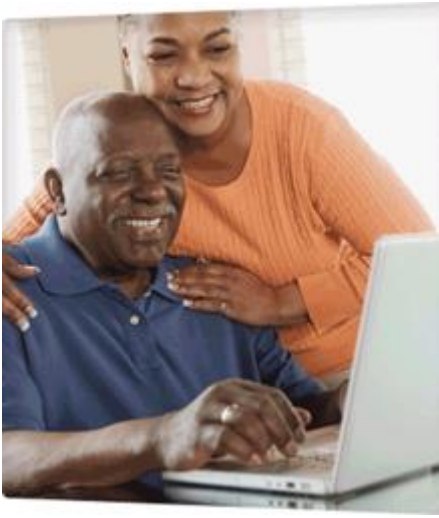
Functional Refactoring



Demo!

Outside in refactoring

Might look like this in C#



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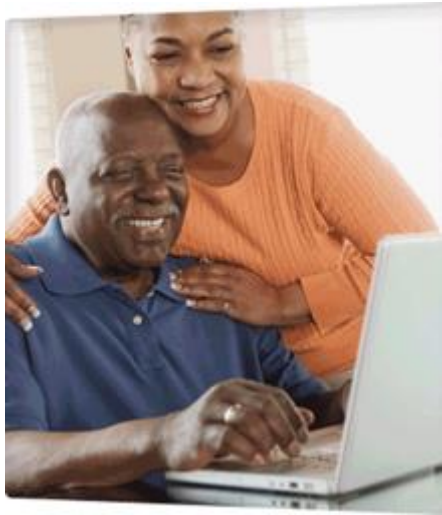


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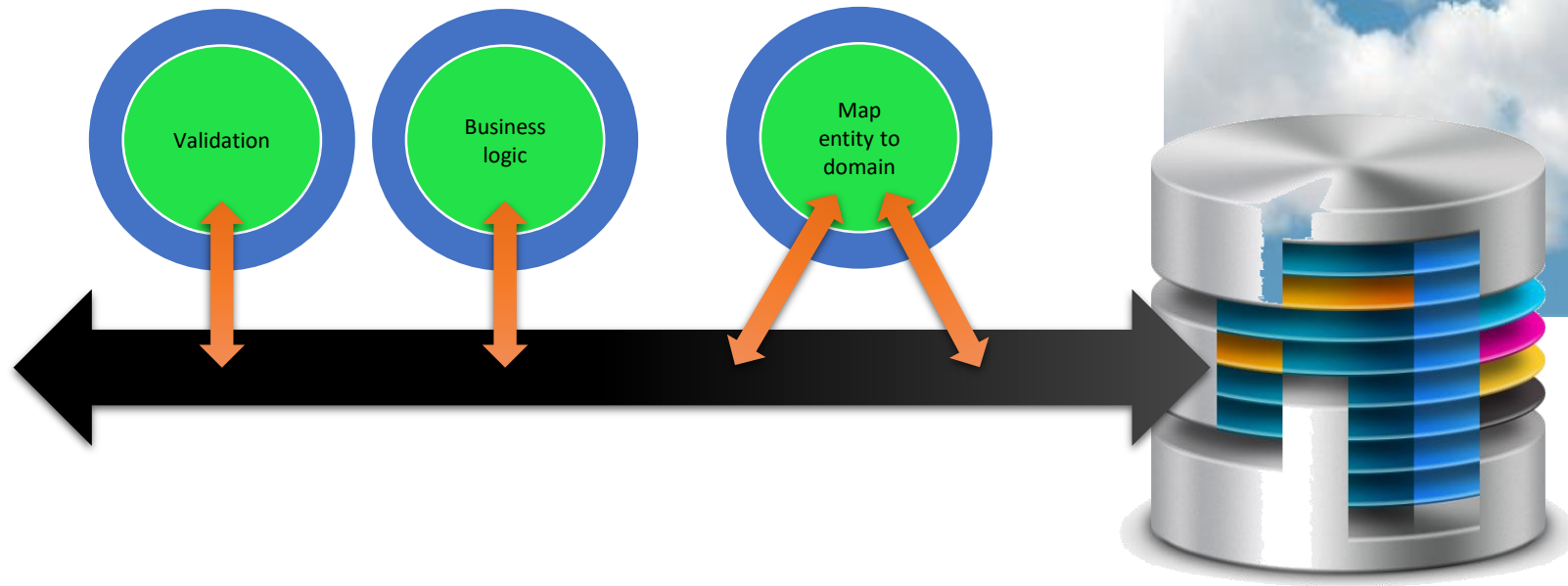


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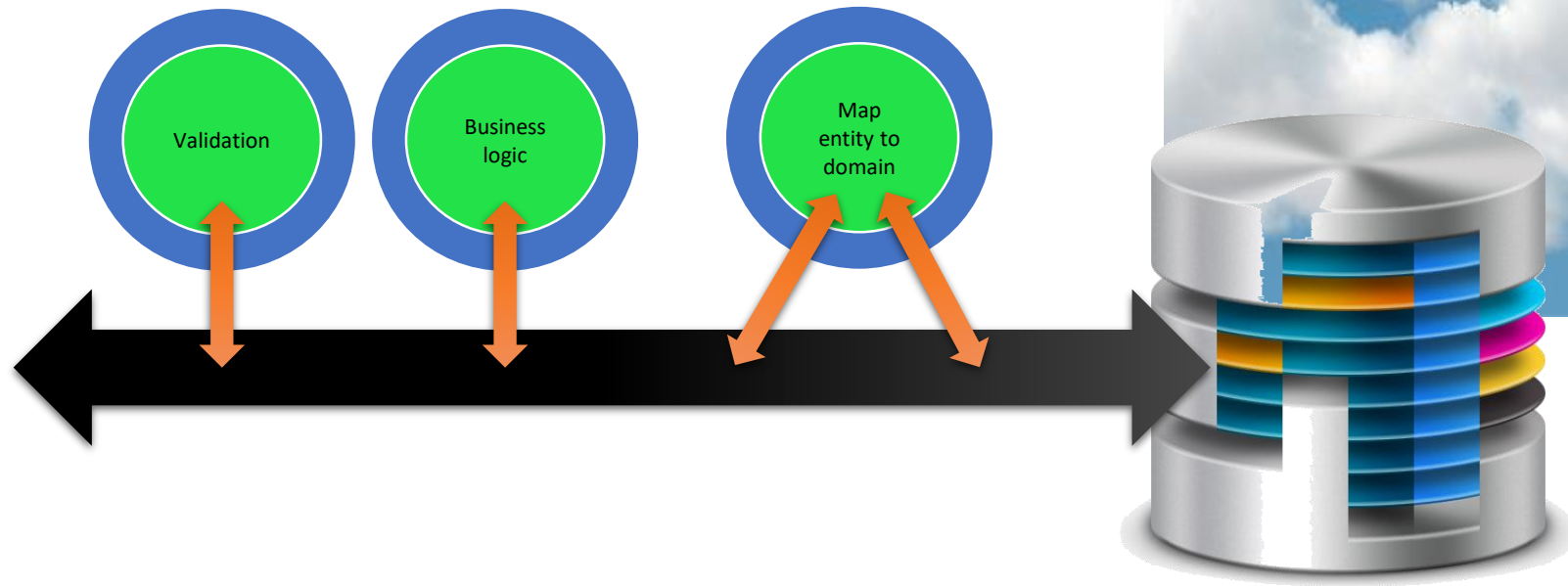
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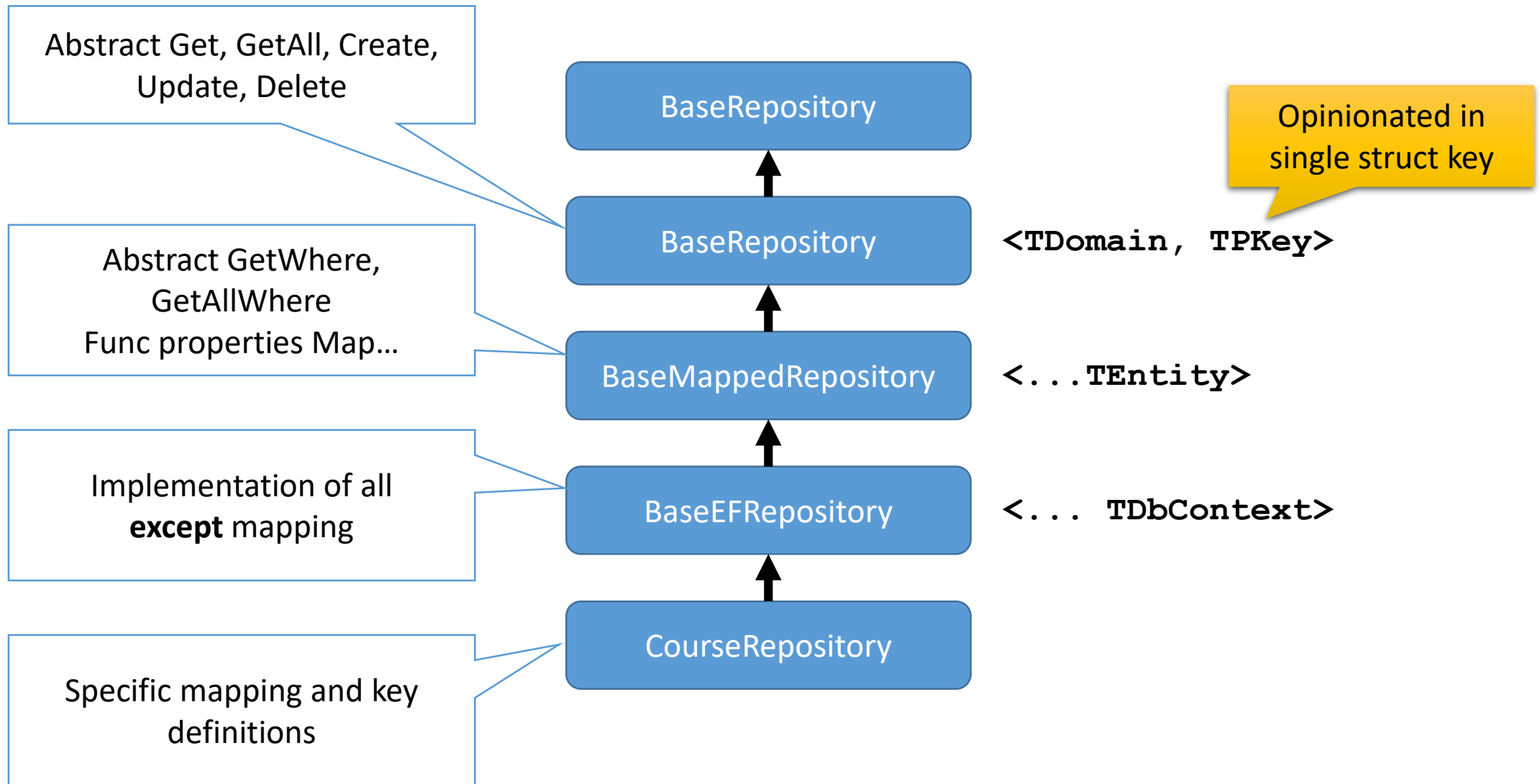
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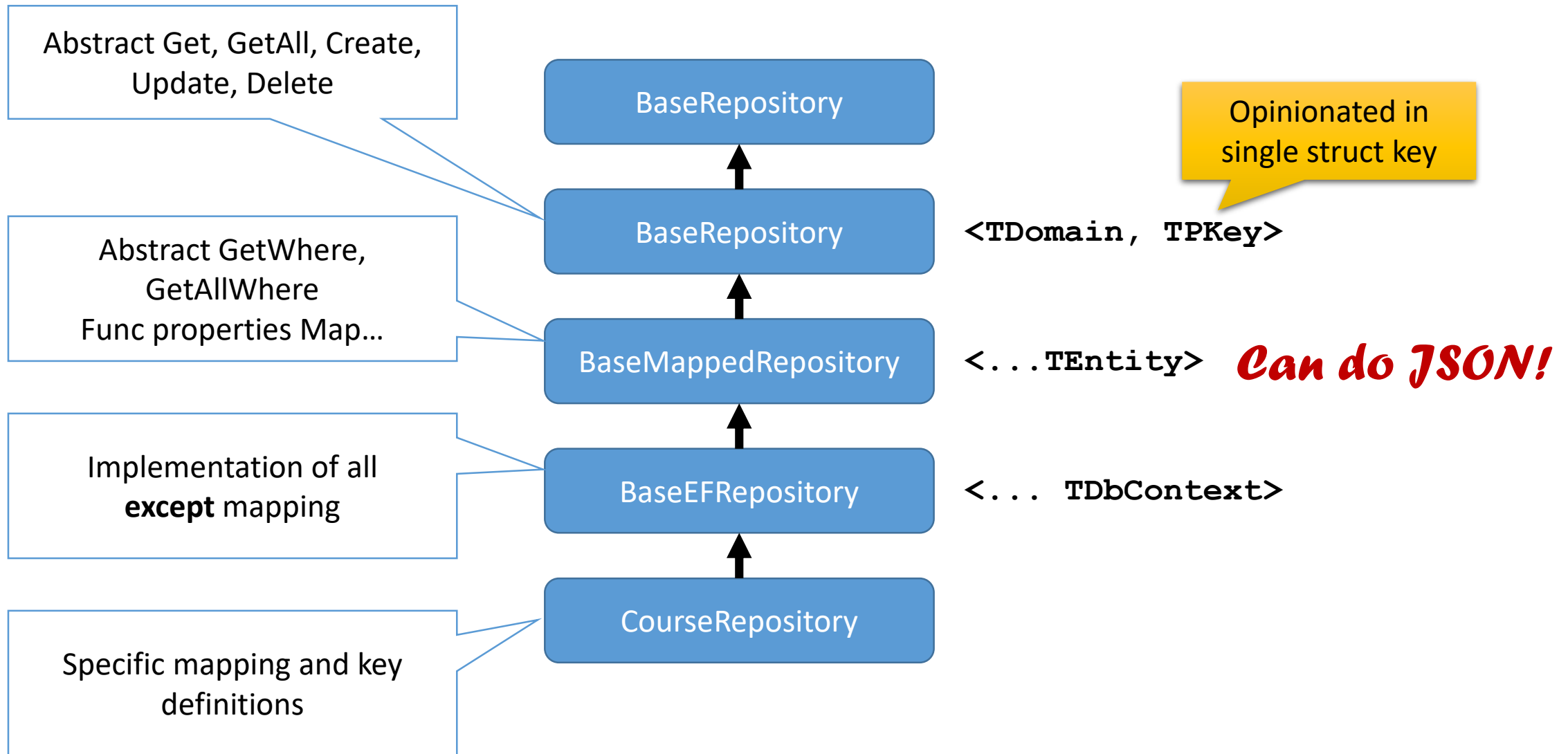


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Generic inheritance hierarchies from a *partial application* perspective

- Base class has no generic type
- Leaf class has all types
- Each intervening class has a purpose and adds generic types

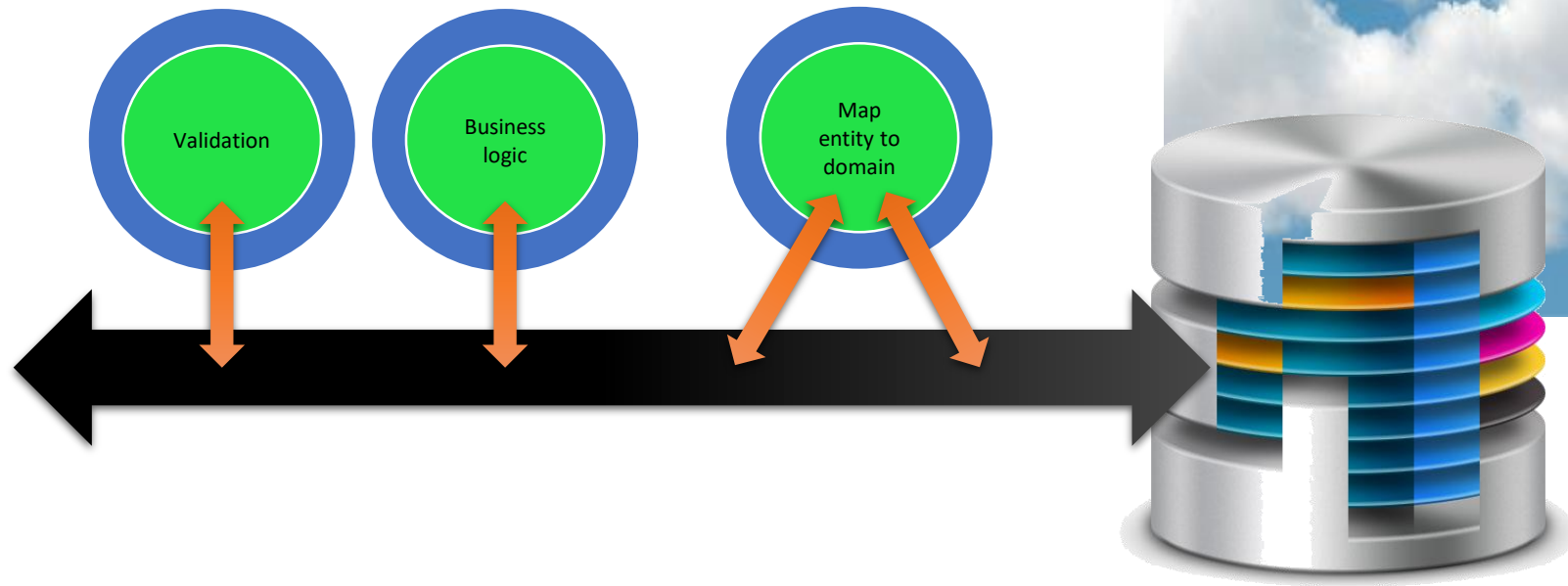




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Questions?

Functional Techniques for C#

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References

- Today's code: <https://github.com/KathleenDollard/ClassTracker>
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 - Manning, 2017
- Pluralsight : *Applying Functional Principles in C#*, Vladimir Khorikov
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- Review of Bacus's paper: <https://medium.com/luteceo-software-chemistry>