Functional Techniques for C#

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https://github.com/KathleenDollard/Slides

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 and C#
- Compiler intensity (policing)
  - JavaScript vs Haskell and C#
- Compiled vs. interpreted
  - C# vs Visual Basic for Applications (VBA)

- Support for REPL
  - PowerShell or F# (C# Interactive)

Why functional in C# (an OO world)?

- Testability
- Parallelism
- Reuse
- Expressiveness
- Reasonableness

- ➢Purity
- ➢Immutability
- ➢Inheritance, helper classes
- ➢Less smelly
- ➢Craftsmanship (naming, SRP, etc)

Functional techniques
allow us to up the game in all these areas

Why C# with Functional

- Lots of usage (your team might be using it)
- Best of strong typing to reduce accidents
  - If you think that's noise, use inference and implicit operators
- Generics to reuse types
- Extension methods to extend types
- Functions first class citizens (strongly typed delegates)
- Expressions trees: a structure to describe delegate contents
- Keep the best of this, add more…

Purity

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

Demo!

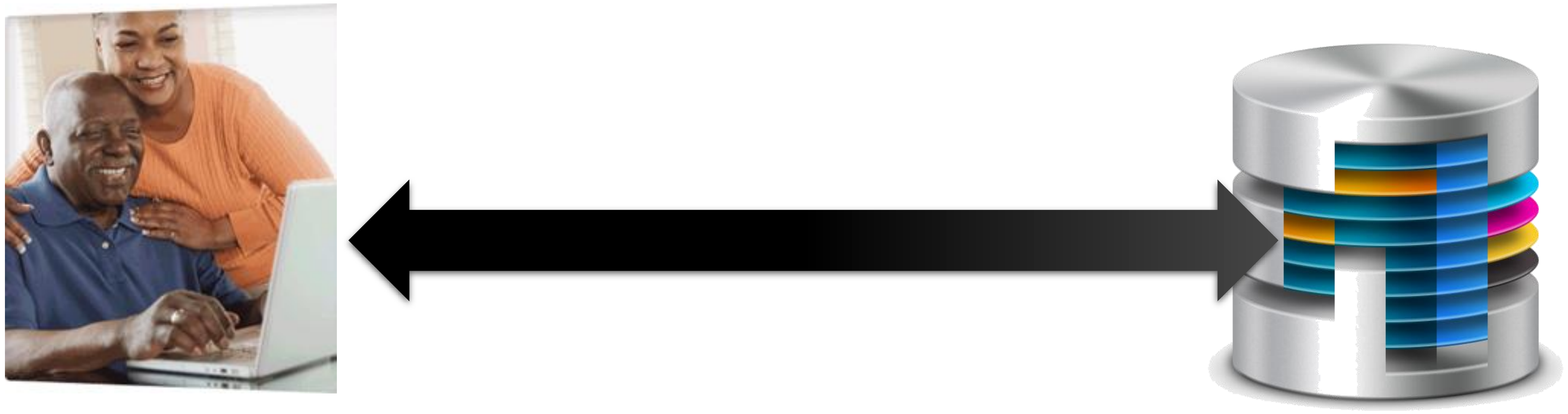
Purity

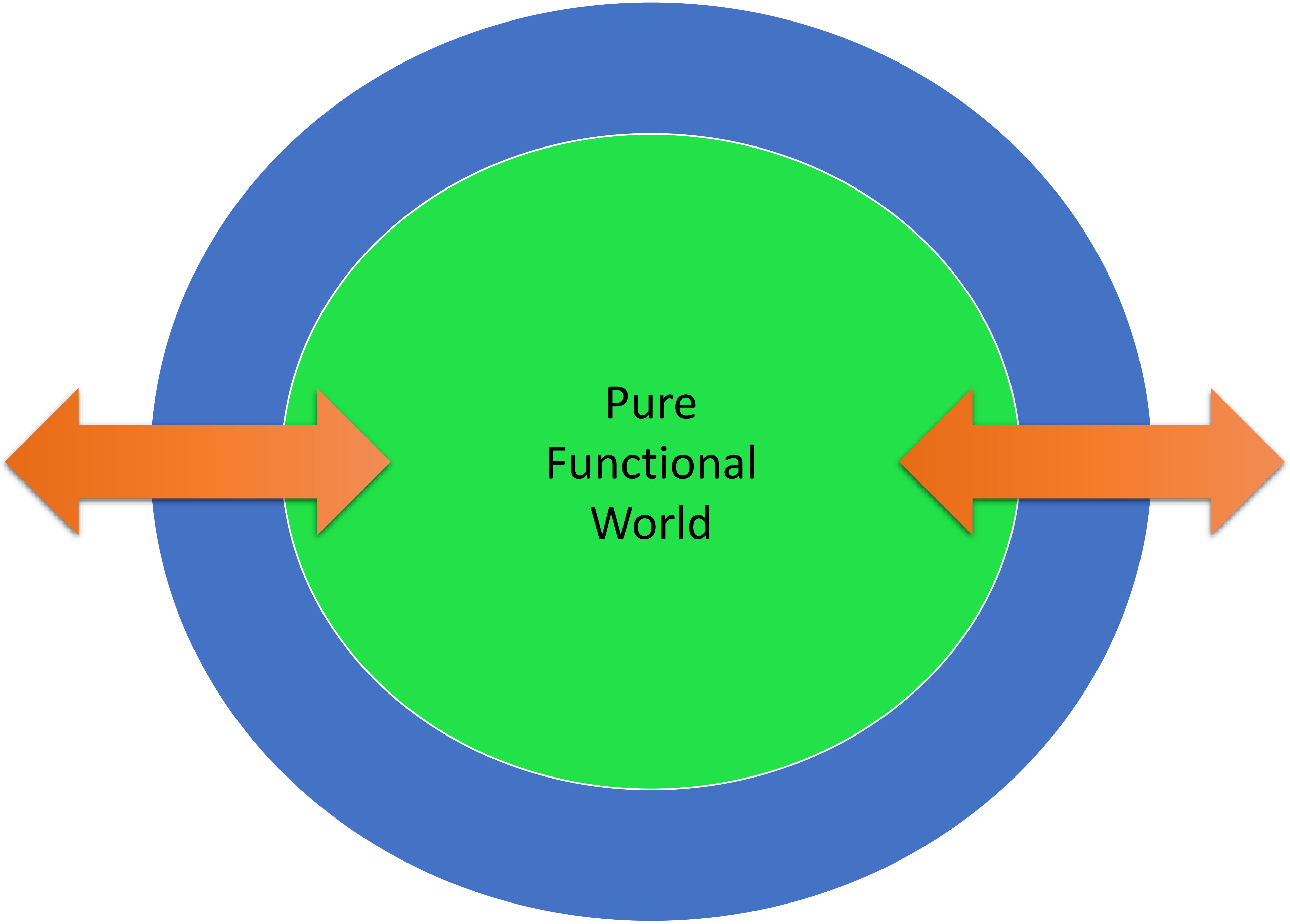
Purity

- 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

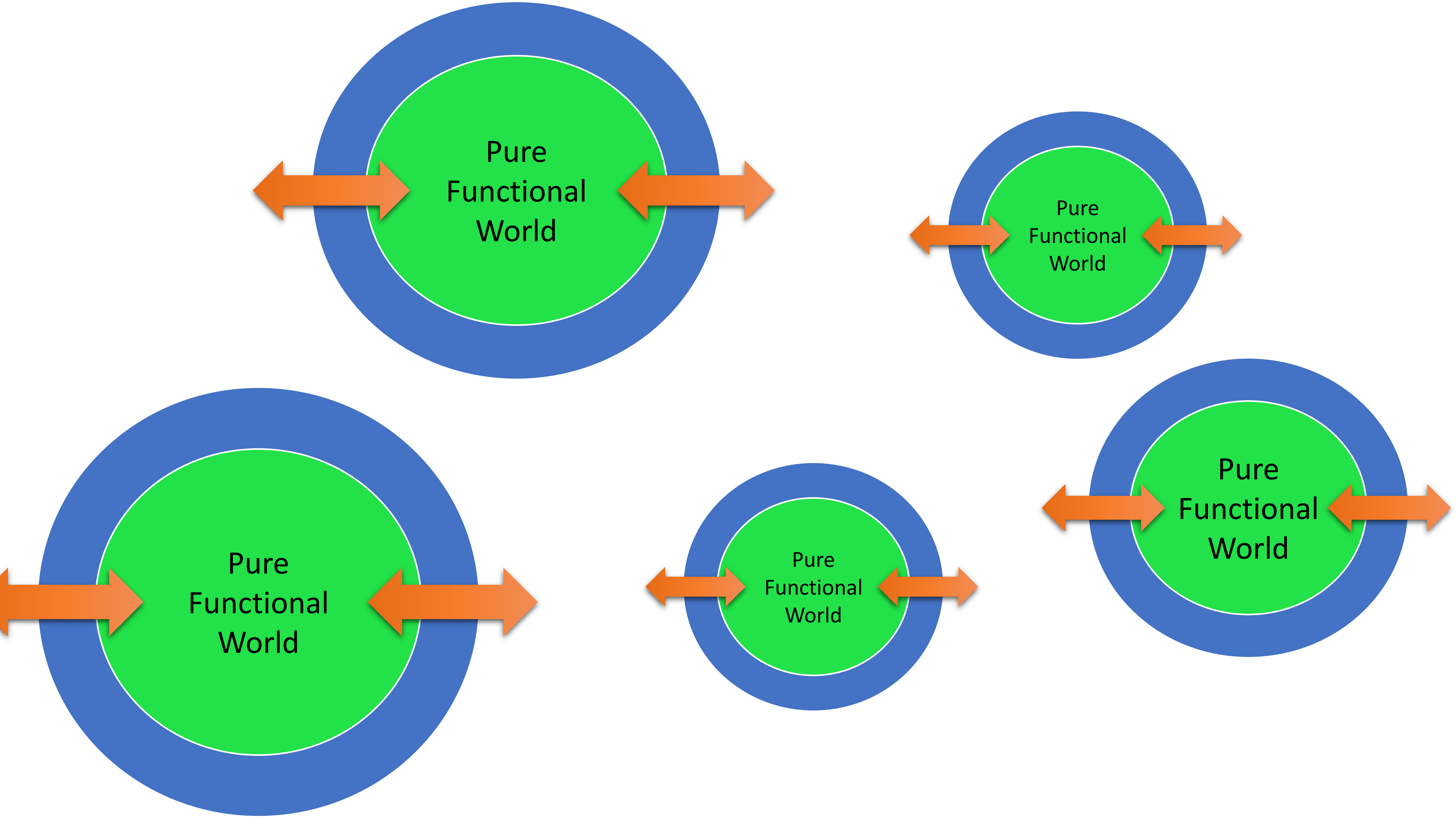
Purity is rather boring

Your app might look like...




Pure Functional World

Separate pure and not pure code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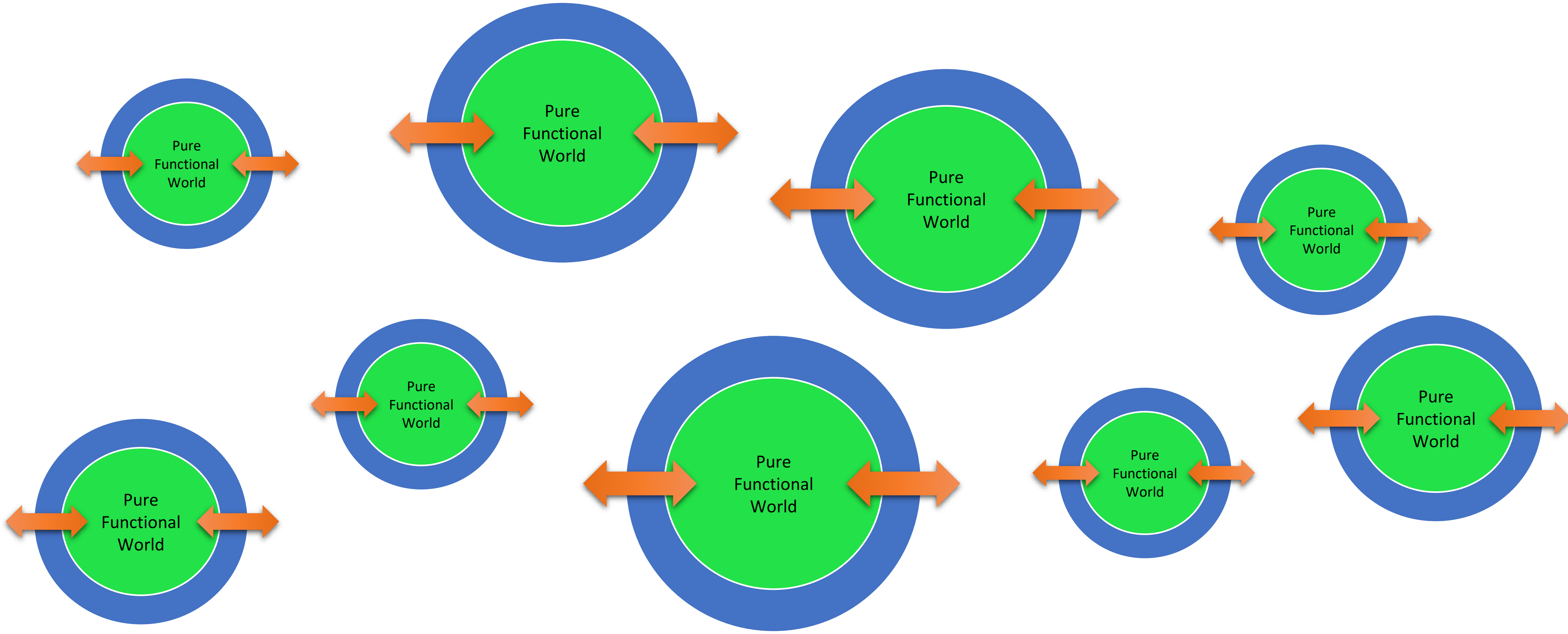
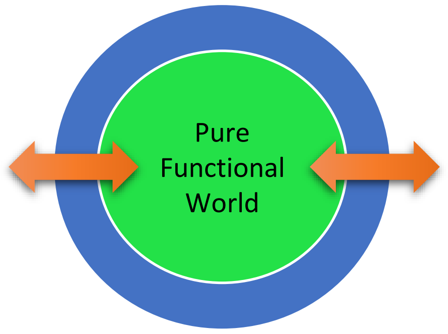
C# ❤ Functional techniques

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

Confusing, since we refer to our automated test tools as unit test tools

Separate pure and not pure code

C# 7 and functional constructs (opinion)

First class functions		
Purity		
Immutability		
OOP		
Strong typing		
Generics		
Pattern matching		
Expression Trees		
Duck typing		
Records		

C# 7 and functional constructs (opinion)

First class functions		A-
Purity		D
Immutability	*Improving*	B-
OOP		A
Strong typing		A
Generics		A
Pattern matching	*Improving*	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

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

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

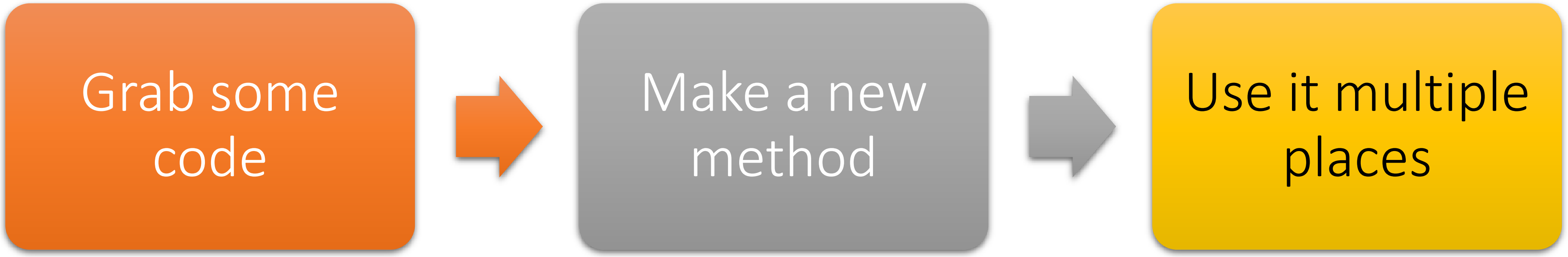
  ```
  var x = 42;
  var y = list.Where(z => z.Id == x);
  ```

  - In memory loops are faster in high performance code (like .NET framework)
  - For your code, they are almost certainly close enough to free
- Expression trees contain code definition
  - Can be understood in different languages
  - Like TSQL

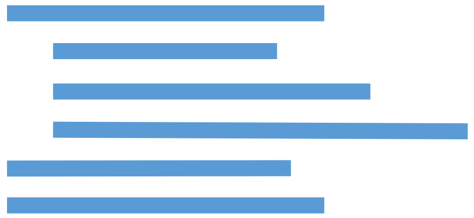
Refactoring to Functional

Imperative (normal) Refactoring

- Inside out refactoring



Imperative Refactoring



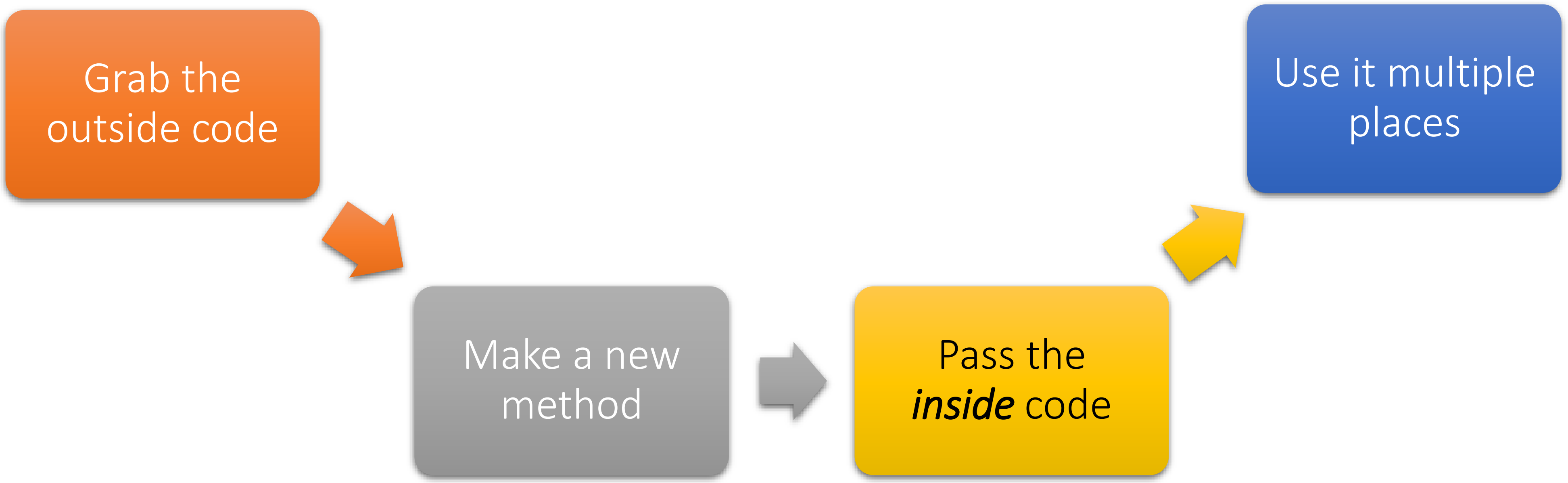
Imperative Refactoring

Demo!

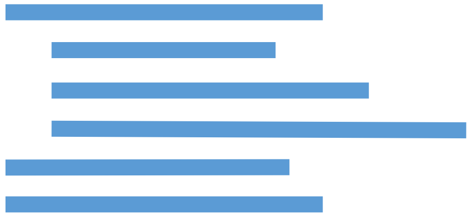
Inside out refactoring (normal)

Functional Refactoring

- Outside in refactoring



Functional Refactoring



Functional Refactoring

Functional Refactoring

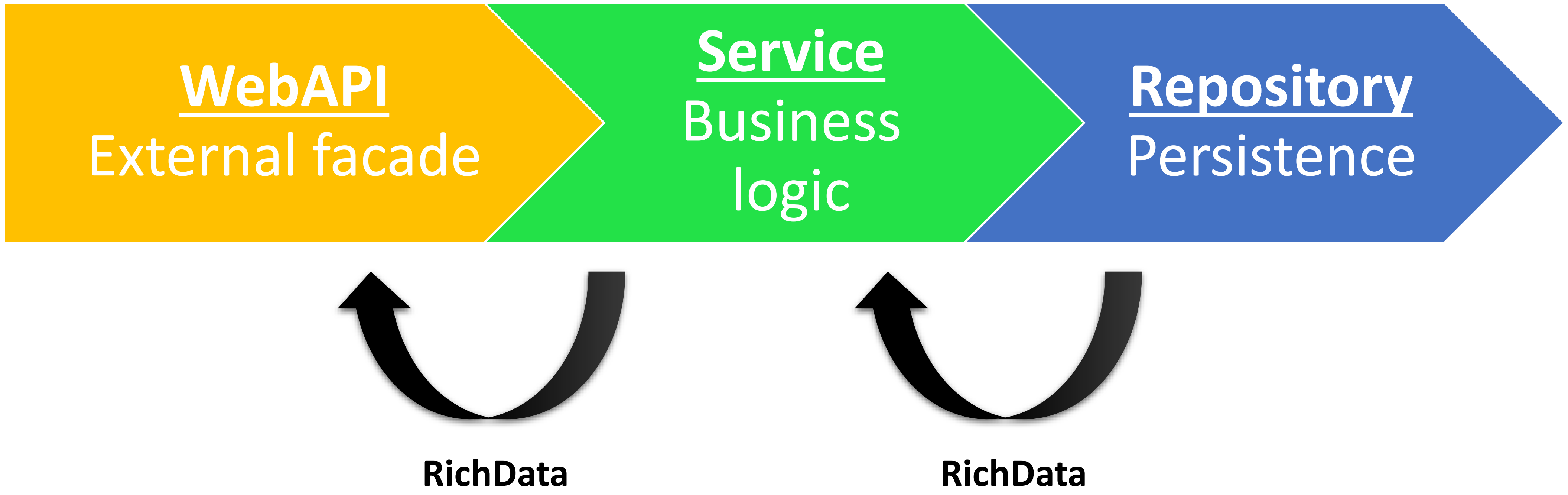
Demo!

Outside in refactoring

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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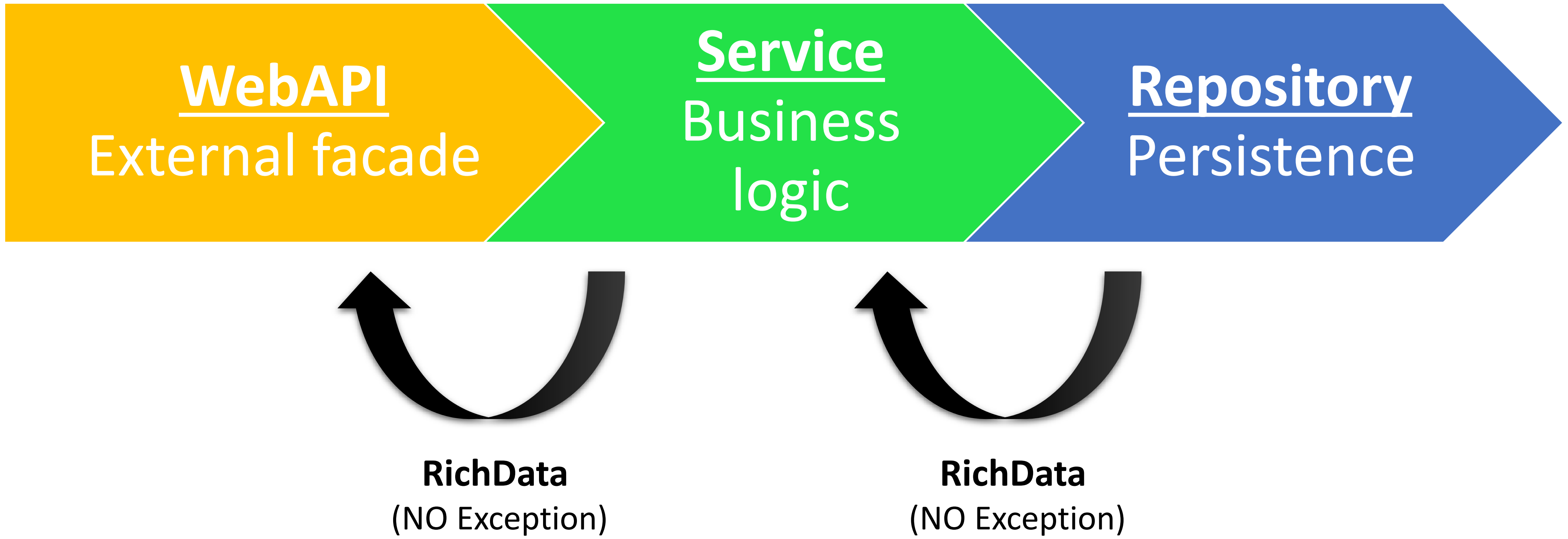
External facade
Service
Business logic
Repository
Persistence
RichData
RichData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(NO Exception)
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Naming is hard

1. Either
2. RichData/RichValue
3. Result
4. Try
5. Validation<Exception<T>>

1) Core FP concept, 2 & 3) Kathleen 4) Sander 5) Enrico

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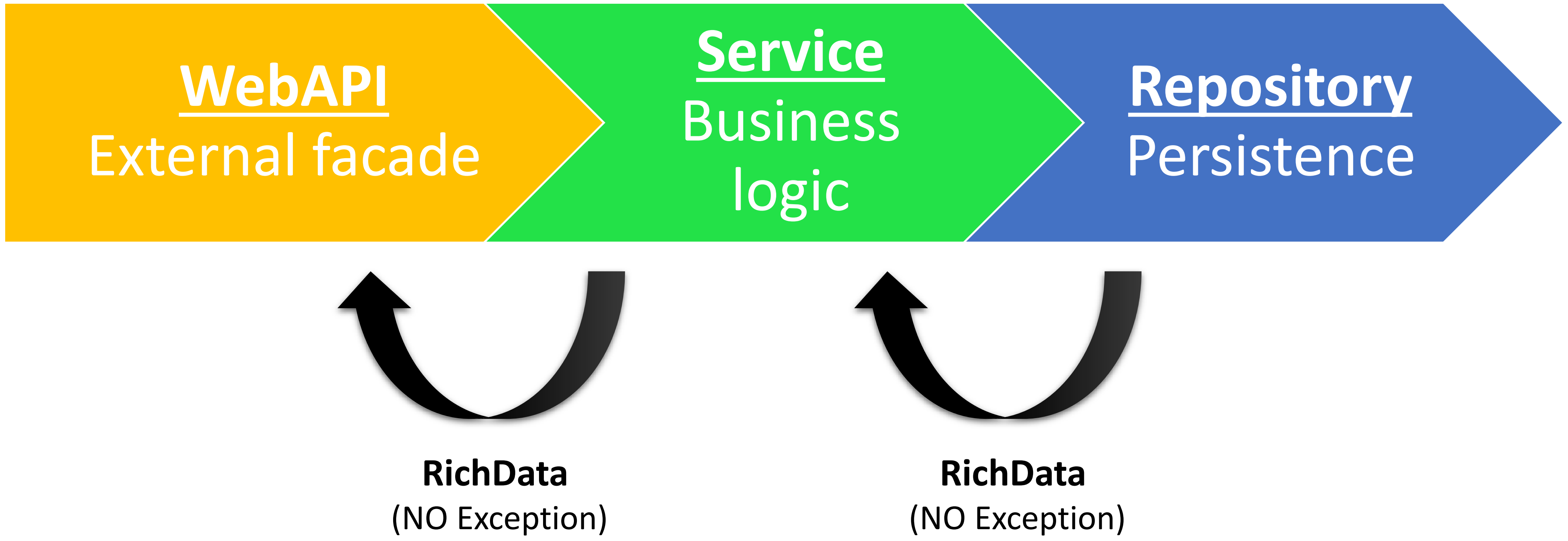
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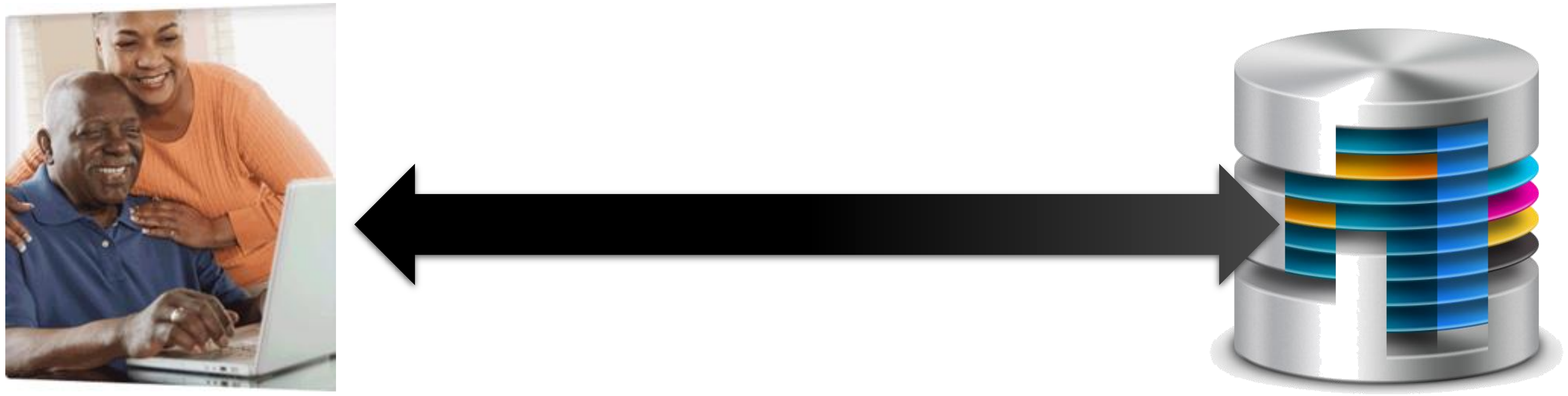

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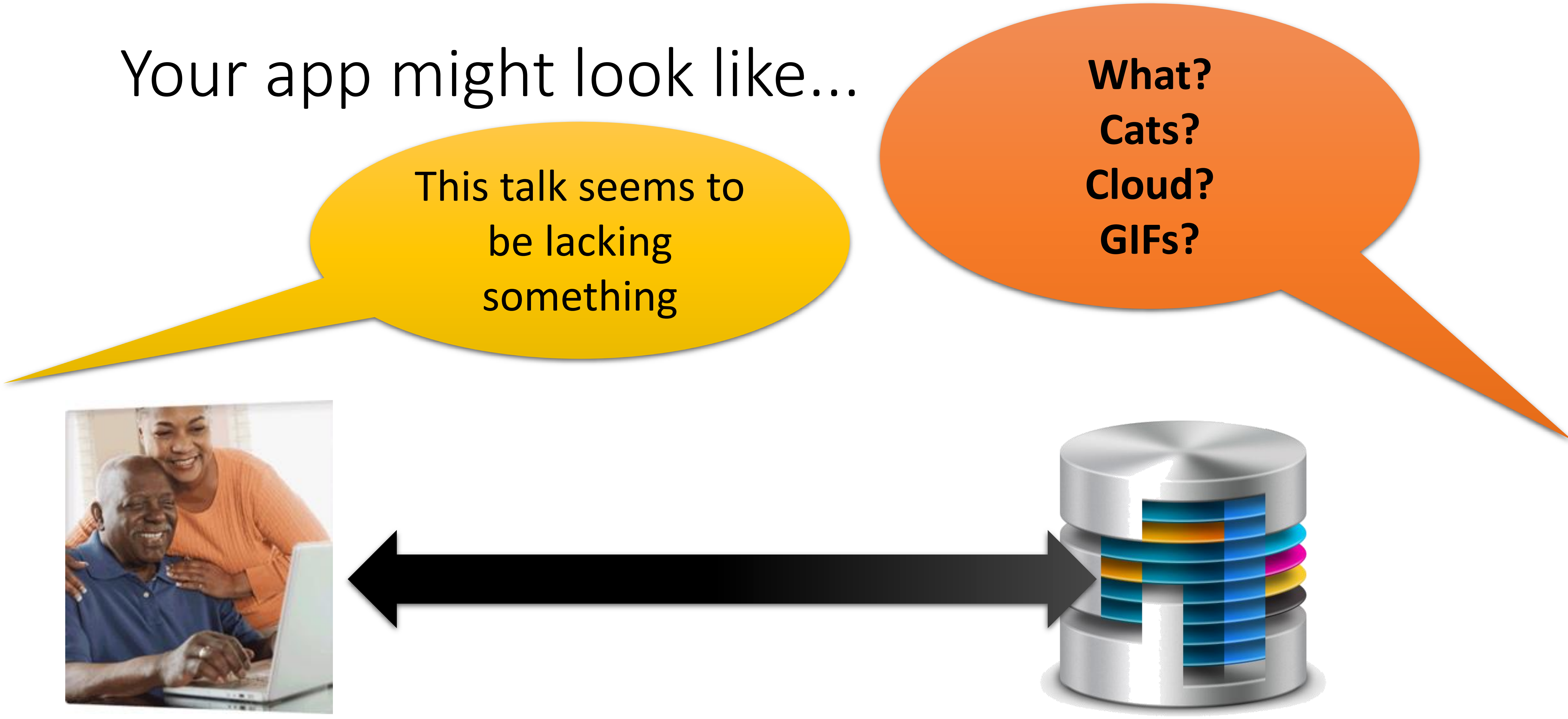

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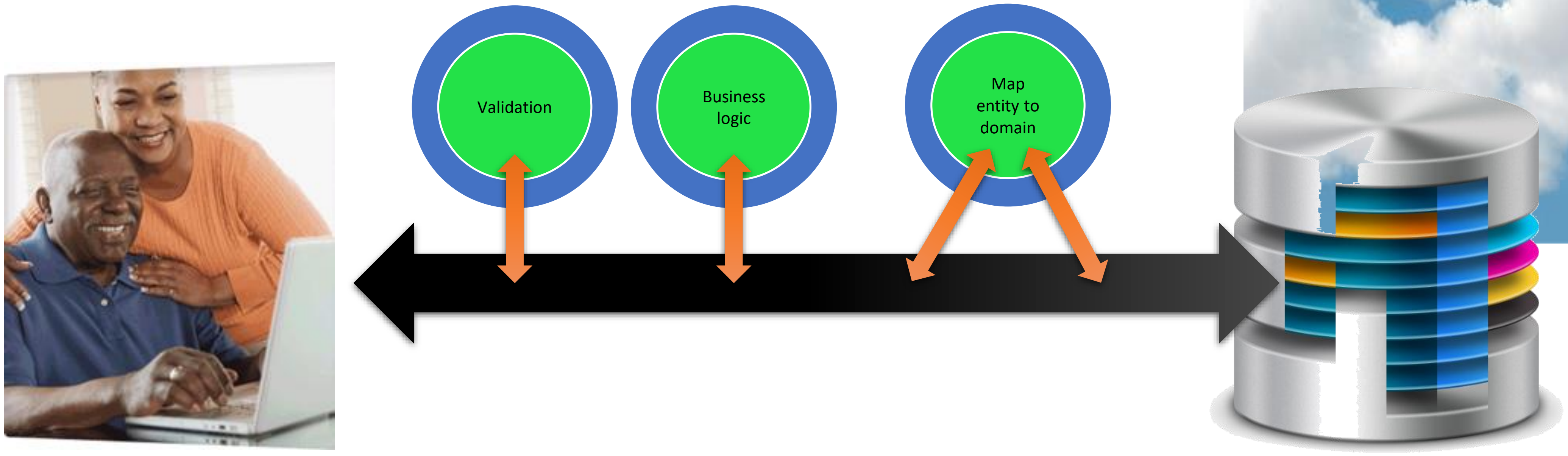

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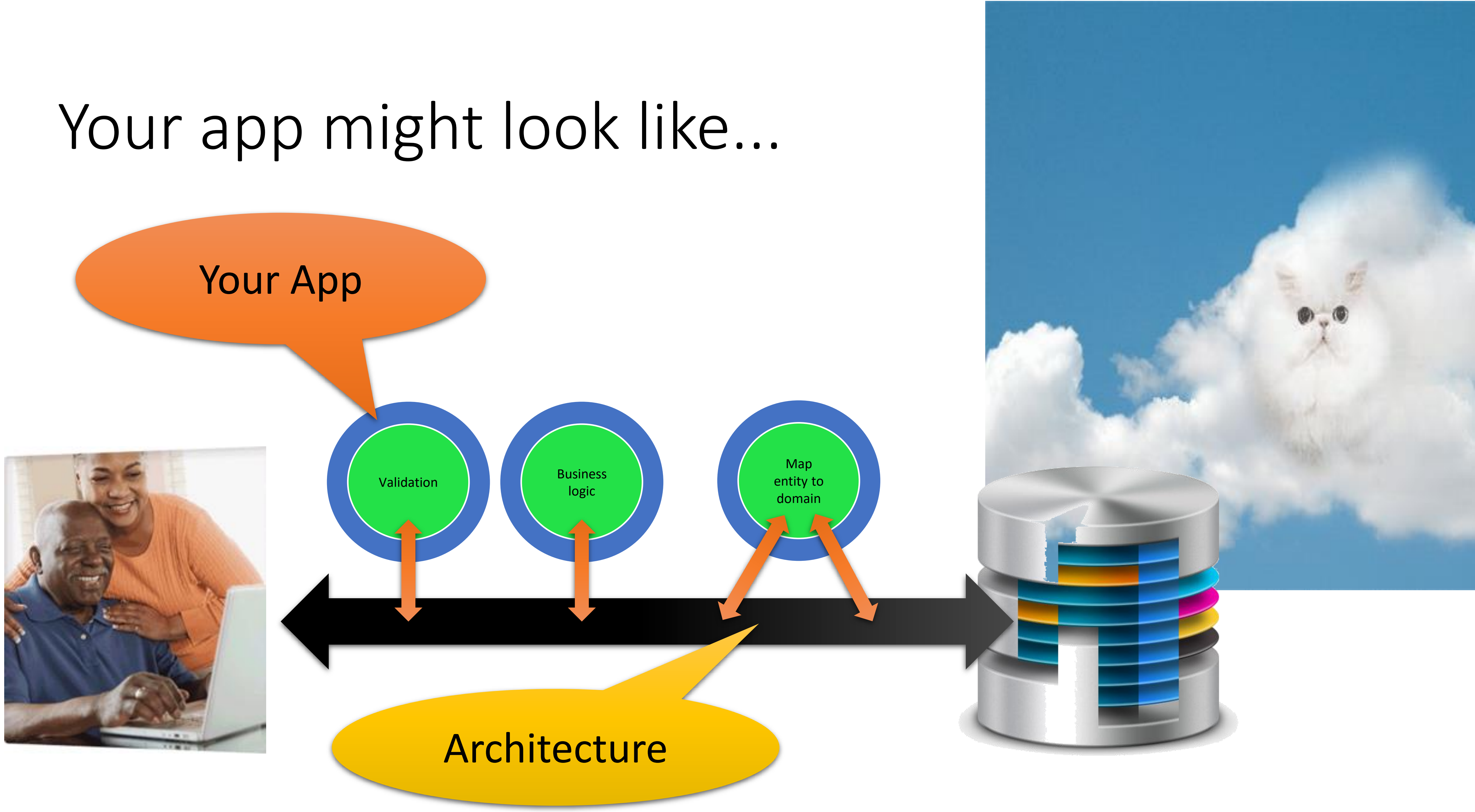
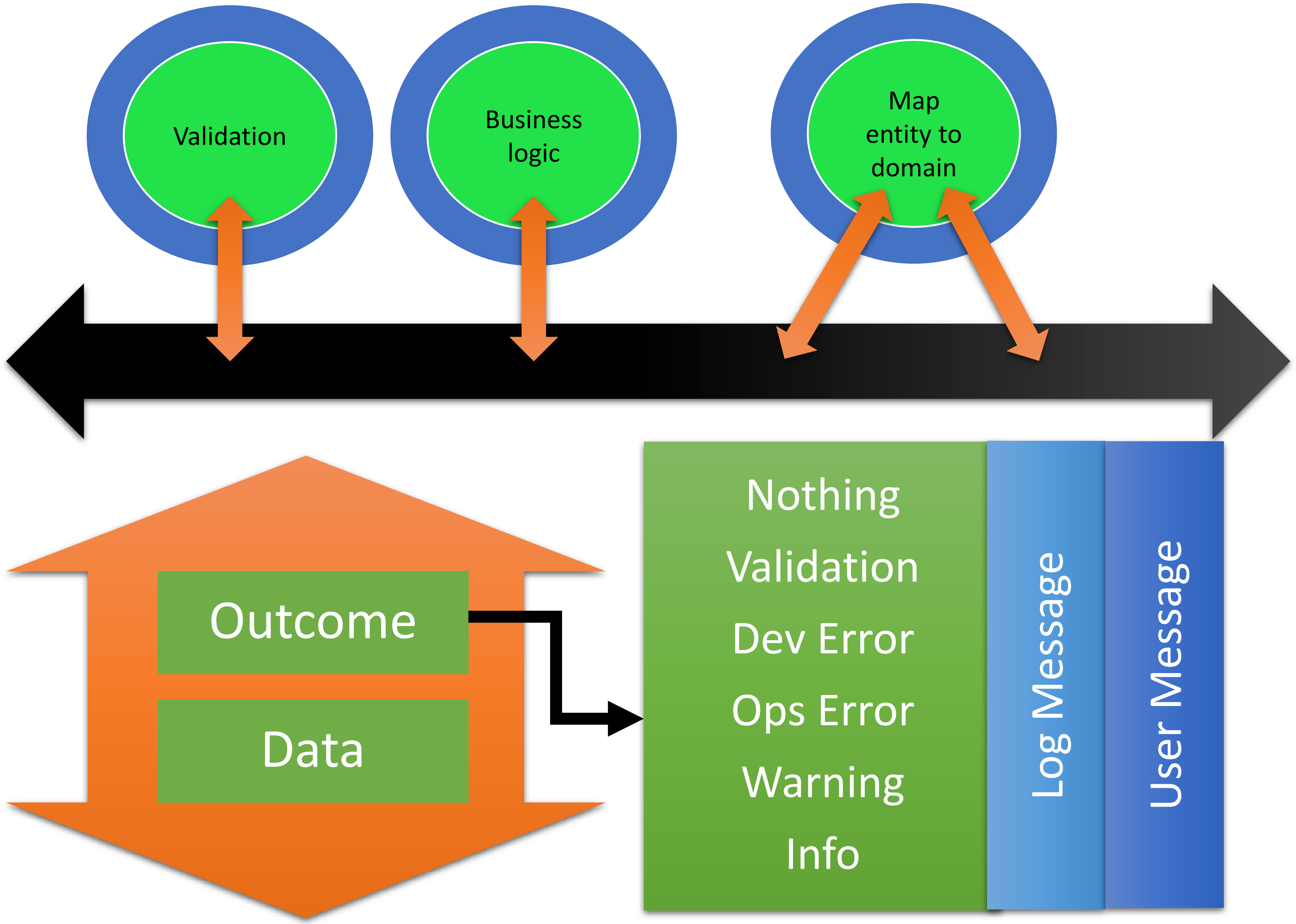




Validation
Business logic
Map entity to domain
Outcome
Data
Nothing
Validation
Dev Error
Ops Error
Warning
Info
Log Message
User Message

Demo!

Outcome

RichData<TData>

Useful things in C#

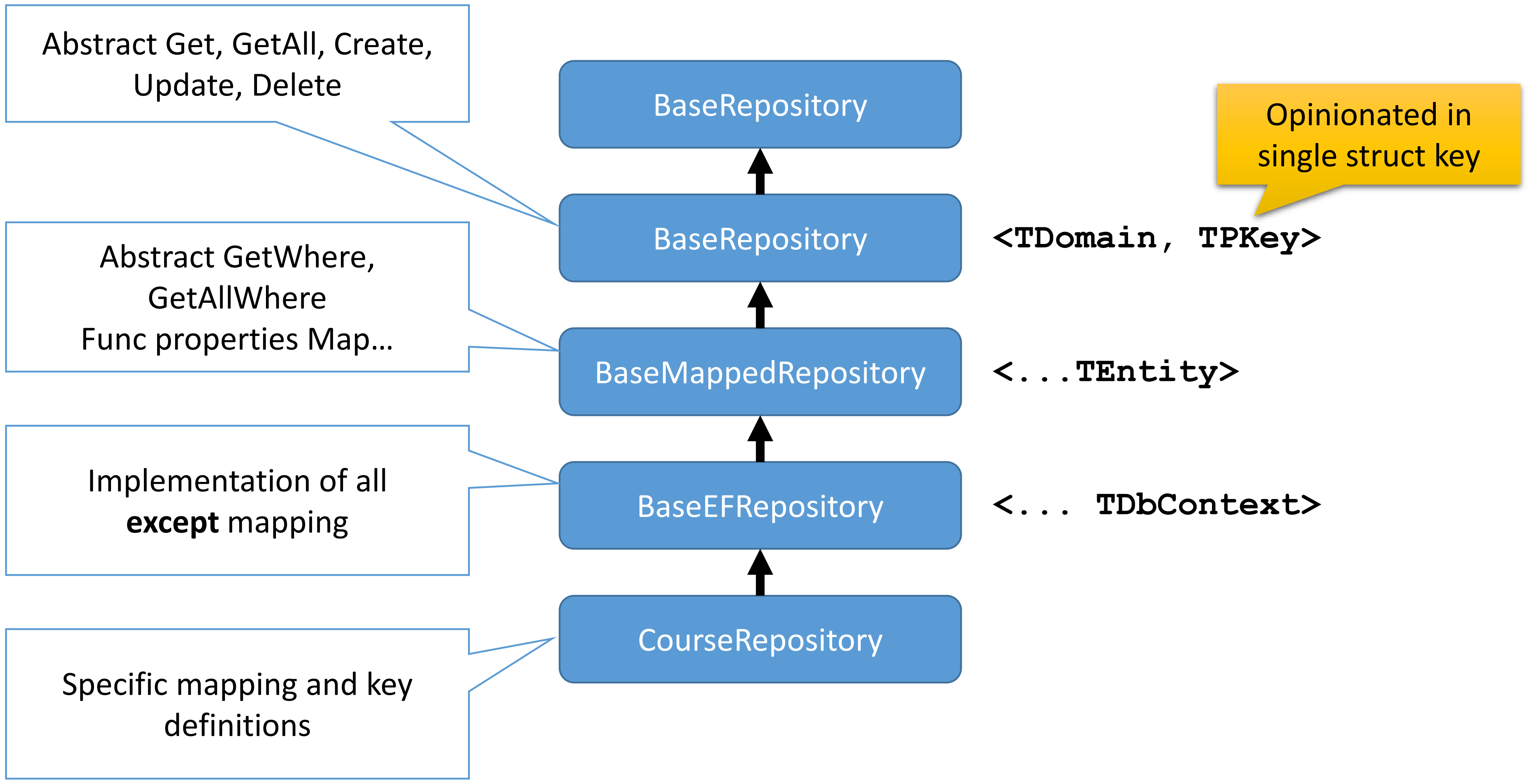
- Expression-body members
- Generic inheritance hierarchies
- Expression trees
- Local functions
- Pattern matching (enhanced switch statement)
- Tuples
- Throw expression

8

- Pattern matching (switch expression)
- Default interface implementation (rich interfaces)

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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Implementation of all **except** mapping
Specific mapping and key definitions
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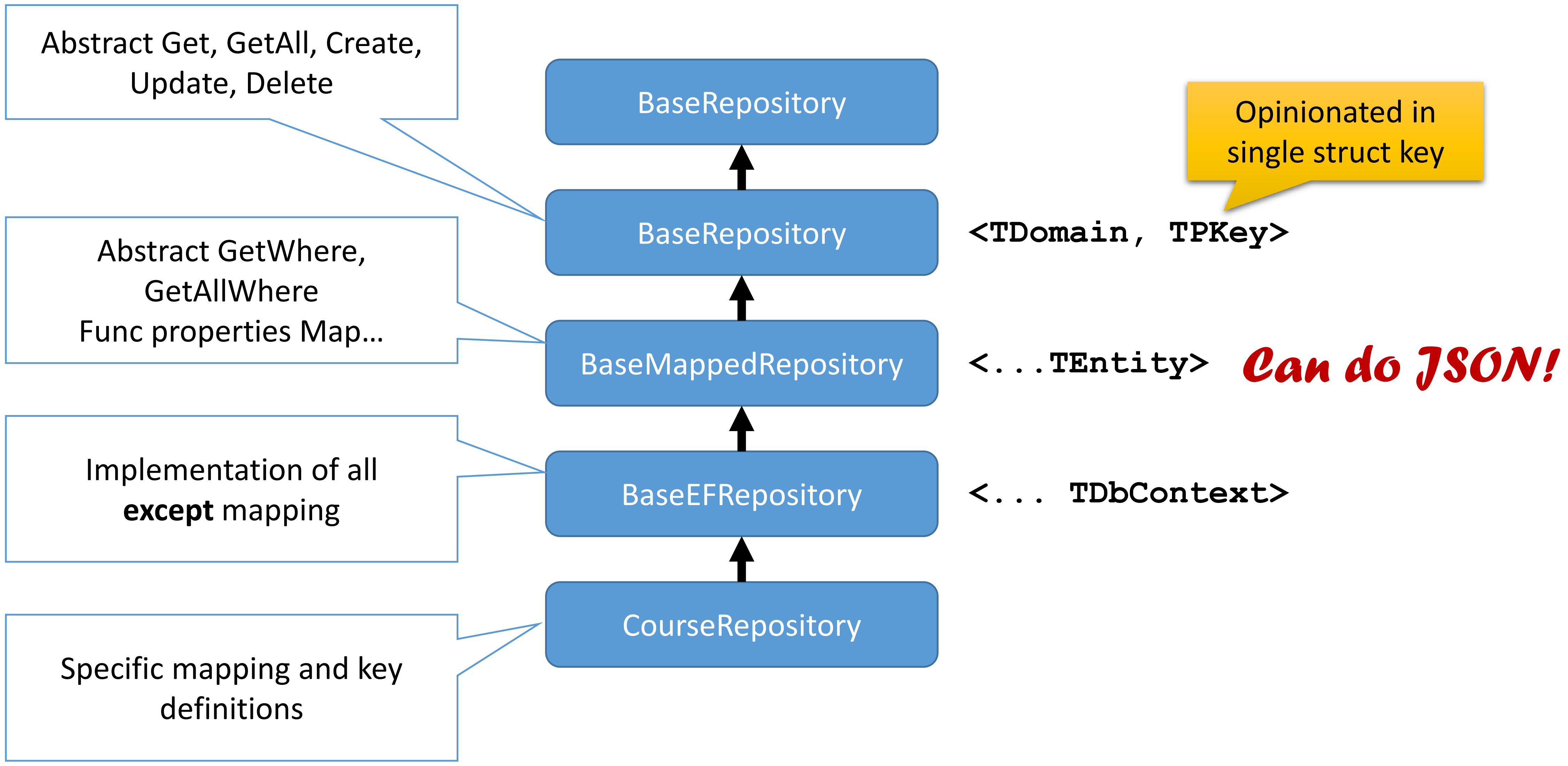
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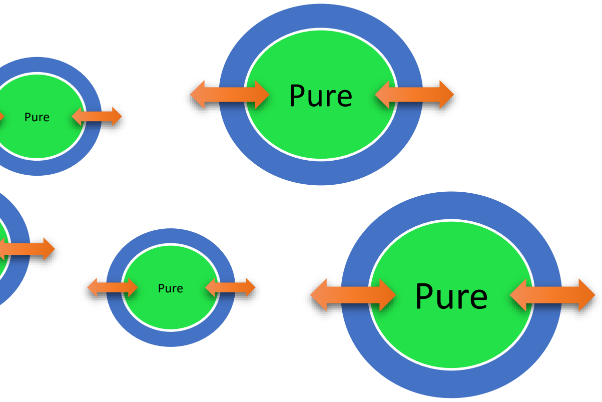
Recap

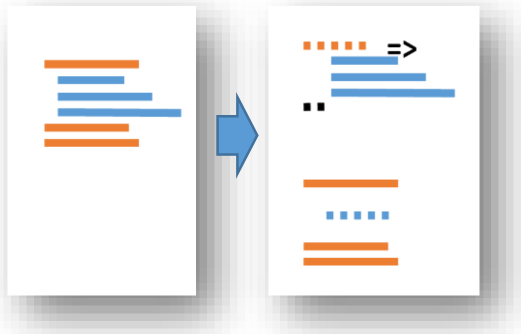
- We have a desire for functional
- Functional includes cultural change
- Fashion can add real value, or not

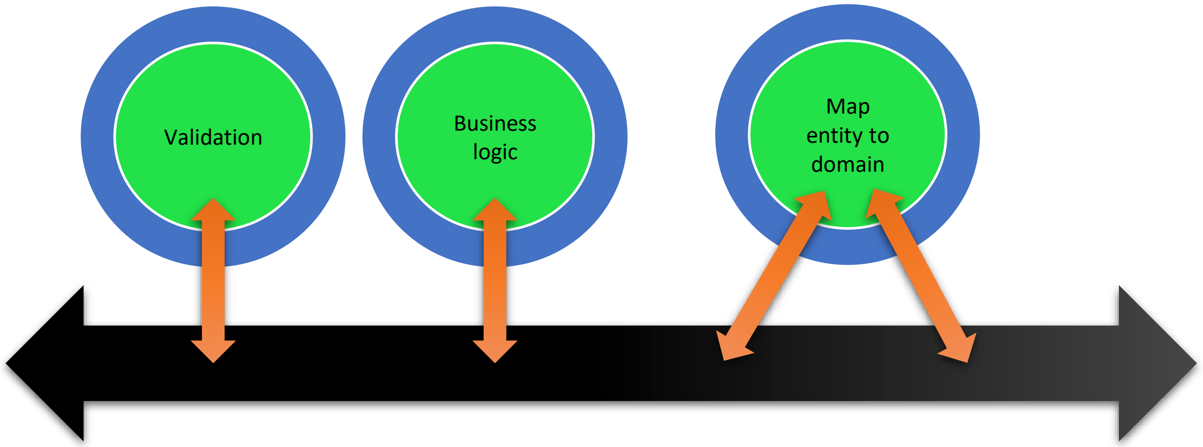
Explore and experiment

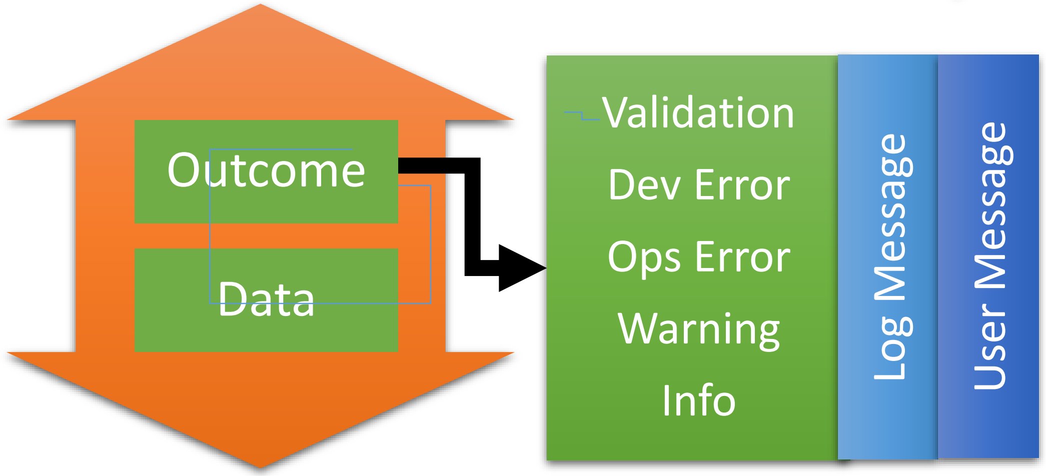
C# ❤ Functional techniques



- Pattern matching
- Generic hierarchies
- And much more







Questions?

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References

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- Pluralsight : *Functional Programming with C#,* Dave Fancher
- Review of Bacus's paper: https://medium.com/luteceo-software-chemistry