FUNCTIONAL PROGRAMMING WITH A MAINSTREAM LANGUAGE

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How does FP look like for enterprise

Introduction to the project's context

- Media planning software: Indicators Calculations
- Performance constrains
- Flexibility needed: more calculations need to be added easily and declaratively
- Any latency will be apparent?
- Productivity and interactivity of the GUI are crucial
- A lot of data on the screen with a lot of simultaneous calculations on each user interaction

How to approach performance in this case?

- Optimization of objects creation?
  - Reuse Data Structures
  - Use low level looping constructs and mutable arrays
- Functional approach with laziness?
  - No mutation
  - Use Streams as lazy lists
  - Compose functions for more modularity

Do it the Lean way

- Started two different strategies of implementation:
  - imperative with excessive use of loops and mutation
  - functional

What I am and what I am not!

- I am a mainstream OOP and imperative programmer: Java, C#
- I am not a functional programming geek: at least I wasn't prior to this experience
- All my FP knowledge dates back to university and school time: knowledge of Lisp that most of us acquired and forgot before stepping into enterprise
- I like to search for applying the suitable programming paradigm to the problem at hand

Do it the Lean way

- Started two different strategies of implementation:
  - imperative with excessive use of loops and mutation
  - functional

What did functional programming buy me more in this experiment?

- Paradigm: OOP vs. Streams
- Abstraction: Functions as first class values
- Recursion, costly but clearer and more readable?
- Another side effect of purity: order does not matter
- More processors? Why not!

Talking Paradigms: OOP vs. Streams

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- Streams as delayed lists
  - Modularity
  - Performance
- Immutability
  - Cuts down complexity enhancing readability : no state tracking
  - Your OO favorite language is optimized for object creation, let the garbage collector do its job!
  - Code safety
- OOP is great for encapsulation

Streams as delayed lists: Modularity

- A program needs to change state to be useful
- In a classical imperative approach, state is all over the place and the program consists of sequential changes of it
- With Streams, state is taken outside the program and gets passed through compound (composed) functions that operate on the stream to produce the result
- With long lists, and when you do not want to iterate the lists twice, delayed lists with list comprehensions give the opportunity to express logic modularly (partitioned into semantically distinct units)

Streams as delayed lists: Modularity

```
IEnumerable<Performance> CalculatePerformanceFor(IEnumerable<RawObject> rawObjects)
{
    return from r in rawObjects select CalculatePerformanceFor(r);
}
```

And in some other module…

```
IEnumerable<Network> ConstructNetworks(IEnumerable<RawObject> rawObjects)
{
    return from p in CalculatePerformanceFor(rawObjects) select new Network(names[p.Id], p);
}
```

yield …

Streams as delayed lists: Performance

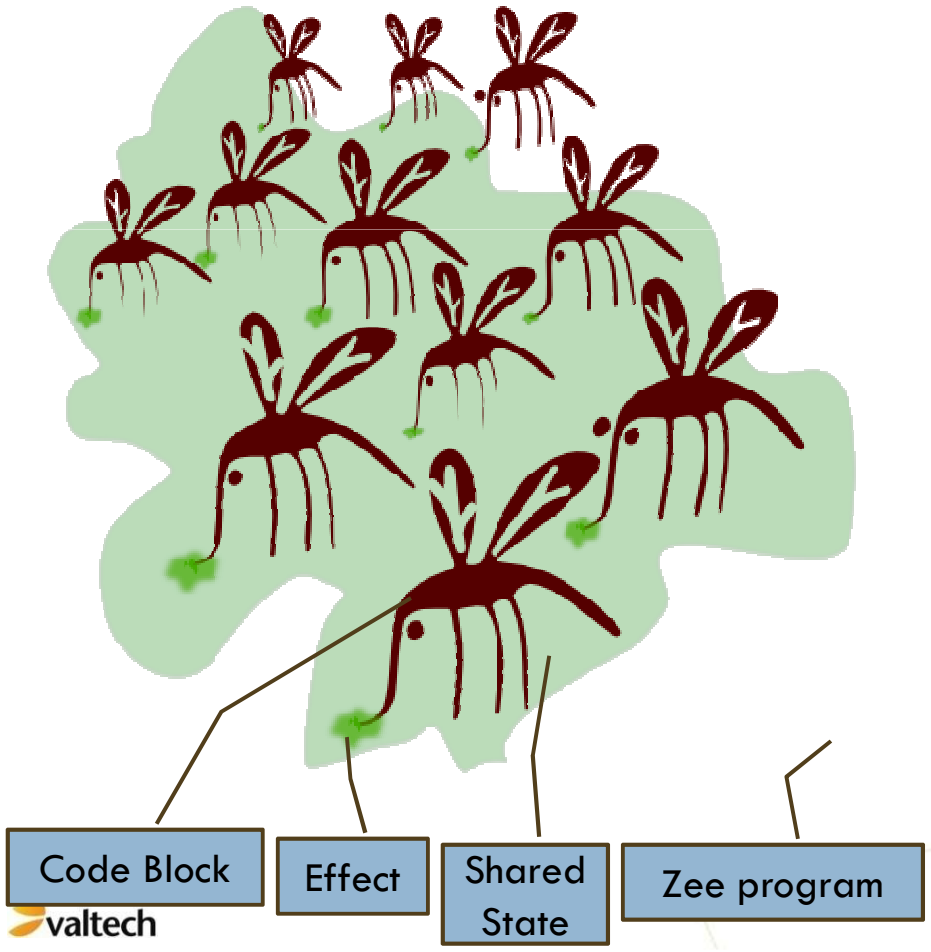
- No useless lists walkthroughs
- Quite tricky to choose where to be strict (.ToList())
- Yet it can be viewed as a decision that can be differed for later

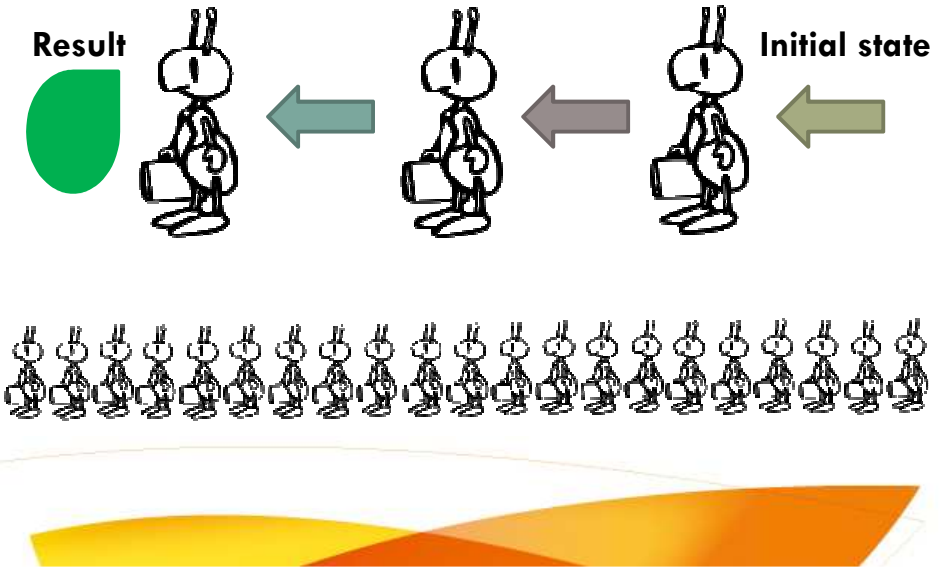
Immutability: Complexity Down, Enhance Readability

- No state tracking
  - Substitution model is far easier to reason about
    - Code turned to work correctly more often from the first time!
  - When correctly composing pure function, I can ignore completely semantics of both the functions and focus on semantics of the new function to go on. That never seemed to work when mutable objects are shared.
  - Shared mutable state cries for a debugger
  - State in not compositional

Immutability: Complexity Down, Enhance Readability

Mosquito Programming vs. Functional Programming





Immutability: Give Your GC Some Work

- Classes Vs. Objects : Procedural vs. OOP
  - In most E-Applications I see no OOP applied but procedural
- Share and Cache

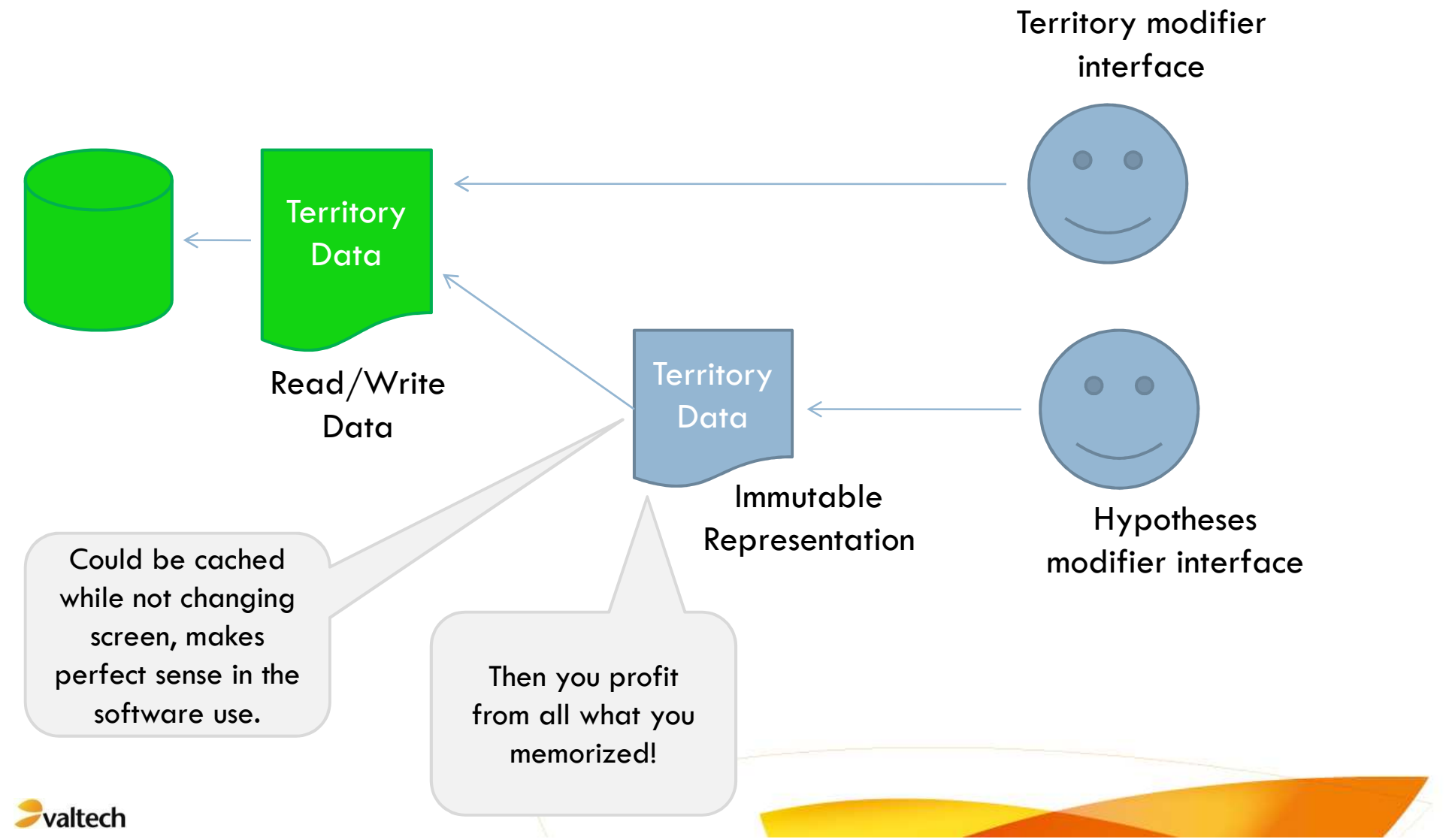
Immutability: Learnt to share

```
public class BaseNetwork
{
    public readonly IEnumerable<Repartition> Repartitions;
    public readonly double GrossRate;

    public BaseNetwork(IEnumerable<Repartition> repartitions, double grossRate)
    {
        Repartitions = repartitions;
        GrossRate = grossRate;
    }

    public readonly Func<int> FacesNumber;
    public readonly Func<double> RatePerFace;
    public BaseNetwork()
    {
        FacesNumber = F.Memorize(() => Repartitions.Sum(r=>r.FacesNumber));
        RatePerFace = F.Memorize(() => GrossRate / FacesNumber());
    }
}
```

Immutability: Caching, Finely optimized for context

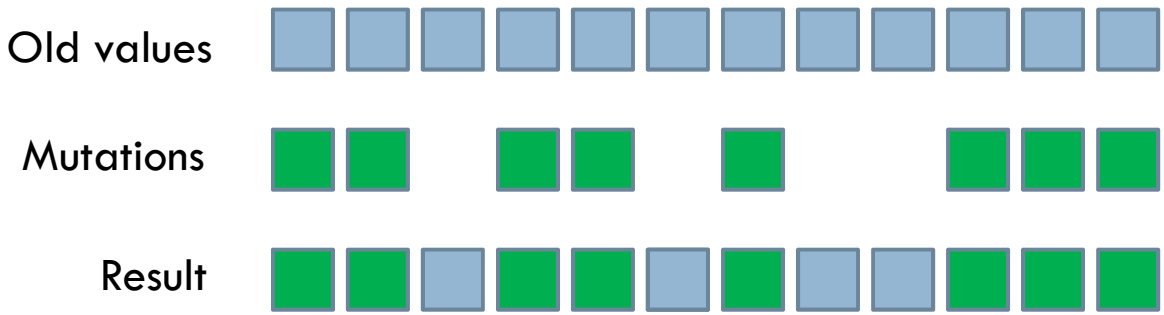
- Data retrieved from database don't need to be mutable all over the application even if they are modifiable in some contexts
- Data Views

Caching: Finely optimized for context



Immutability: Code safety

- Code Safety
  - Reusing mutable structure can have the effect of representing old obsolete values as current
  - WPF example



OOP: Encapsulation

- Immutability doesn't mean abandoning object orientation
- OOP encapsulation for better code organization
- With immutability, all object methods can be memorized if needed, this is interesting especially when sharing instances

OOP: Encapsulation

```
IEnumerable<KeyValuePair<NetworkIdentifier,double>> Calculate1(IEnumerable<BaseNetwork> networks,double some_n)
{
    return from n in networks
           let totalFacesNumber = n.Repartitions.Sum(r => r.FacesNumber)
           let ratePerFace = n.GrossRate/totalFacesNumber
           select new KeyValuePair<NetworkIdentifier, double>(n.Id, ratePerFace * some_n);
}
IEnumerable<KeyValuePair<NetworkIdentifier, double>> Calculate2(IEnumerable<BaseNetwork> networks, double some_n)
{
    return from n in networks
           select new KeyValuePair<NetworkIdentifier, double>(n.Id, n.RatePerFace() * some_n);
}
```

Functions as First Class Values

Functions as First Class Values

- Mutable State Vs. Closures and Partial Application
- Presenter return actions to be executed on the view
- Continuation monad
  - More interface responsiveness
  - Less apparent latency
- AOP with no framework (Memorize)
- With Functions as First Class Values a lot of Design Patterns become obsolete

Closures and Partial Functions Application

- Being immutable everywhere, you will be faced sometimes a situation where you have different parameters values of a function in different scopes
- Yet you want to stay immutable yet modular!
- Partial application supports your modular design

Closures and Partial Functions Application

In some module we have

```
SomeResult GetSomeResult(int totalFacesNumberOnT,NetworkIdentifier nId, int networkFacesNumberOnT)...
```

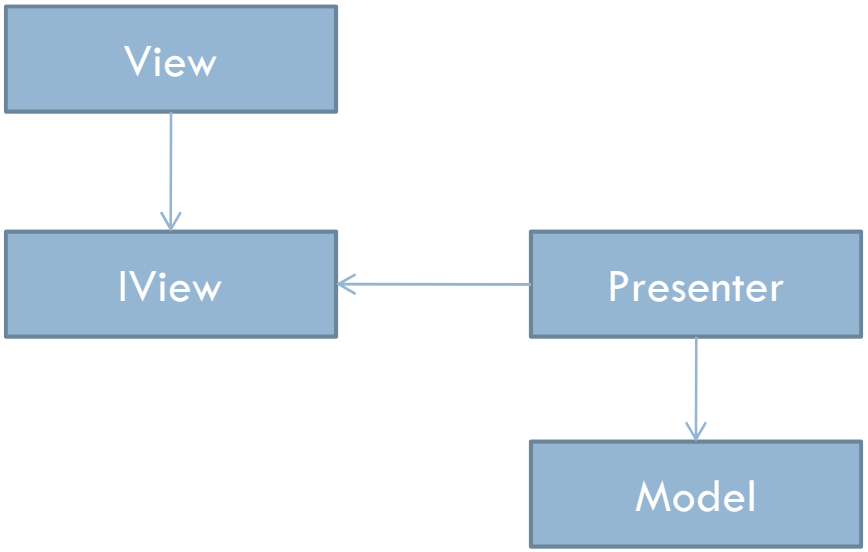
And in some other

```
SomeOtherResult DoSomeCalculations(int totalFacesNumberOnT)
{
    Func<NetworkIdentifier, int, SomeResult> calculateP = (id, nfOnT) => GetSomeResult(totalFacesNumberOnT, id, nfOnT);
```

Then this could be passed to yet another!

MVP the Functional way

- Model View Presenter



MVP the Functional way

- Presenter as a service

```
Action<IShowAvailableNetworksView> ChangeTarifNetOfNetworks(IEnumerable<Network> localNetworks, IEnumerable<Networ
{
    var changedLocalNetworks = service.ChangeTarifNetOfNetworks(tauxNego, localNetworks);
    var changedNationalNetworks = service.ChangeTarifNetOfNetworks(tauxNego, nationalNetworks);

    return v =>
    {
        v.NationalAvailableNetworks = changedNationalNetworks;
        v.LocalAvailableNetworks = changedLocalNetworks;
    };
}
```

```
this.ExecuteOrScheduleOnceForWhenVisible("ChangeTarifNetData",
    () =>
    Presenter.ChangeTarifNetOfNetworks(localNetworks, nationalNetworks, tauxNego));
```

Continuation Monad

- WPF and threads
  - Graphical components are not truthful about their types
  - When threads are engaged, they no longer present their type
  - M<CompoenentType>
  - from c in m …
  - Threads logic and freezing is done by the monad
  - Same could be done for exceptions

Design Patterns

- Most GOF Design Patterns are not of a great values with the existence of a higher order functions (closure)
- Lambda expressions are very easy to create at call site and are quite expressive
- Polymorphism is hard to reason about
- Functions are compositional

Recursion, costly but clearer and more readable?

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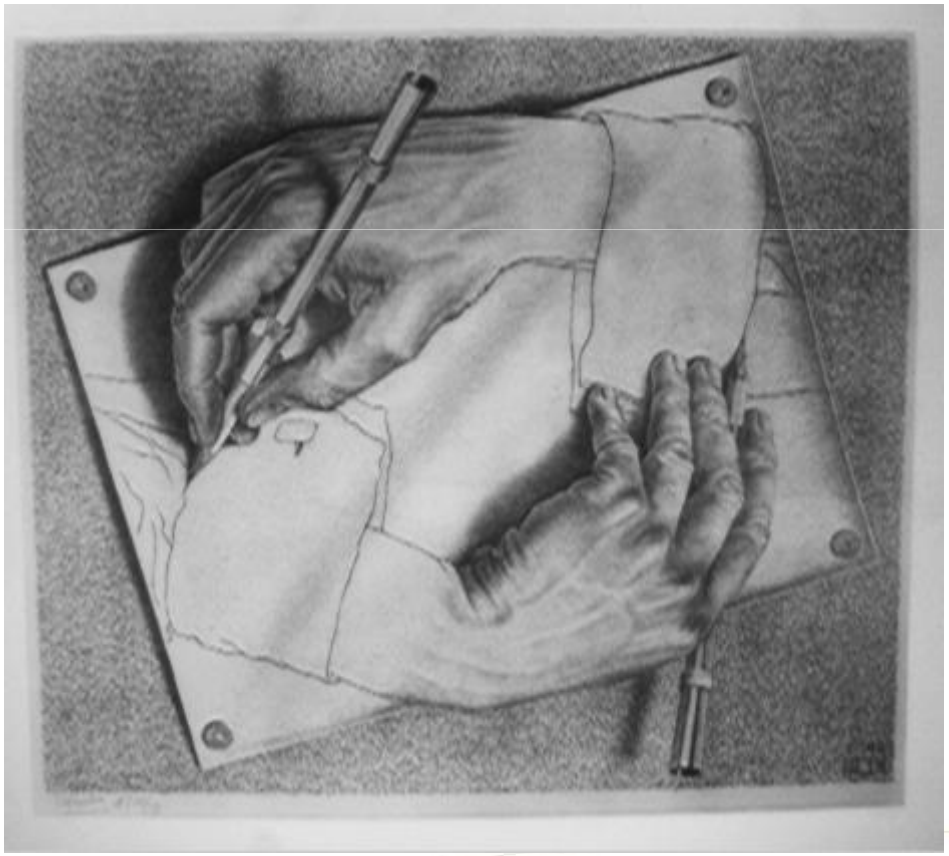
- Recursive calls are often more expressive
- Not optimized C# (tail recursion)
  - Use *fold* and *map*
  - Memorize it because you are pure!

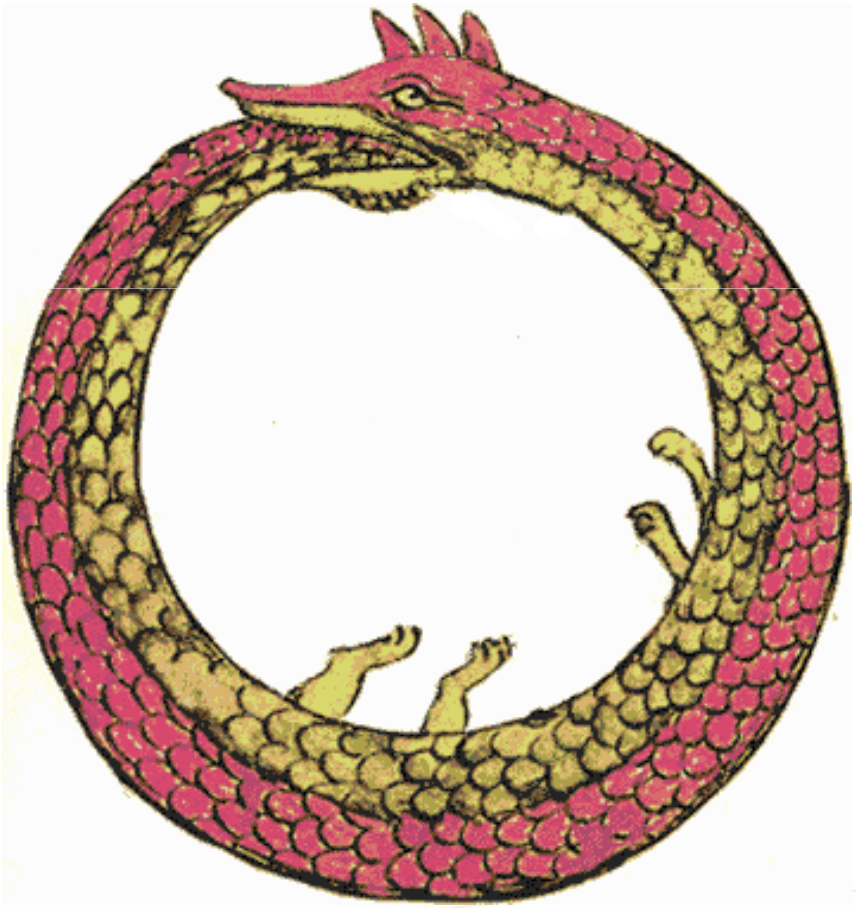
Expressiveness of recursive calls

- They are often more expressive



Not optimized in C#

- Tail recursion



Not optimized in mainstream languages

- Use fold and map
  - Select and Aggregate
  - Abstractions of some recursive forms that help being declarative without sacrificing performance

Not optimized in mainstream languages

- Memorize it because you are pure!
  - Memorize can be introduced as an aspect
    - Interchange MemorizeFix and Y for performance tuning

Another side effect of purity: order does not matter

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- Future<T>
- More processors? No problem!

Purity: Future<T>

```
var populationTotal=
        Future<int>.Create(
            ()=>(from t in territoryBaseGeos.Distinct()
                 select t.GeoPopulation).Sum());

some other work and calculations

var pnxGFTotalTerritoire =
        Future.Create(
            ()=>(from g in repartitionsThatMatchTheTerritory
                 from m in g
                 select m.Left)
                    .Where(r=>r.Network.SousUniverId == NetworkReferentiel.PosterSousUnivers.GRAND_FORMAT)
                    .Sum(r=>r.FacesNumberByBaseGeography));

var offreTotalTerritoire =
        Future<double>.Create(
            ()=>(from gm in repartitionsThatMatchTheTerritory
                 select CalculateOffreReseauxOnTerritory(gm.Key, gm.Select(m => m.Left))).Sum());

var globals = new GlobalHypotheseValues(populationTotal.Value,
                                        pnxGFTotalTerritoire.Value,
                                        offreTotalTerritoire.Value);
```

Purity: More Processors

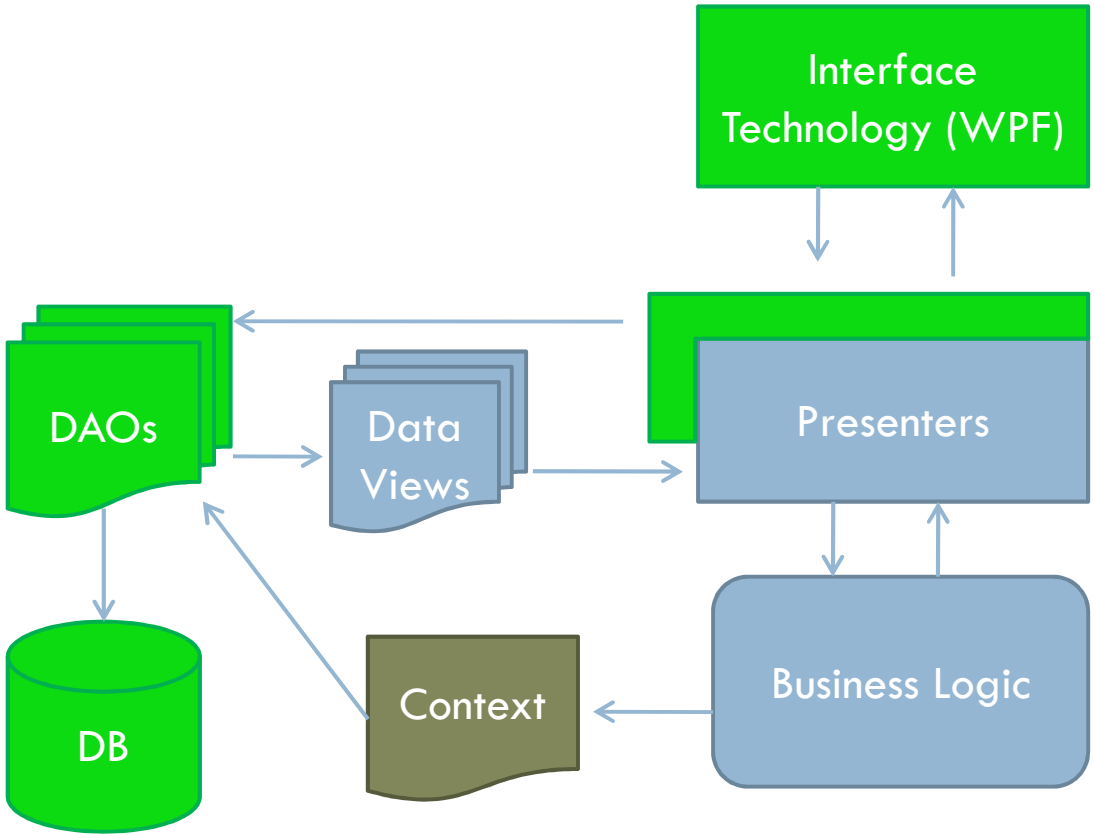
- Parallelize it, you are pure
  - LinQ .AsParallel()
- Or are you?
  - Failed on first shared mutable state
  - Need locks in Memorize

Purity: More Processors

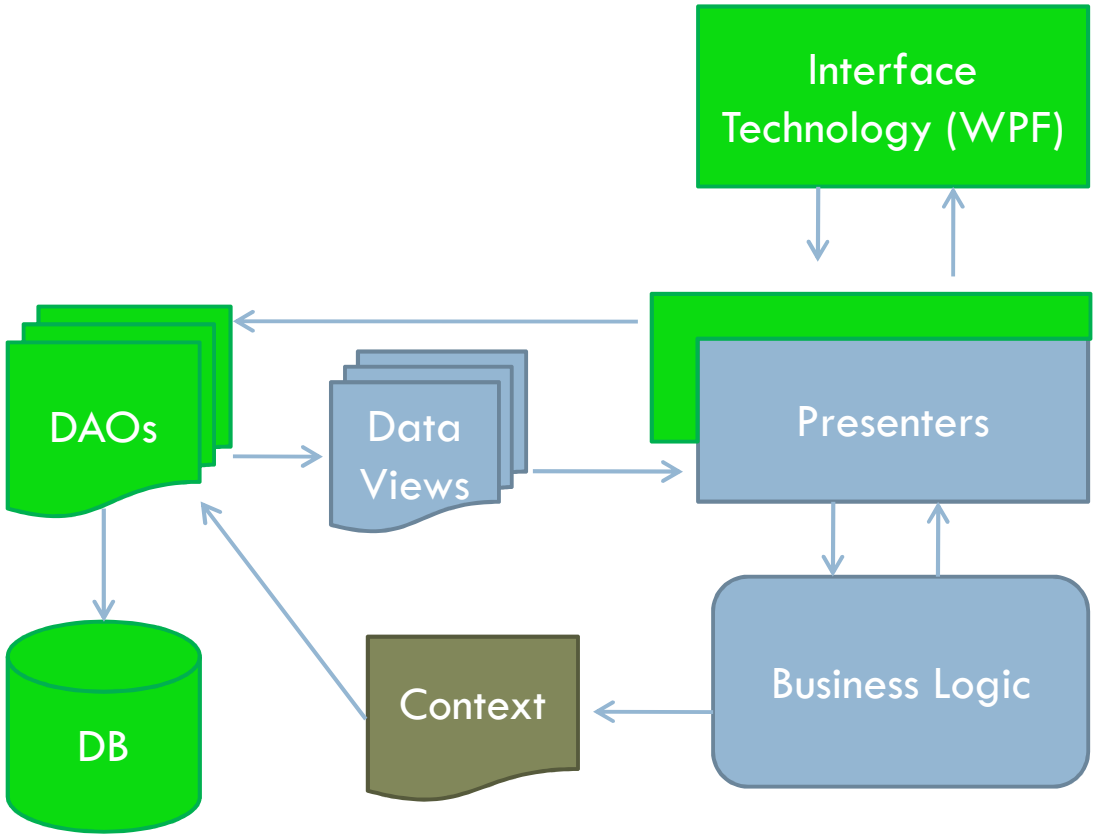
```
public static Func<A,U, R> Memorize<A,U, R>(this Func<A,U, R> f)
{
    var map = DictionaryHelper<R>.CreateDictionary(new { a = default(A), u = default(U) });
    return (a,u) =>
    {
        R value;
        if (map.TryGetValue(new {a = a,u = u},out value))
            return value;
        else lock(map)
        {
            if (map.TryGetValue(new { a = a, u = u }, out value))
                return value;
            else
            {
                value = f(a,u);
                map.Add(new {a = a,u = u}, value);
            }
        }

        return value;
    };
}
```

Architecture View

Architectural View



Architectural View



In FP Terms:

Is IO or "Effect"

Is pure

Frameworks?

Frameworks?

- ORM mapping
  - SQL is a DSL
  - Too far generalization for persistence
    - Same data could be represented differently in different views
  - Light tools are the key to light code, FP provide mechanism for light tools in contrast to container style giant abstractions
  - Context bound solutions, resist some attempts to generalization
  - Strict loading with well defined entity graphs boundaries over Lazy lousy loading

Frameworks?

- AOP
  - Framework is not necessary
  - First class functions is a good mechanism for expressing aspects

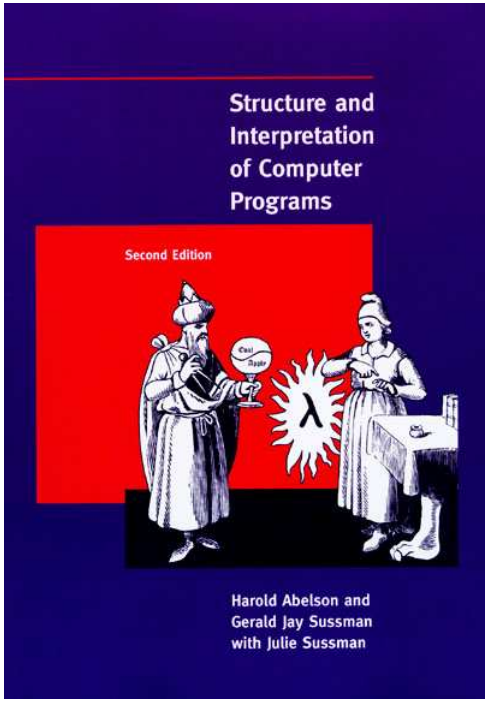
Overview

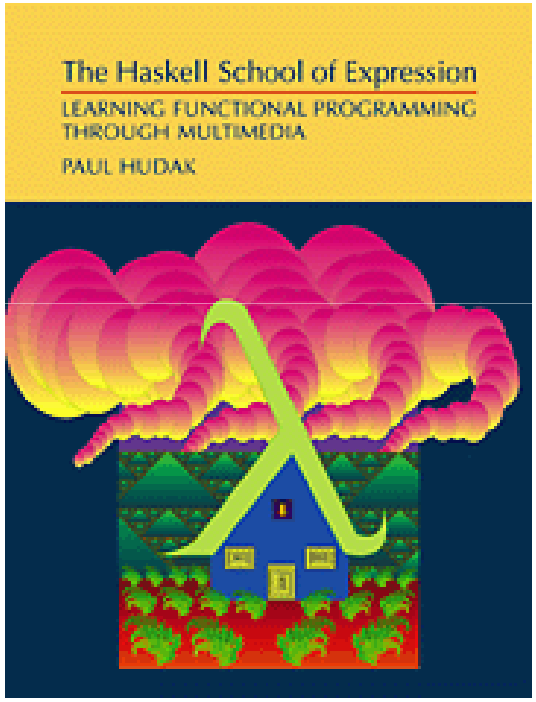
- Mutability is addictive and effects are like cancer
- Imperative programming is very attractive, only discipline can help in a mixed paradigm environment
- Less is more, FP simplicity is key to productivity

Regrets

- Function types are ugly without type inference
- Laziness unleashes evil! Keep attention
  - No checked exception
  - Effects not expressed in the type system
- Null everywhere is a big source of bugs

Inspiration





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