

Продолжение про F#

Юрий Литвинов

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Последовательности

Ленивый тип данных

F#

```
seq {0 .. 2}  
seq {11 .. 1000000000000001}
```

F#

open System.IO

let rec allFiles dir =

Seq.append

 (dir |> **Directory**.GetFiles)

 (dir |> **Directory**.GetDirectories

 |> **Seq**.map allFiles

 |> **Seq**.concat)

Типичные операции с последовательностями

Операция	Тип
Seq.append	$\#seq <'a> \rightarrow \#seq <'a> \rightarrow seq <'a>$
Seq.concat	$\#seq <\#seq <'a>> \rightarrow seq <'a>$
Seq.choose	$('a \rightarrow 'b\ option) \rightarrow \#seq <'a> \rightarrow seq <'b>$
Seq.empty	$seq <'a>$
Seq.map	$('a \rightarrow 'b) \rightarrow \#seq <'a> \rightarrow \#seq <'b>$
Seq.filter	$('a \rightarrow bool) \rightarrow \#seq <'a> \rightarrow seq <'a>$
Seq.fold	$('s \rightarrow 'a \rightarrow 's) \rightarrow 's \rightarrow seq <'a> \rightarrow 's$
Seq.initInfinite	$(int \rightarrow 'a) \rightarrow seq <'a>$

Задание последовательностей

F#

```
let squares = seq { for i in 0 .. 10 -> (i, i * i) }  
seq { for (i, isquared) in squares ->  
      (i, isquared, i * isquared) }
```

F#

```
let checkerboardCoordinates n =  
    seq { for row in 1 .. n do  
          for col in 1 .. n do  
              if (row + col) % 2 = 0 then  
                  yield (row, col) }
```

Ленивое чтение из файла

```
F#  
  
let rec allFiles dir =  
    seq { for file in Directory.GetFiles(dir) -> file  
          for subdir in Directory.GetDirectories dir ->>  
            (allFiles subdir) }
```

```
F#  
  
let reader =  
    seq {  
        use reader = new StreamReader(  
            File.OpenRead("test.txt")  
        )  
        while not reader.EndOfStream do  
            yield reader.ReadLine() }
```

Записи

F#

```
type Person =  
    { Name: string;  
      DateOfBirth: System.DateTime; }
```

F#

```
{ Name = "Bill";  
  DateOfBirth = new System.DateTime(1962, 09, 02) }  
  
{ new Person  
  with Name = "Anna"  
  and DateOfBirth = new System.DateTime(1968, 07, 23) }
```

Клонирование записей

F#

```
type Car =  
    {  
        Make : string  
        Model : string  
        Year : int  
    }
```

F#

```
let thisYear's = { Make = "SomeCar";  
                  Model = "Luxury Sedan";  
                  Year = 2010 }  
let nextYear's = { thisYear's with Year = 2011 }
```

Размеченные объединения

Discriminated unions

F#

```
type Route = int
```

```
type Make = string
```

```
type Model = string
```

```
type Transport =
```

```
    | Car of Make * Model
```

```
    | Bicycle
```

```
    | Bus of Route
```


Известные примеры

F#

```
type 'a option =  
    | None  
    | Some of 'a
```

F#

```
type 'a list =  
    | []  
    | (::) of 'a * 'a list
```

Использование размеченных объединений

F#

```
type IntOrBool = I of int | B of bool
```

```
let i = I 99
```

```
let b = B true
```

F#

```
type C = Circle of int | Rectangle of int * int
```

```
[1..10]
```

```
> List.map Circle
```

```
[1..10]
```

```
> List.zip [21..30]
```

```
> List.map Rectangle
```

Использование в match

F#

```
type Tree<'a> =  
    | Tree of 'a * Tree<'a> * Tree<'a>  
    | Tip of 'a
```

```
let rec size tree =  
    match tree with  
    | Tree(_, l, r) -> 1 + size l + size r  
    | Tip _ -> 1
```

Пример

Дерево разбора логического выражения

F#

```
type Proposition =
```

```
| True  
| And of Proposition * Proposition  
| Or of Proposition * Proposition  
| Not of Proposition
```

```
let rec eval (p: Proposition) =
```

```
    match p with
```

```
    | True -> true  
    | And(p1, p2) -> eval p1 && eval p2  
    | Or(p1, p2) -> eval p1 || eval p2  
    | Not(p1) -> not (eval p1)
```

```
printfn "%A" <| eval (Or(True, And(True, Not True)))
```

Взаимосвязанные типы

F#

```
type node =  
    { Name : string;  
      Links : link list }  
and link =  
    | Dangling  
    | Link of node
```

Замена цикла рекурсией

Императивное разложение на множители

F#

```
let factorizeImperative n =  
    let mutable primefactor1 = 1  
    let mutable primefactor2 = n  
    let mutable i = 2  
    let mutable fin = false  
    while (i < n && not fin) do  
        if (n % i = 0) then  
            primefactor1 <- i  
            primefactor2 <- n / i  
            fin <- true  
        i <- i + 1  
    if (primefactor1 = 1) then None  
    else Some (primefactor1, primefactor2)
```

Замена цикла рекурсией

Рекурсивное разложение на множители

F#

```
let factorizeRecursive n =  
    let rec find i =  
        if i >= n then None  
        elif (n % i = 0) then Some(i, n / i)  
        else find (i + 1)  
    find 2
```

Хвостовая рекурсия, проблема

Императивный вариант

F#

open System.Collections.Generic

```
let createMutableList() =  
    let l = new List<int>()  
    for i = 0 to 100000 do  
        l.Add(i)  
    l
```


Хвостовая рекурсия, проблема

Рекурсивный вариант, казалось бы

F#

```
let createImmutableList() =  
    let rec createList i max =  
        if i = max then  
            []  
        else  
            i :: createList (i + 1) max  
    createList 0 100000
```

Факториал без хвостовой рекурсии

F#

```
let rec factorial x =  
    if x <= 1  
    then 1  
    else x * factorial (x - 1)
```

F#

```
let rec factorial x =  
    if x <= 1  
    then  
        1  
    else  
        let resultOfRecursion = factorial (x - 1)  
        let result = x * resultOfRecursion  
        result
```

Факториал с хвостовой рекурсией

F#

```
let factorial x =  
    let rec tailRecursiveFactorial x acc =  
        if x <= 1 then  
            acc  
        else  
            tailRecursiveFactorial (x - 1) (acc * x)  
    tailRecursiveFactorial x 1
```

После декомпиляции в C#

C#

```
public static int tailRecursiveFactorial(int x, int acc)
{
    while (true)
    {
        if (x <= 1)
        {
            return acc;
        }
        acc *= x;
        x--;
    }
}
```

Паттерн “Аккумулятор”

F#

```
let rec map f list =  
    match list with  
    | [] -> []  
    | hd :: tl -> (f hd) :: (map f tl)
```

```
let map f list =  
    let rec mapTR f list acc =  
        match list with  
        | [] -> acc  
        | hd :: tl -> mapTR f tl (f hd :: acc)  
    mapTR f (List.rev list) []
```

Аккумулятор — функция

```
F#  
  
let printListRev list =  
    let rec printListRevTR list cont =  
        match list with  
        | [] -> cont ()  
        | hd :: tl ->  
            printListRevTR tl (fun () ->  
                printf "%d " hd; cont () )  
    printListRevTR list (fun () -> printfn "Done!")
```

Когда всё не так просто

F#

```
type ContinuationStep<'a> =  
    | Finished  
    | Step of 'a * (unit -> ContinuationStep<'a>)
```

```
let rec linearize binTree cont =  
    match binTree with  
    | Empty -> cont()  
    | Node(x, l, r) ->  
        Step(x, (fun () -> linearize l (fun () ->  
            linearize r cont)))
```

Собственно, обход

```
F#  
  
let iter f binTree =  
    let steps = linearize binTree (fun () -> Finished)  
  
    let rec processSteps step =  
        match step with  
        | Finished -> ()  
        | Step(x, getNext) -> f x  
            processSteps (getNext())  
  
    processSteps steps
```


Юнит-тестирование в F#

- ▶ Работают все дотнетовские библиотеки (NUnit, MsTest и т.д.)
- ▶ Есть обёртки, делающие код тестов более “функциональным” (FsUnit)
- ▶ Есть чисто F#-овские штуки: FsCheck, Unquote
 - ▶ на самом деле, не совсем F#-овские, но в C# такого нет

FsUnit, пример

```
module ``Project Euler - Problem 1`` =
```

```
  open NUnit.Framework
```

```
  open FsUnit
```

```
let GetSumOfMultiplesOf3And5 max =
```

```
  seq{3 .. max - 1}
```

```
  |> Seq.fold(fun acc number ->
```

```
    (if (number % 3 = 0 || number % 5 = 0) then
```

```
      acc + number else acc)) 0
```

```
[<Test>]
```

```
let ``Sum of multiples of 3 and 5 to 10 should return 23`` () =
```

```
  GetSumOfMultiplesOf3And5(10) |> should equal 23
```

FsUnit, матчеры

1 |> should equal 1

1 |> should **not**' (equal 2)

10.1 |> should (equalWithin 0.1) 10.11

"ships" |> should startWith "sh"

"ships" |> should **not**' (endsWith "ss")

"ships" |> should haveSubstring "hip"

[1] |> should contain 1

[] |> should **not**' (contain 1)

anArray |> should haveLength 4

(**fun** () -> failwith "BOOM!") |> ignore)

|> should throw typeof<**System**.Exception>

shouldFail (**fun** () -> 5/0 |> ignore)

FsUnit, ещё матчеры

true |> should be True

false |> should **not**' (be True)

"" |> should be EmptyString

null |> should be Null

anObj |> should **not**' (be sameAs otherObj)

11 |> should be (greaterThan 10)

10.0 |> should be (lessThanOrEqualTo 10.1)

0.0 |> should be ofExactType<**float**>

1 |> should **not**' (be ofExactType<**obj**>)

FsUnit, и ещё матчеры

Choice<int, **string**>.Choice1Of2(42) |> should be (choice 1)

"test" |> should be instanceOfType<**string**>

"test" |> should **not** (be instanceOfType<int>)

2.0 |> should **not** (be NaN)

[1;2;3] |> should be unique

[1;2;3] |> should be ascending

[1;3;2] |> should **not** (be ascending)

[3;2;1] |> should be descending

[3;1;2] |> should **not** (be descending)

FsCheck

Библиотека, которая берёт функцию и закидывает её случайно сгенерёнными тестами:

open **FsCheck**

```
let revRevsOrig (xs:list<int>) = List.rev(List.rev xs) = xs
```

```
Check.Quick revRevsOrig
```

```
// Ok, passed 100 tests.
```

```
let revsOrig (xs:list<int>) = List.rev xs = xs
```

```
Check.Quick revsOrig
```

```
// Falsifiable, after 2 tests (2 shrinks) (StdGen (338235241,296278002)):
```

```
// Original:
```

```
// [3; 0]
```

```
// Shrunk:
```

```
// [1; 0]
```

Unquote

Вообще интерпретатор F#-а, очень полезный для тестирования:

```
[<Test>]
```

```
let ``Unquote demo`` () =
```

```
    test <@ ([3; 2; 1; 0] |> List.map ((+) 1)) = [1 + 3..1 + 0] @>
```

```
// ([3; 2; 1; 0] |> List.map ((+) 1)) = [1 + 3..1 + 0]
```

```
// [4; 3; 2; 1] = [4..1]
```

```
// [4; 3; 2; 1] = []
```

```
// false
```

Foq

Ну и, конечно же, mock-объекты:

```
[<Test>]
```

```
let ``Foq demo`` () =
```

```
    let mock = Mock<System.Collections.Generic.IList<int>>>()  
        .Setup(fun x -> <@ x.Contains(any()) @>).Returns(true)  
        .Create()
```

```
mock.Contains 1 |> Assert.True
```