F#

Succinct, Expressive, Functional

The F# Team
Microsoft Developer Division
Microsoft Research

Topics

- What is F# about?
- Some Simple F# Programming
- A Taste of Parallel/Reactive with F#

What is F# about?

Or: *Why is Microsoft investing in functional programming anyway?*

Simplicity

Economics

Programmer Productivity

Simplicity

Code!

```
//F#
open System
let a = 2
Console.WriteLine a
```

```
//C#
using System;

namespace ConsoleApplication1
{
  class Program
  {
    static int a()
    {
        return 2;
    }
    static void Main(string[] args)
    {
        Console.WriteLine(a);
    }
  }
}
```

More Noise Than Signal!

Pleasure

```
type Command = Command of (Rover -> unit)

let BreakCommand     =
    Command(fun rover -> rover.Accelerate(-1.0))

let TurnLeftCommand  =
    Command(fun rover -> rover.Rotate(-5.0<degs>))
```

Pain

```
abstract class Command
 {
     public virtual void Execute();
 }
 abstract class MarsRoverCommand : Command
 {
     protected MarsRover Rover { get; priva

     public MarsRoverCommand(MarsRover rove
     {
         this.Rover = rover;
     }
 }
 class BreakCommand : MarsRoverCommand
 {
     public BreakCommand(MarsRover rover)
         : base(rover)
     {
     }
     public override void Execute()
     {
         Rover.Rotate(-5.0);
     }
 }
class TurnLeftCommand : MarsRoverCommand
 {
     public TurnLeftCommand(MarsRover rover
```

Pleasure

```
type Expr =
    | True
    | And of Expr * Expr
    | Nand of Expr * Expr
    | Or of Expr * Expr
    | Xor of Expr * Expr
    | Not of Expr
```

Pain

```
public abstract class Expr { }
public abstract class UnaryOp :Expr
{
    public Expr First { get; private set; }
    public UnaryOp(Expr first)
    {
        this.First = first;
    }
}

public abstract class BinExpr : Expr
{
    public Expr First { get; private set; }
    public Expr Second { get; private set; }

    public BinExpr(Expr first, Expr second)
    {
        this.First = first;
        this.Second = second;
    }
}

public class TrueExpr : Expr { }

public class And : BinExpr
{
    public And(Expr first, Expr second) : base(fi
```

http://stepheneasey.wordpress.com/tag/c/

Pleasure

```
let rotate (x,y,z) = (z,x,y)
```

```
let reduce f (x,y,z) =
    f x + f y + f z
```

Pain

```
Tuple<V,T,U> Rotate(Tuple<T,U,V> t)
{
    return new
   Tuple<V,T,U>(t.Item3,t.Item1,t.Item2);
}
```

```
int Reduce(Func<T,int> f,Tuple<T,T,T> t)
{
    return f(t.Item1) + f(t.Item2) + f
   (t.Item3);
}
```

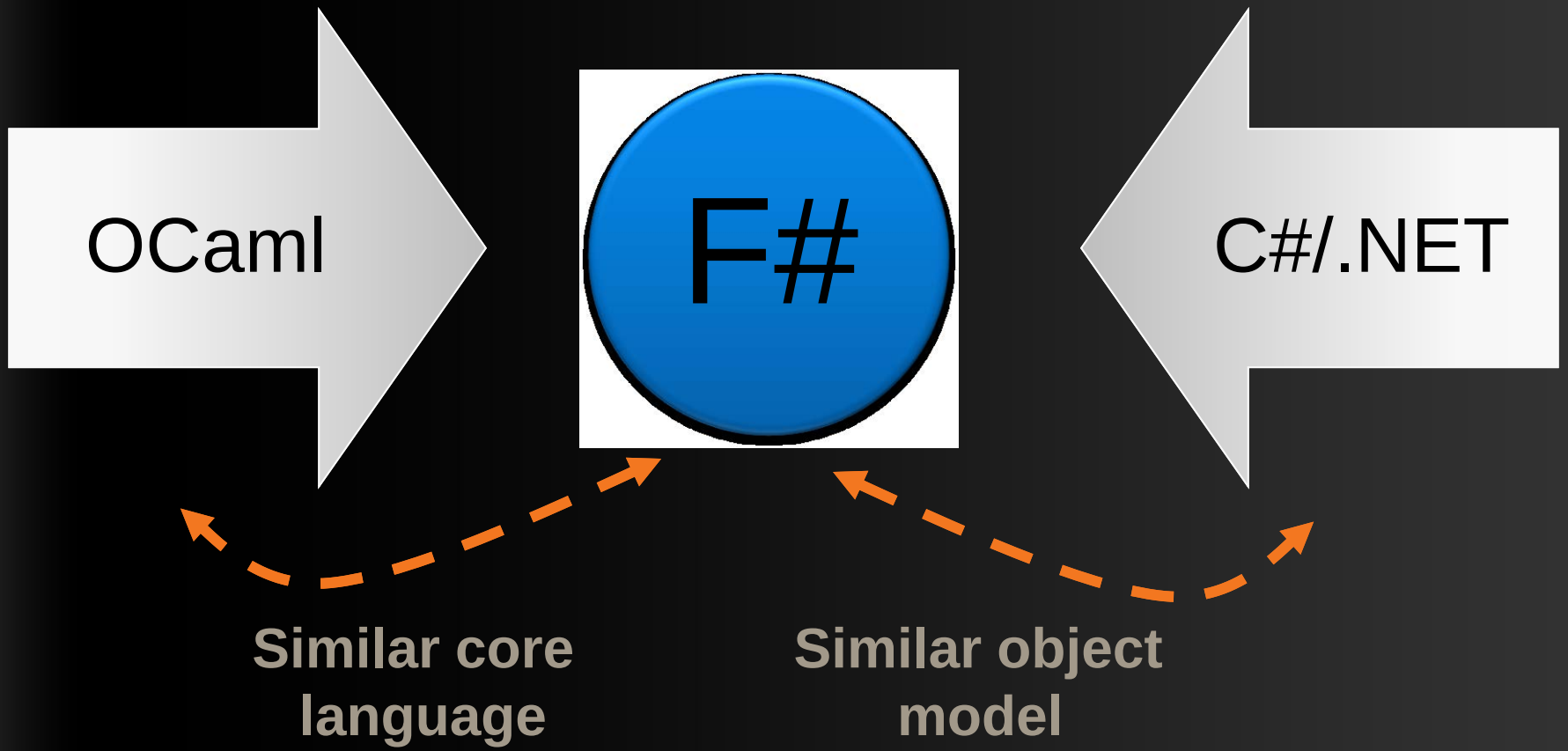
You
Can
Interoperate
With
Everything

Everything
Can
Interoperate
With
You

Economics

Fun!

F#: Influences



F#: Combining Paradigms

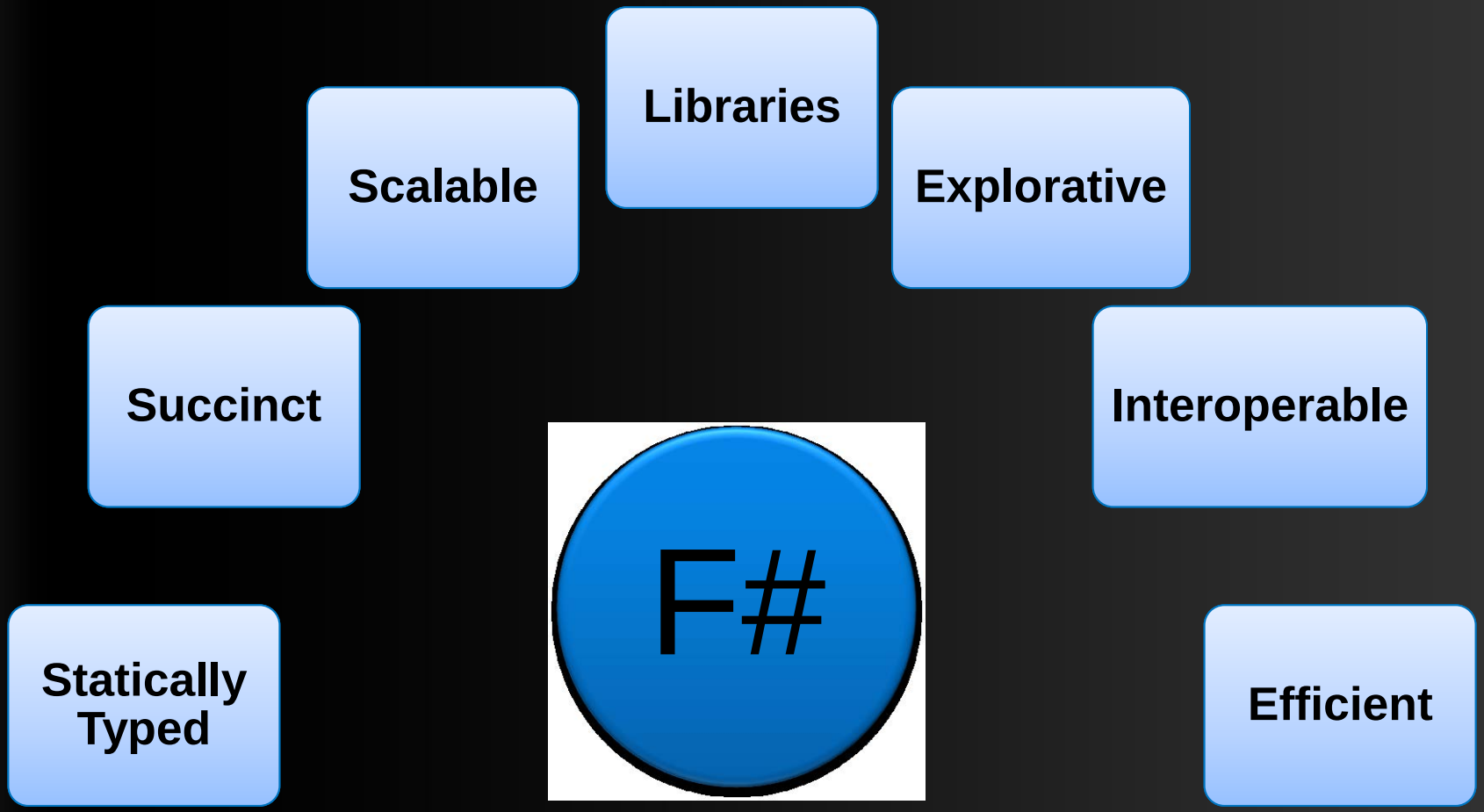
I've been coding in F# lately, for a production task.

*F# allows you to **move smoothly** in your programming style... I start with pure functional code, shift slightly towards an object-oriented style, and in production code, I sometimes have to do some imperative programming.*

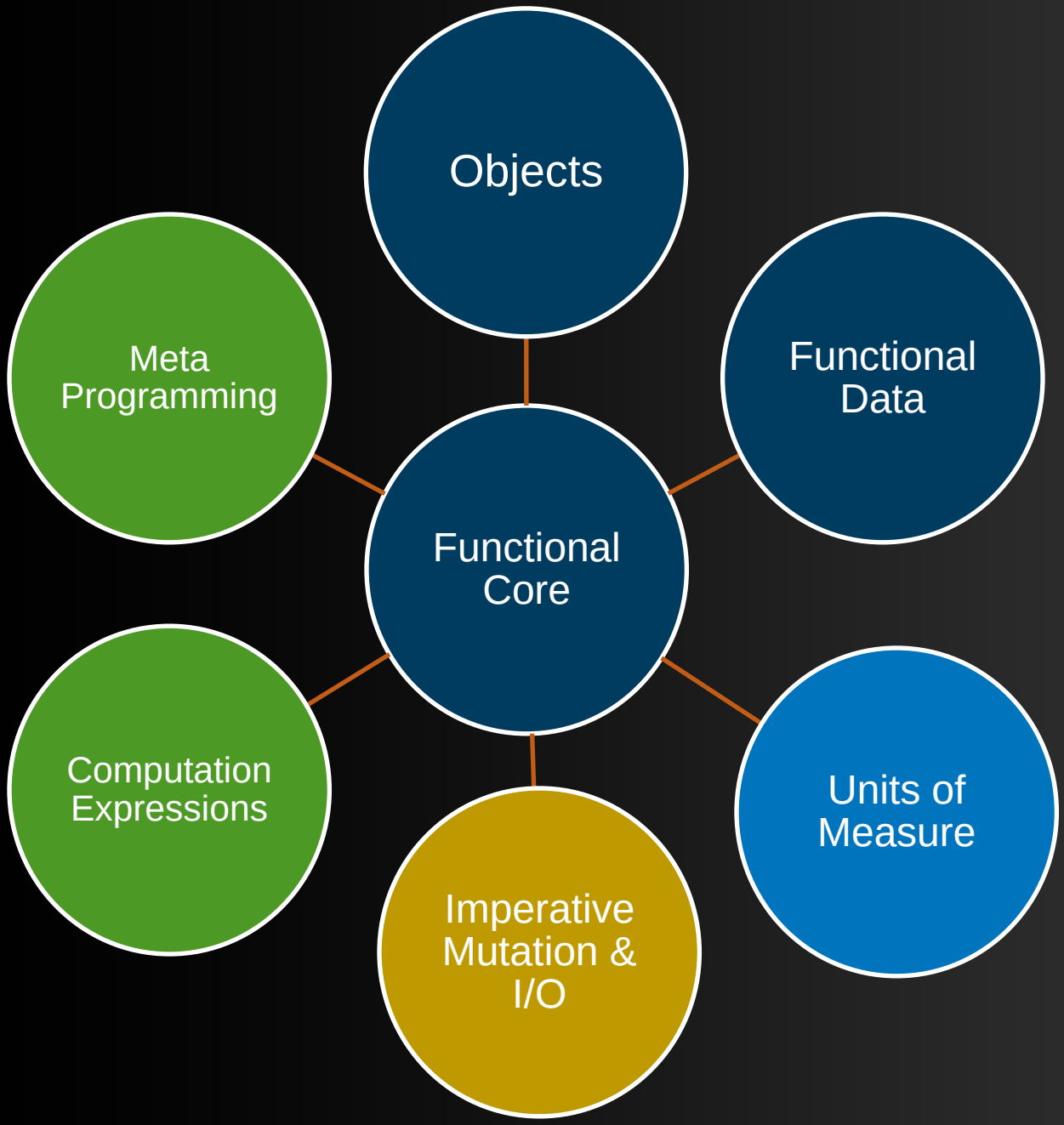
*I can **start with a pure idea**, and still **finish my project with realistic code**. You're never disappointed in any phase of the project!*

Julien Laugel, Chief Software Architect, www.eurostocks.com

F#: The Combination Counts!



F# in More Detail


Objects
Meta Programming
Functional Data
Functional Core
Computation Expressions
Units of Measure
Imperative Mutation & I/O

Quick Tour

Comments

```
// comment

(* comment *)

/// XML doc comment
let x = 1
```

Quick Tour

Overloaded Arithmetic

`x + y`	**Addition**
`x - y`	**Subtraction**
`x * y`	**Multiplication**
`x / y`	**Division**
`x % y`	**Remainder/modulus**
`-x`	**Unary negation**

Booleans

`not` *expr*	**Boolean negation**
expr `&&` *expr*	**Boolean "and"**
expr `||` *expr*	**Boolean "or"**

Orthogonal & Unified Constructs

- Let “let” simplify your life…

Type inference. The **safety** of C# with the **succinctness** of a scripting language

Bind a static value

Bind a static function

Bind a local value

Bind a local function

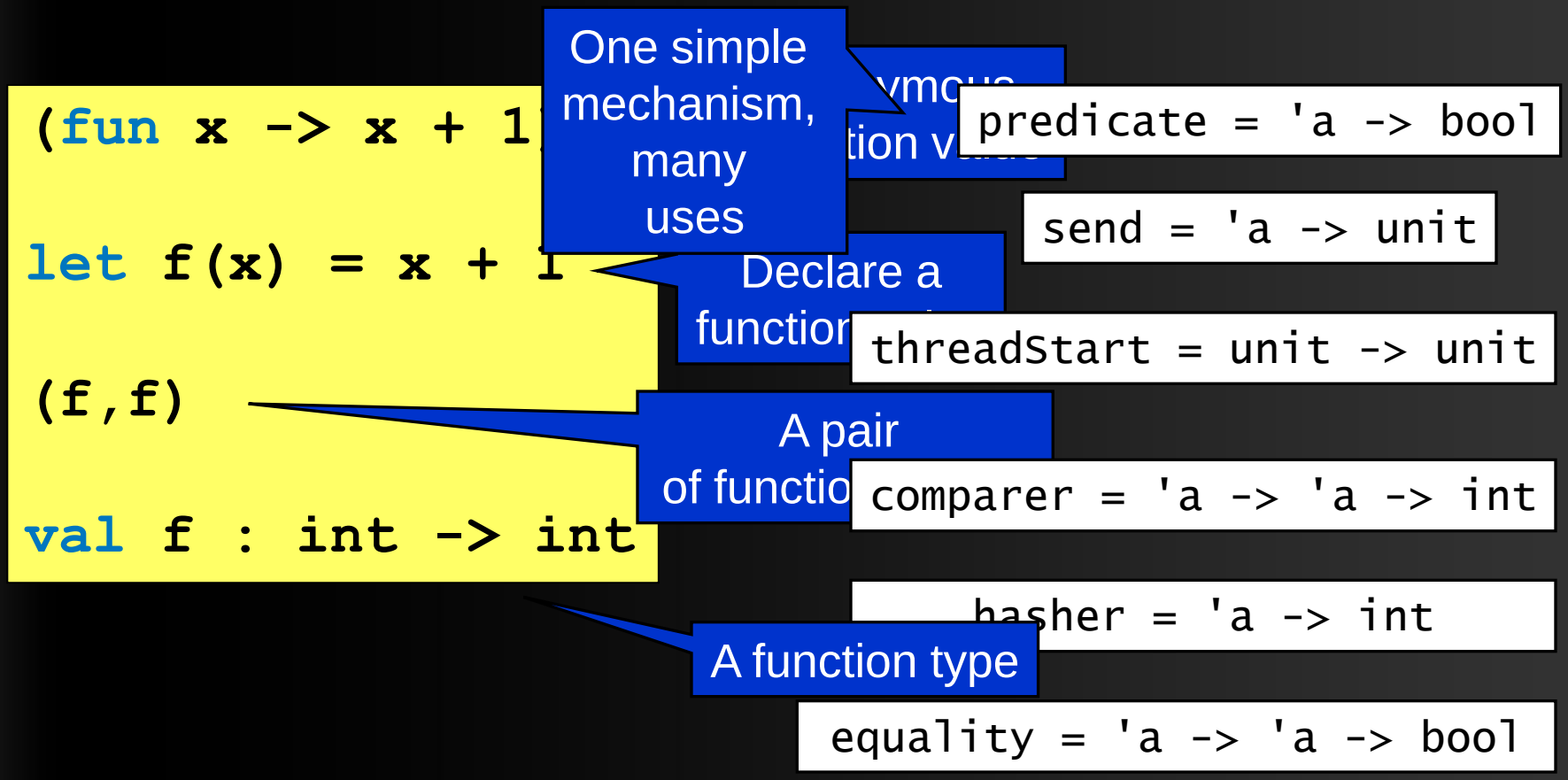
```
let data = (1,2,3)

let f(a,b,c) =
    let sum = a + b + c
    let g(x) = sum + x*x
    g(a), g(b), g(c)
```

Demo: Let’s WebCrawl…

Orthogonal & Unified Constructs

- Functions: like delegates + unified and simple



F# - Functional

```
let f x = x+1

let pair x = (x,x)

let fst (x,y) = x

let data = (Some [1;2;3], Some [4;5;6])

match data with
| Some(nums1), Some(nums2) -> nums1 @ nums2
| None, Some(nums)    -> nums
| Some(nums), None    -> nums
| None, None          -> failwith "missing!"
```

F# - Functional

```
List.map          Seq.fold

Array.filter      Lazy          Set.union

Map     LazyList     Events     Async...
```

Range Expressions

List via query

```
[ 0..1000 ]
[ for x in 0..10 -> (x, x * x) ]
[| for x in 0..10 -> (x, x * x) |]
seq { for x in 0..10 -> (x, x * x) }
```

Array via query

IEnumerable via query

Immutability the norm…

```
//-----------------------------------
// Part 1. Adjust some constants

let PI = 3.141592654

PI <- 4.0
```

This value is not

Error List

1 Error | Warnings | 0

	Descripti
1	This value ... t mutable.

Values may not be changed

```
type Person =
    { Name : string;
      Birth: DateTime }

let bob =
    { Name = "bob";
      Birth = DateTime(15,8,1980) }

// OK
let bobJunior =
    { bob with Birth = DateTime(23,5,2006) }

// Not OK!
bob.Birth <- DateTime(23,5,2006)
```

Data is immutable by default

✓ **Copy & Update**

✘ **Not Mutate**

Error List

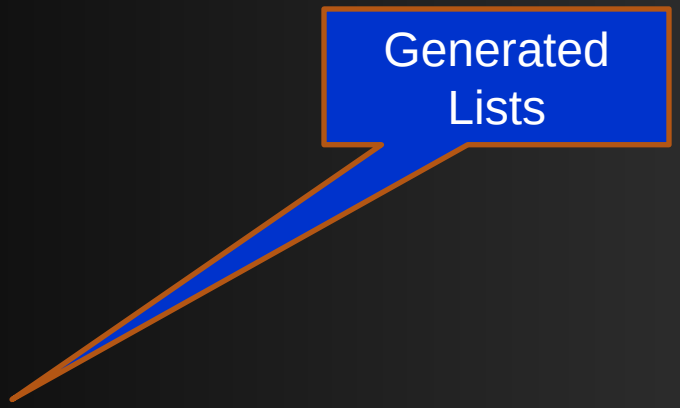
1 Error | 0 Warning

	Description	File	Line	Column
1	error FS0005: This field is not mutable	test.fs	18	1

In Praise of Immutability

- Immutable objects can be relied upon
- Immutable objects can transfer between threads
- Immutable objects can be aliased safely
- Immutable objects lead to (different) optimization opportunities

F# - Lists




```
open System.IO
let rec allFiles(dir) =
   [ for file in Directory.GetFiles(dir) do
         yield file
     for sub in Directory.GetDirectories(dir) do
         yield! allFiles(sub) ]

allFiles(@"C:\Demo")
```

F# - Sequences

On-demand sequences

```
open System.IO
let rec allFiles(dir) =
   seq
    { for file in Directory.GetFiles(dir) do
         yield file
      for sub in Directory.GetDirectories(dir) do
         yield! allFiles(sub) }

allFiles(@"C:\WINDOWS")
    |> Seq.take 100
    |> show
```

Pipelines

Weakly Typed? Slow?

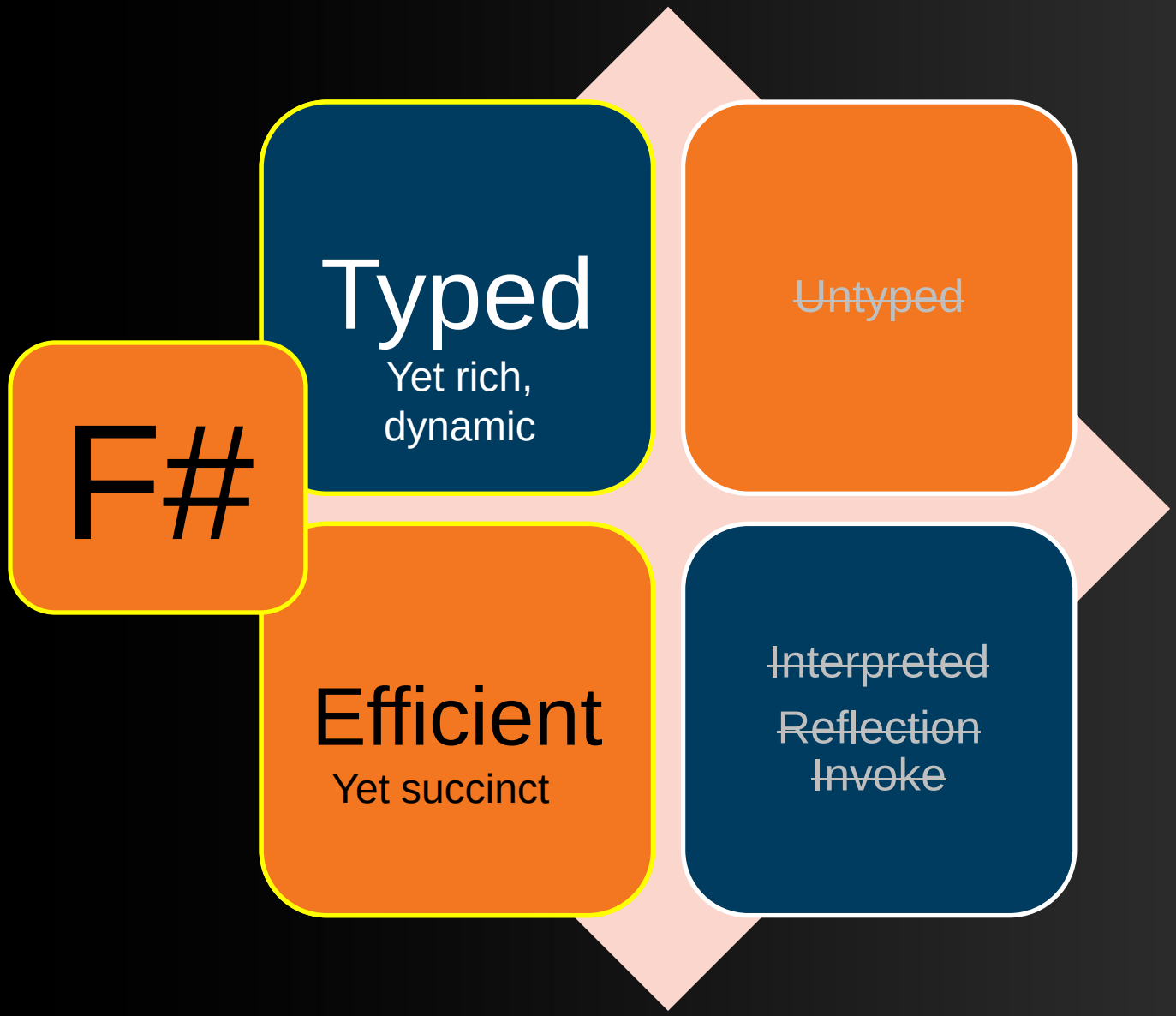
```
//F#
#light
open System
let a = 2
Console.WriteLine(a)
```

```
//C#
using System;

namespace ConsoleApplication1
{
    class Program
    {
        static int a()
        {
            return 2;
        }

        static void Main(string[]

            Console.WriteLine(a);
        }
    }
}
```


F#
Typed
Yet rich, dynamic
~~Untyped~~
Efficient
Yet succinct
~~Interpreted~~
~~Reflection~~
~~Invoke~~

Objects

Class Types

```
type ObjectType(args) =

    let internalValue = expr
    let internalFunction args = expr
    let mutable internalState = expr

    member x.Prop1 = expr
    member x.Meth2 args = expr
```

Constructing Objects

```
new FileInfo(@"c:\misc\test.fs")
```

F# - Objects + Functional

```
type Vector2D(dx:double,dy:double) =

    member v.DX = dx

    member v.DY = dy

    member v.Length = sqrt(dx*dx+dy*dy)

    member v.Scale(k) = Vector2D(dx*k,dy*k)
```

Inputs to object construction

Exported properties

Exported method

F# - Objects + Functional

```
type Vector2D(dx:double,dy:double) =

    let norm2 = dx*dx+dy*dy

    member v.DX = dx

    member v.DY = dy

    member v.Length = sqrt(norm2)

    member v.Norm2 = norm2
```

Internal (pre-computed) values and functions

F# - Objects + Functional

```
type HuffmanEncoding(freq:seq<char*int>) =

    ...
    < 50 lines of beautiful functional code>
    ...

    member x.Encode(input: seq<char>) =
          encode(input)

    member x.Decode(input: seq<char>) =
          decode(input)
```

Immutable inputs

Internal tables

Publish access

F# - Objects + Functional

```
type Vector2D(dx:double,dy:double) =

    let mutable currDX = dx

    let mutable currDX = dy

    member v.DX = currDX

    member v.DY = currDY

    member v.Move(x,y) =
          currDX <- currDX+x
          currDY <- currDY+y
```

Internal state

Publish internal state

Mutate internal state

F# and adCenter

- 4 week project, 4 machine learning experts
- 100million probabilistic variables
- Processes 6TB of training data
- Real time processing

AdPredict: What We O

- Quick Coding
- Agile Coding
- Scripting
- Performance
- Memory-Faithful
- Succinct
- Symbolic
- .NET Integration

F#'s powerful type inference means less typing, more thinking

Type-inferred code is easily refactored

"Hands-on" exploration.

Immediate scaling to massive data sets

mega-data structures, 16GB machines

Live in the **domain**, not the language

Schema compilation and "Schedules"

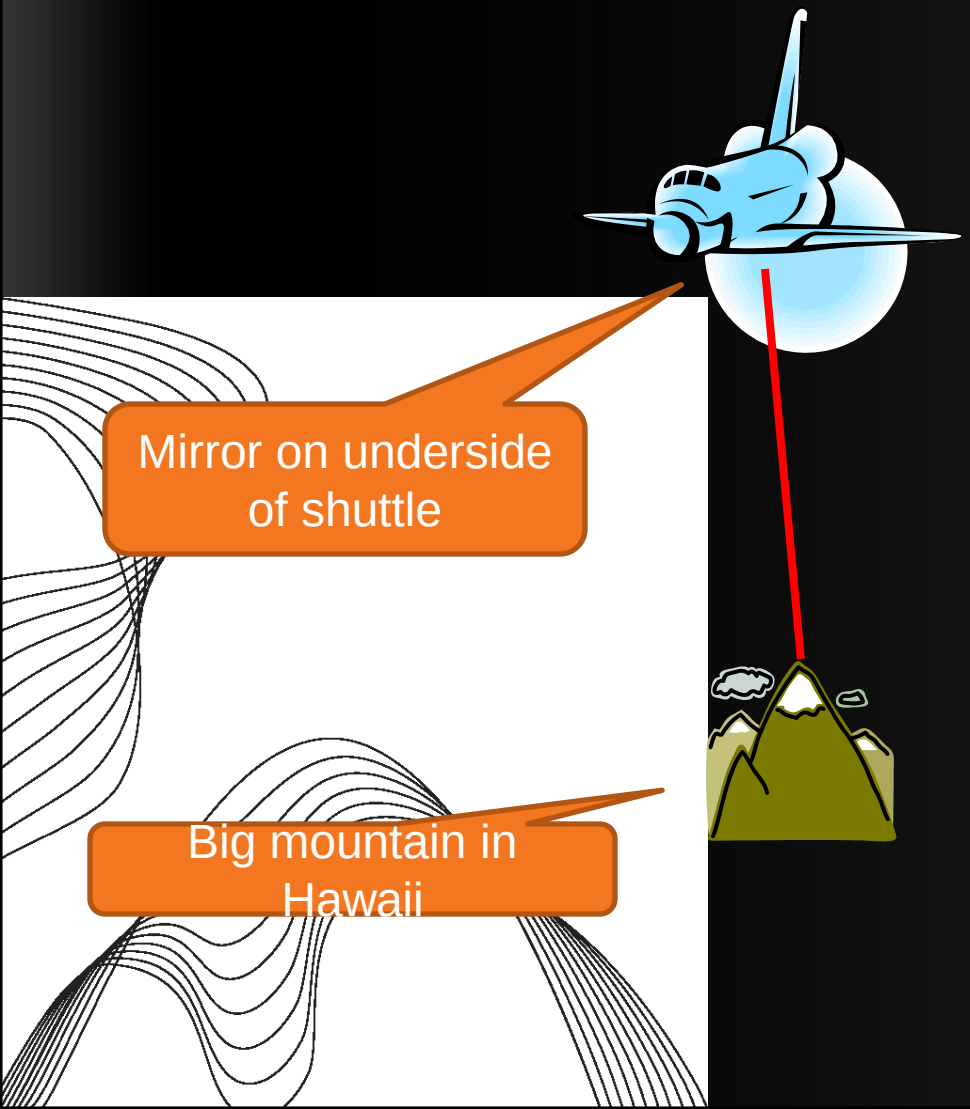
Especially Excel, SQL Server

Smooth Transitions

- Researcher's Brain → Realistic, Efficient Code
- Realistic, Efficient Code → Component
- Component → Deployment

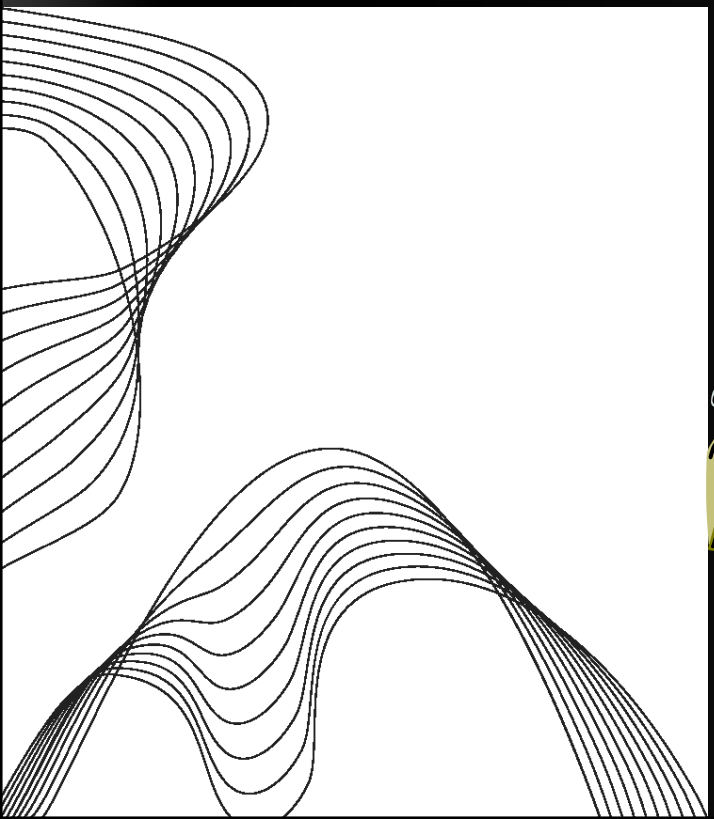
UNITS OF MEASURE

1985



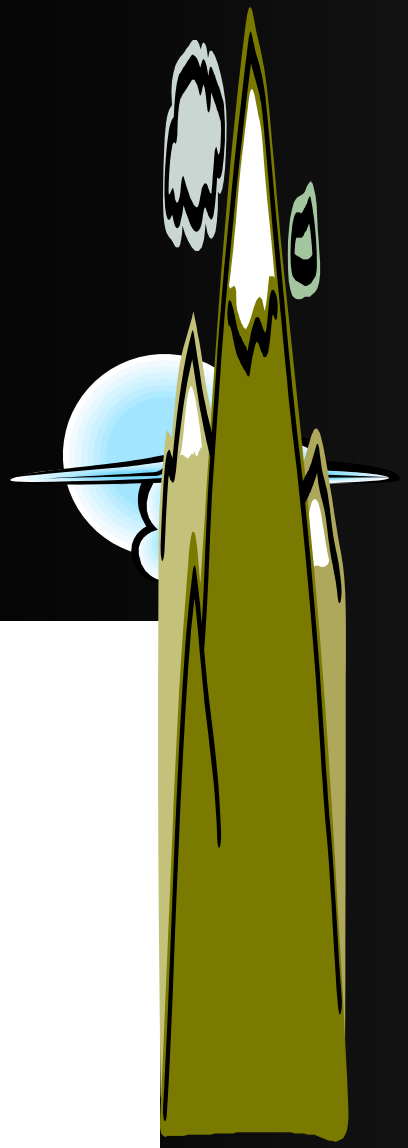
SDI experiment:
The plan

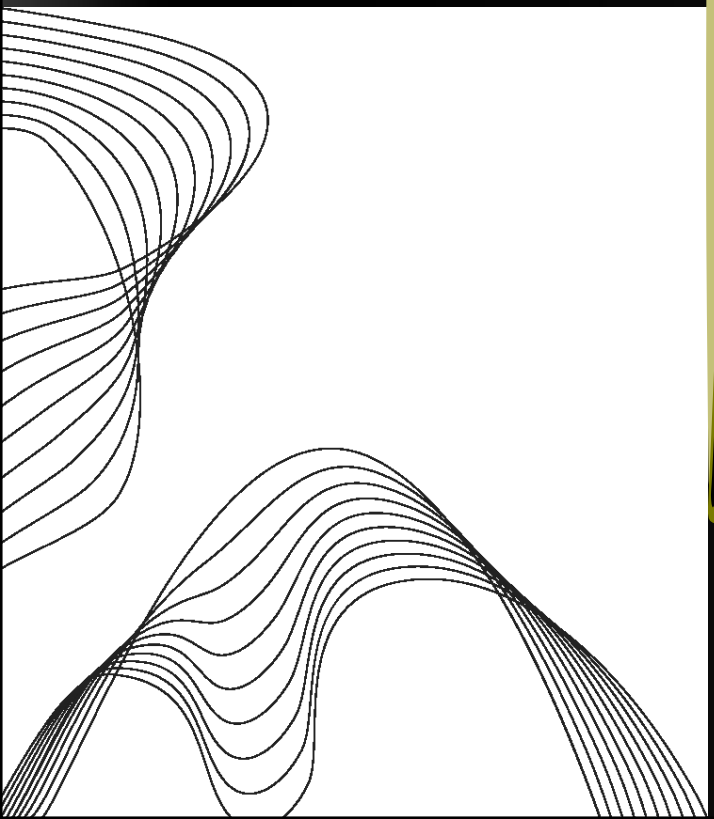
1985



SDI experiment:
The reality

1985





The reality

NASA Mars Climate Orbiter, 1999

CNN.com

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Metric system used by NASA for many years

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NASA's Climate Orbiter was lost September 23, 1999

By Robin Lloyd
CNN Interactive Senior Writer

(CNN) -- NASA lost a $125 million Mars orbiter because a Lockheed Martin engineering team used English units of measurement while the agency's team used the more conventional metric system for a key spacecraft operation, according to a review finding released Thursday.

The units mismatch prevented navigation information from transferring between the Mars Climate Orbiter spacecraft team in at Lockheed Martin in Denver and the flight team at NASA's Jet Propulsion Laboratory in Pasadena, California.

NASA Mars Climate Orbiter, 1999

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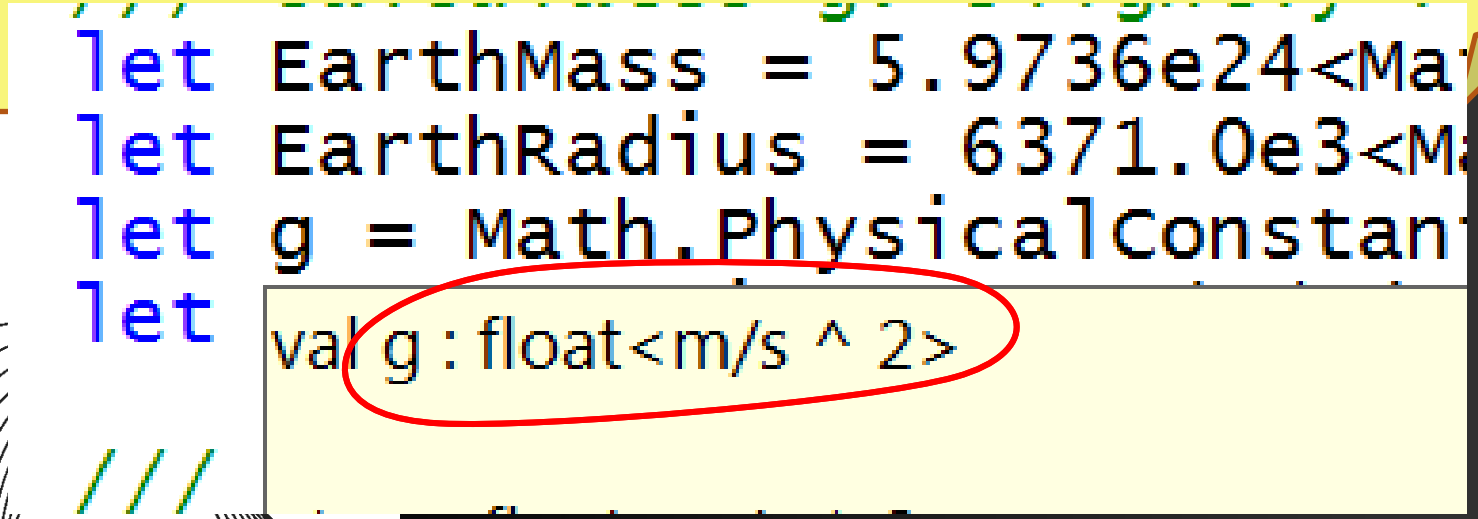
The units mismatch prevented navigation information from transferring between the Mars Climate Orbiter spacecraft team in at Lockheed Martin in Denver and the flight team at NASA's Jet Propulsion Laboratory in Pasadena, California.

```
let EarthMass = 5.9736e24<kg>

// Average between pole and equator radii
let EarthRadius = 6371.0e3<m>

// Gravitational acceleration on surface of Earth
let g = PhysicalConstants.G * EarthMass / (EarthRadius * EarthRadius)
```



F# Async/Parallel

async { ... }

A Building Block for Async/Parallel/Reactive Design Patterns

```
async { ... }
```

- For users:

You can run it, but it may take a while

Or, your builder says...

OK, I can do the job, but I might have to talk to someone else about it. I'll get back to you when I'm done

DEMO

The F# Approach

In parallel programming,

F# is a **power tool**

for good architects and good developers

- Good Architecture
  - Know your techniques
  - Know your requirements
  - Know your limits (CPU, disk, network, latency)
- Translate Good Architecture into Good Code with F#
  - A great platform
  - A massive increase in isolation and immutability
  - A massive reduction in mutation

async { ... }

```
async { let! image = ReadAsync "cat.jpg"
        let image2 = f image
        do! writeAsync image2 "dog.jpg"
        do printfn "done!"
        return image2 }
```

Asynchronous "non-blocking" action

Continuation/ Event callback

You're actually writing this (approximately):

```
async.Delay(fun () ->
    async.Bind(ReadAsync "cat.jpg", (fun image ->
        let image2 = f image
        async.Bind(writeAsync "dog.jpg",(fun () ->
            printfn "done!"
            async.Return())))))
```

async { ... }

- Built on a much more general mechanism called “computation expressions”

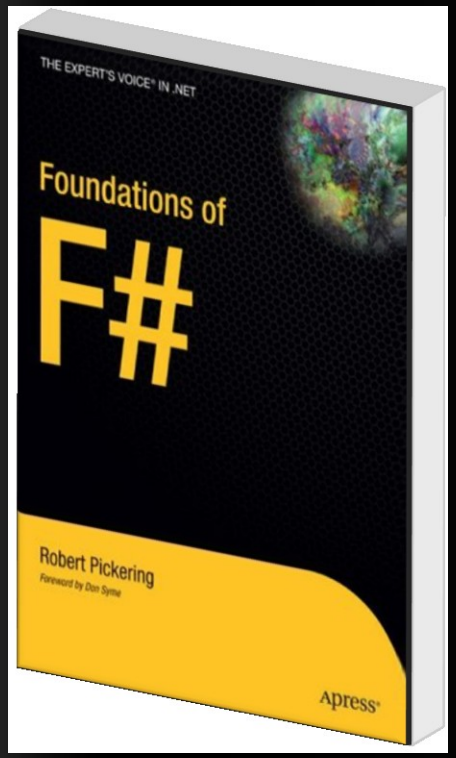
seq { ... }	(queries/sequences)
eventStream { ... }	(queries over event streams)
parser { ... }	(parser combinators)
resumable { ... }	(resumptions)

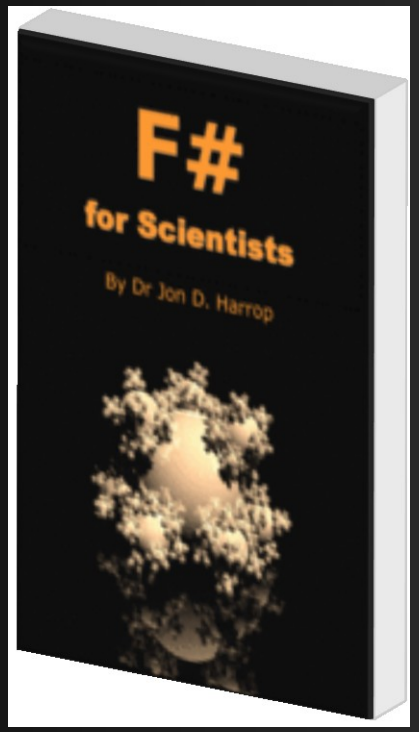
DEMO

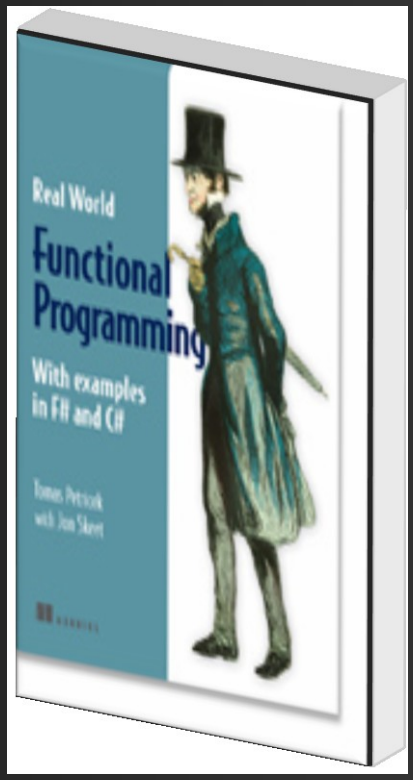
8 Ways to Learn

- FSI.exe
- Samples Included
- Go to definition
- Lutz' Reflector
- http://cs.hubfs.net
- Codeplex Fsharp Samples
- Books
- ML

Books about F#







Visit www.fsharp.net

Getting F#

- September 2008: CTP released

F# will be a supported language in Visual Studio 2010

- Next stop: Visual Studio 2010 Beta 1

Look for it soon!

Questions & Discussion