

# Syntax Matters:

Writing abstract computations in F#

Tomas Petricek

University of Cambridge

Don Syme

Microsoft Research

# Non-standard computations in various languages and F#

# C# 5.0 asynchronous methods

```
async Task<string> GetLength(string url) {  
    var html = await DownloadAsync(url);  
    return html.Length;  
}
```

*getLength : string → Async<int>*

```
let getLength url = async {  
    let! html = downloadAsync url  
    return html.Length }  
}
```

# Python **generators**

```
def duplicate(inputs):  
    for number in inputs:  
        yield number  
        yield number * 10
```

*duplicate* : *seq*<int> → *seq*<int>

```
let duplicate inputs = seq {  
    for number in inputs do  
        yield number  
        yield number * 10 }
```

Not just  
a monad!

Unifying single-purpose syntax  
with **F# computation expressions**

# F# computation expressions

Unify **single-purpose** extensions

- Custom **binding**

- Custom **returning** or **yielding**

- Custom **loops** and **exceptions**

**Computation expression** principles

- Unify** single-purpose syntax

- Reuse **standard syntax** of F#

- Allow flexible custom **interpretation**

# What **types** of computations?

**Library author** decides

**Adding operations** enables constructs

**Flexible types** of operations

Enable custom for loops

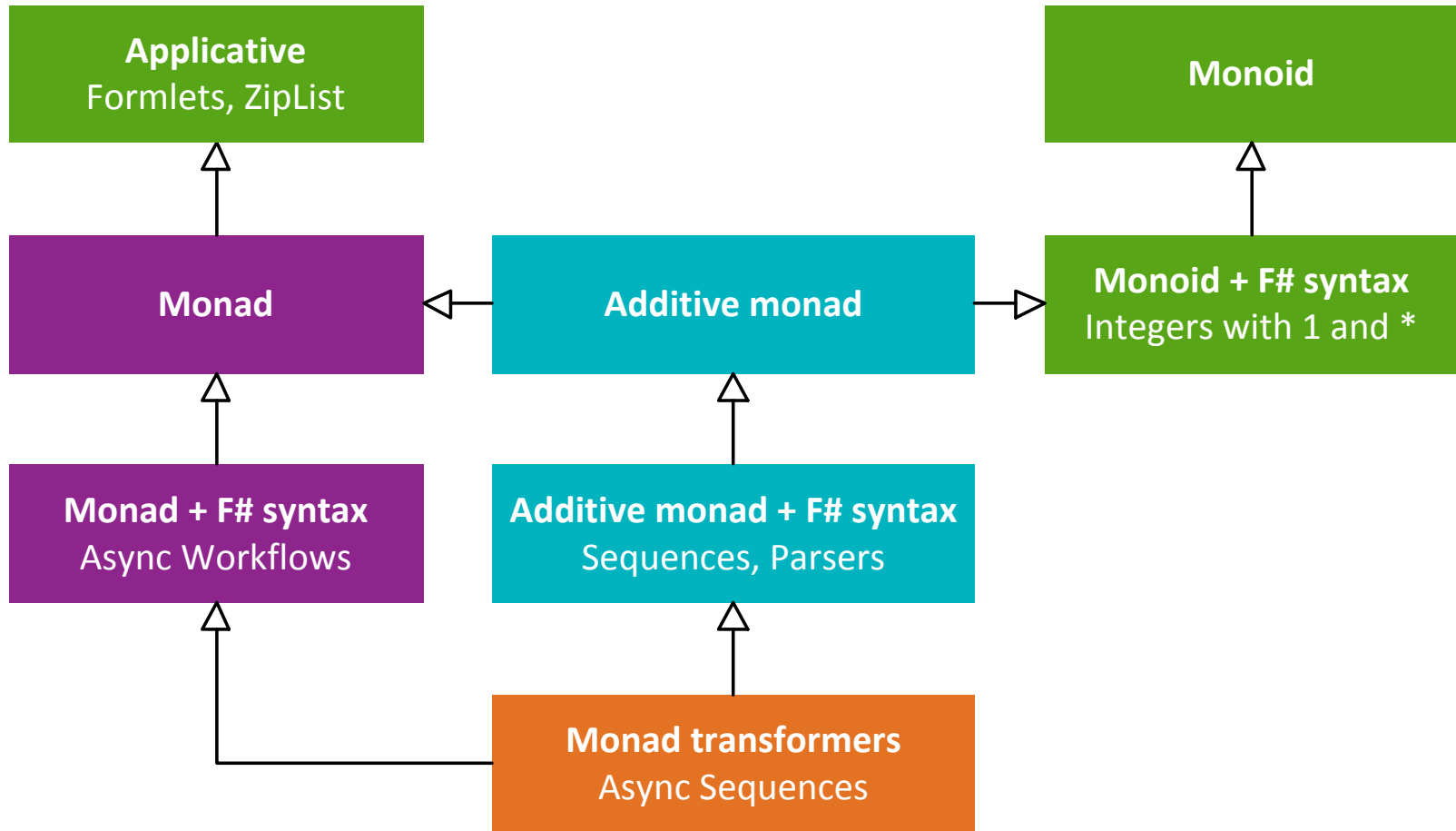
**for** :  $[\alpha] \rightarrow (\alpha \rightarrow \text{Mnd } \beta) \rightarrow \text{Mnd } \beta$

**for** :  $\text{Seq } \alpha \rightarrow (\alpha \rightarrow \text{Mnd } \beta) \rightarrow \text{Mnd } \beta$

Paper identifies **common abstractions**

Finds the most **intuitive syntax**

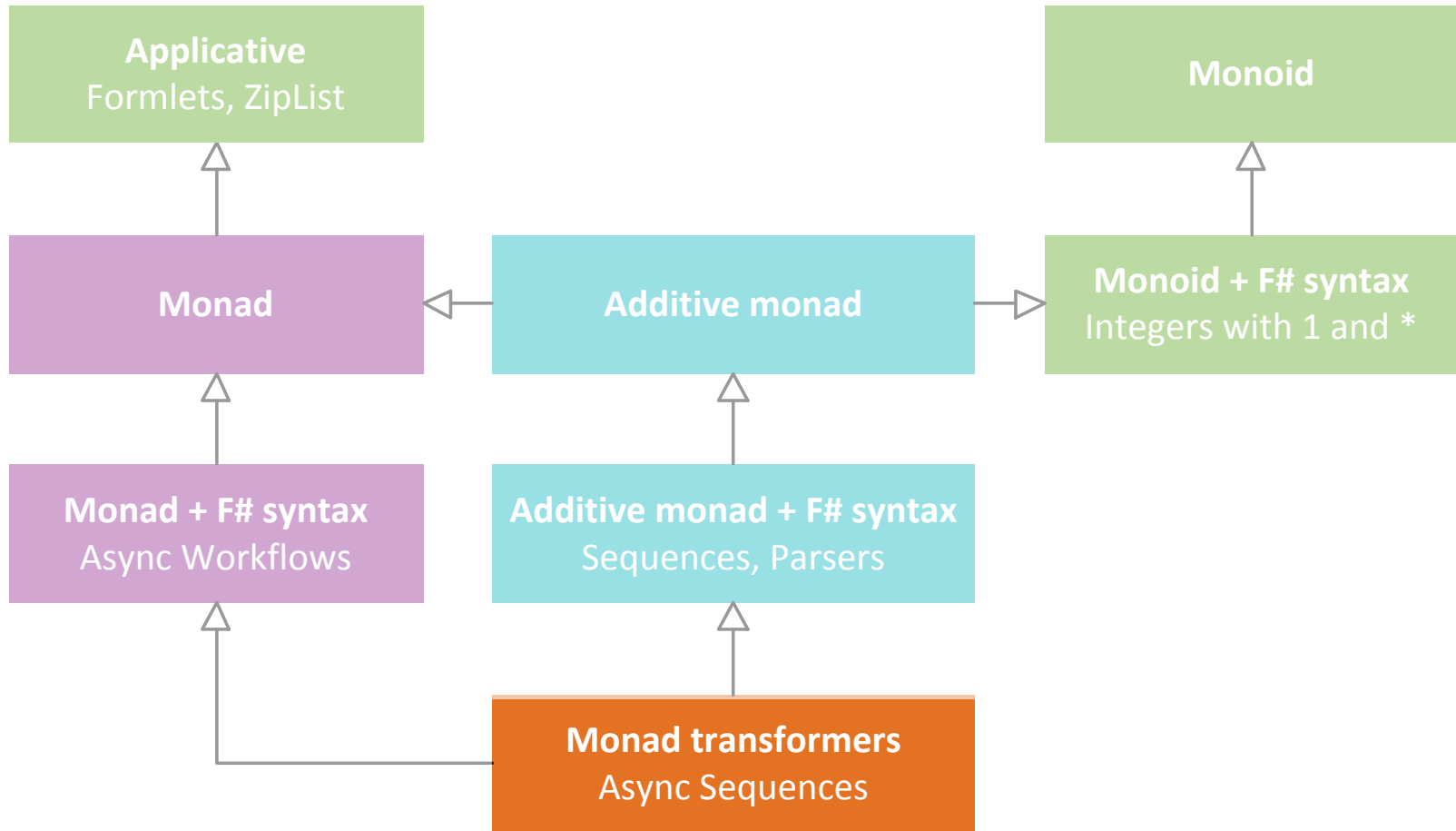
# What can we express?





Common **computation types**  
and **syntax** for them

# What can we express?



# Asynchronous and sequences

## List transformer applied to async monad

```
let pages = asyncSeq {  
  for url in addressStream do  
    let! html = wc.AsyncDownload(url)  
    yield url, html }
```

normal bind

lifted bind

**for** :  $\text{AsyncSeq } \alpha \rightarrow (\alpha \rightarrow \text{AsyncSeq } \beta) \rightarrow \text{AsyncSeq } \beta$

**bind** :  $\text{Async } \alpha \rightarrow (\alpha \rightarrow \text{AsyncSeq } \beta) \rightarrow \text{AsyncSeq } \beta$

**for** :  $[\alpha] \rightarrow (\alpha \rightarrow \text{AsyncSeq } \beta) \rightarrow \text{AsyncSeq } \beta$

# Summary

## Syntax matters!

Reinterpretation of standard syntax

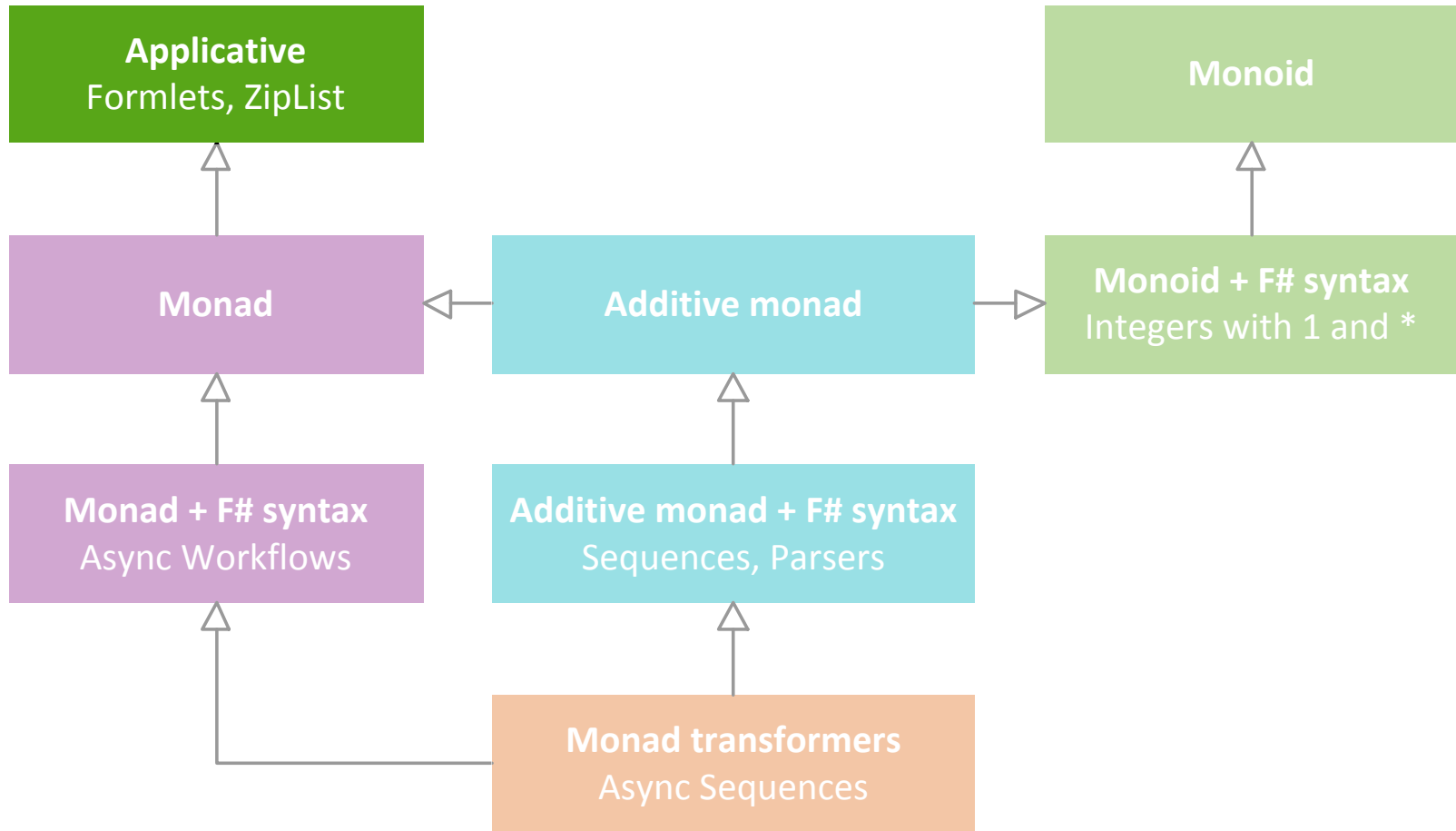
Better intuition than combinators

## Flexibility is good!

Wide range of computations

Intuitive syntax for a computation

# What can we express?



# Applicative formlets

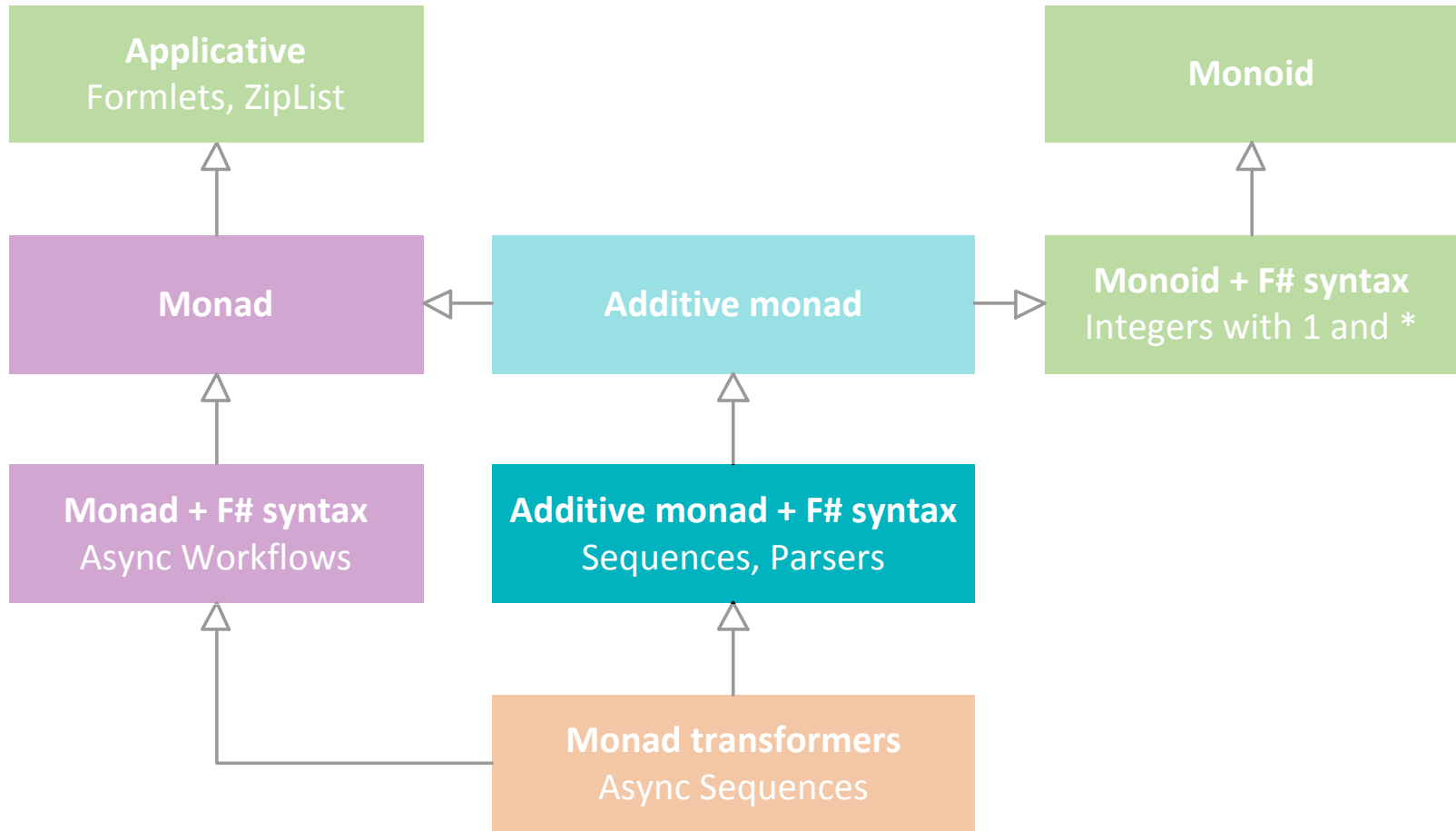
## Generalization of monad

Computation structure cannot depend on values

```
let userFormlet = formlet {  
  let! name = Formlet.textBox  
  and gender = Formlet.dropDown ["Male"; "Female"]  
  return name + " " + gender }
```

```
map      : Formlet  $\alpha \rightarrow (\alpha \rightarrow \beta) \rightarrow$  Formlet  $\beta$   
merge   : Formlet  $\alpha \rightarrow$  Formlet  $\beta \rightarrow$  Formlet  $(\alpha \times \beta)$   
return  :  $\alpha \rightarrow$  Formlet  $\alpha$ 
```

# What can we express?



# Additive monad for sequences

Combines monad and monoid

Uses **for** for monadic binding

```
seq { yield! Directory.GetFiles(dir)  
      for subdir in Directory.GetDirectories(dir) do  
      yield! listFiles subdir }
```

```
for      : Seq  $\alpha$   $\rightarrow$  ( $\alpha \rightarrow$  Seq  $\beta$ )  $\rightarrow$  Seq  $\beta$   
combine : Seq  $\alpha \rightarrow$  Seq  $\alpha \rightarrow$  Seq  $\alpha$   
yield    :  $\alpha \rightarrow$  Seq  $\alpha$ 
```



# Additive monad for parsers

Combines monad and monoid

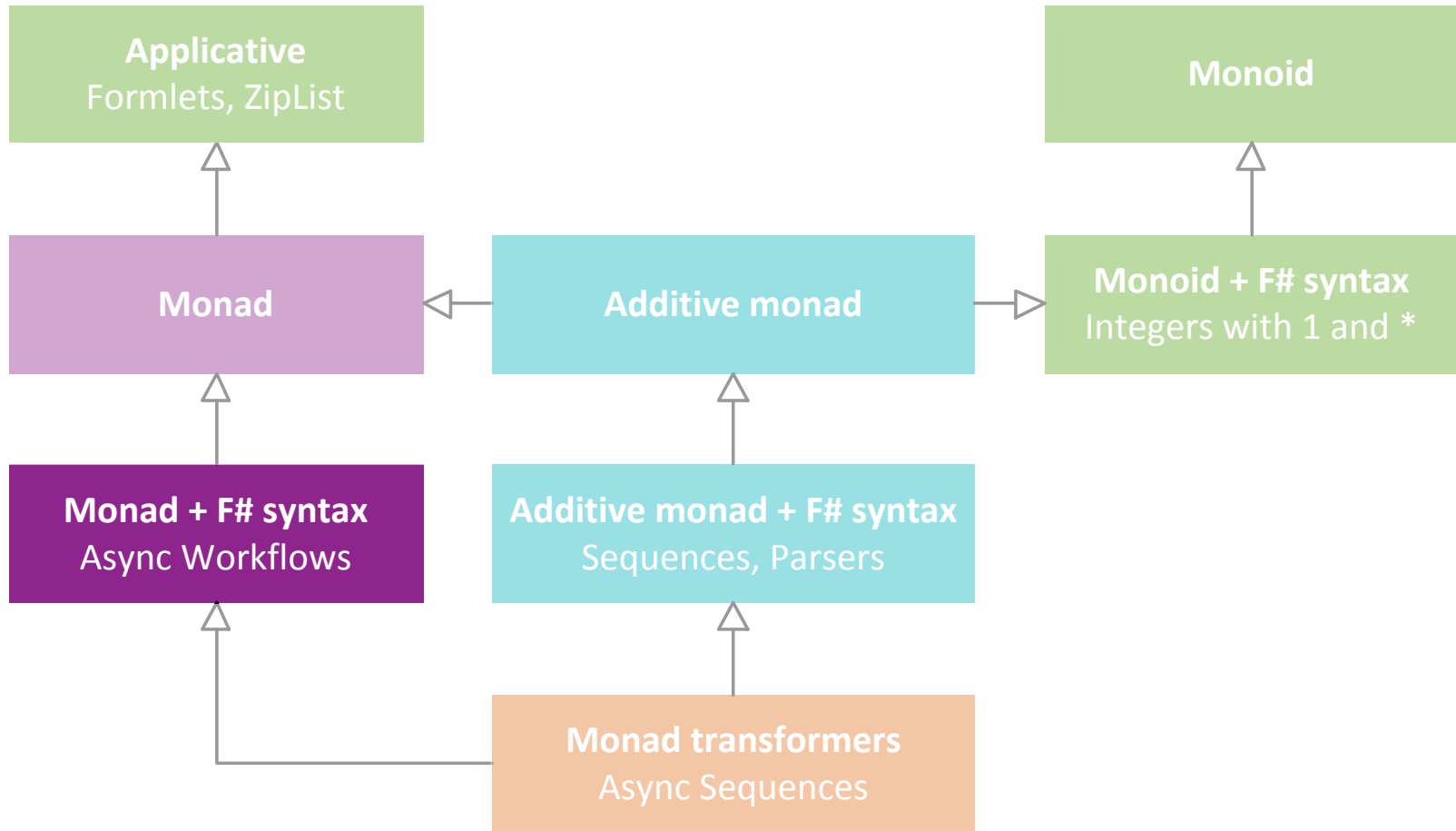
Uses **let!** for monadic binding

```
let rec some p = parse {  
  let! x = p  
  let! xs = many p  
  return x::xs }
```

```
and many p = parse {  
  return! some p  
  return [] }
```

```
bind      : Seq  $\alpha$   $\rightarrow$  ( $\alpha \rightarrow$  Seq  $\beta$ )  $\rightarrow$  Seq  $\beta$   
combine  : Seq  $\alpha \rightarrow$  Seq  $\alpha \rightarrow$  Seq  $\alpha$   
return    :  $\alpha \rightarrow$  Seq  $\alpha$ 
```

# What can we express?



# Monadic async workflows

## Monad with standard F# control flow

```
async {  
    while true do  
        for color in [green; orange; red] do  
            do! Async.Sleep(1000)  
            displayLight color }  
}
```



```
bind : Async  $\alpha$   $\rightarrow$  ( $\alpha \rightarrow$  Async  $\beta$ )  $\rightarrow$  Async  $\beta$   
for : [ $\alpha$ ]  $\rightarrow$  ( $\alpha \rightarrow$  Async 1)  $\rightarrow$  Async 1  
while : (1  $\rightarrow$  bool)  $\rightarrow$  Async 1  $\rightarrow$  Async 1
```