

# Генерики в F#

Юрий Литвинов

06.03.2020г

# Шаблонные типы

```
type 'a list = ...
```

```
type list<'a> = ...
```

```
List.map : ('a -> 'b) -> 'a list -> 'b list
```

```
let map<'a,'b> : ('a -> 'b) -> 'a list -> 'b list =  
    List.map
```

```
let rec map (f : 'a -> 'b) (l : 'a list) =
```

```
    match l with
```

```
    | h :: t -> (f h) :: (map f t)
```

```
    | [] -> []
```

# Автоматическое обобщение

```
let getFirst (a, b, c) = a
```

```
let mapPair f g (x, y) = (f x, g y)
```

## F# Interactive

```
val getFirst: 'a * 'b * 'c -> 'a
```

```
val mapPair : ('a -> 'b) -> ('c -> 'd)  
-> ('a * 'c) -> ('b * 'd)
```

# Generic-сравнение

```
val compare : 'a -> 'a -> int
```

```
val (=) : 'a -> 'a -> bool
```

```
val (<) : 'a -> 'a -> bool
```

```
val (<=) : 'a -> 'a -> bool
```

```
val (>) : 'a -> 'a -> bool
```

```
val (>=) : 'a -> 'a -> bool
```

```
val (min) : 'a -> 'a -> 'a
```

```
val (max) : 'a -> 'a -> 'a
```

# Сравнение сложных типов

## F# Interactive

```
> ("abc", "def") < ("abc", "xyz");;
```

```
val it : bool = true
```

```
> compare (10, 30) (10, 20);;
```

```
val it : int = 1
```

```
> compare [10; 30] [10; 20];;
```

```
val it : int = 1
```

```
> compare [| 10; 30 |] [| 10; 20 |];;
```

```
val it : int = 1
```

```
> compare [| 10; 20 |] [| 10; 30 |];;
```

```
val it : int = -1
```

# Generic-печать

## F# Interactive

```
> any_to_string (Some(100, [1.0; 2.0; 3.1415]));;
```

```
val it : string = "Some (100, [1.0; 2.0; 3.1415])"
```

```
> sprintf "result = %A" ([1], [true]);;
```

```
val it : string = "result = ([1], [true])"
```

```
val it : int = -1
```

# Boxing/unboxing

## F# Interactive

```
> box 1;;
```

```
val it : obj = 1
```

```
> box "abc";;
```

```
val it : obj = "abc"
```

```
> let sobj = box "abc";;
```

```
val sobj : obj = "abc"
```

```
> (unbox<string> sobj);;
```

```
val it : string = "abc"
```

```
> (unbox sobj : string);;
```

```
val it : string = "abc"
```

# Сериализация

```
open System.IO
```

```
open System.Runtime.Serialization.Formatters.Binary
```

```
let writeValue outputStream (x: 'a) =  
    let formatter = new BinaryFormatter()  
    formatter.Serialize(outputStream, box x)
```

```
let readValue inputStream =  
    let formatter = new BinaryFormatter()  
    let res = formatter.Deserialize(inputStream)  
    unbox res
```



## Сериализация, пример использования

```
let addresses = Map.ofList [  
    "Jeff", "123 Main Street, Redmond, WA 98052";  
    "Fred", "987 Pine Road, Phila., PA 19116";  
    "Mary", "PO Box 112233, Palo Alto, CA 94301" ]  
  
let fsOut = new FileStream("Data.dat", FileMode.Create)  
writeValue fsOut addresses  
fsOut.Close()  
  
let fsIn = new FileStream("Data.dat", FileMode.Open)  
let res : Map<string, string> = readValue fsIn  
fsIn.Close()
```

# Алгоритм Евклида, не генерик

```
let rec hcf a b =  
    if a = 0 then b  
    elif a < b then hcf a (b - a)  
    else hcf (a - b) b
```

## F# Interactive

```
val hcf : int -> int -> int
```

```
> hcf 18 12;;
```

```
val it : int = 6
```

```
> hcf 33 24;;
```

```
val it : int = 3
```

# Алгоритм Евклида, генерик

```

let hcfGeneric (zero, sub, lessThan) =
    let rec hcf a b =
        if a = zero then b
        elif lessThan a b then hcf a (sub b a)
        else hcf (sub a b) b
    hcf

```

```

let hcfInt = hcfGeneric (0, (-), (<))
let hcfInt64 = hcfGeneric (0L, (-), (<))
let hcfBigInt = hcfGeneric (0I, (-), (<))

```

## F# Interactive

```

val hcfGeneric: 'a * ('a -> 'a -> 'a) * ('a -> 'a -> bool)
    -> ('a -> 'a -> 'a)

```

## Словари операций

```
type Numeric<'a> =  
    { Zero: 'a;  
      Subtract: ('a -> 'a -> 'a);  
      LessThan: ('a -> 'a -> bool); }  
  
let hcfGeneric (ops : Numeric<'a>) =  
    let rec hcf a b =  
        if a = ops.Zero then b  
        elif ops.LessThan a b then hcf a  
            (ops.Subtract b a)  
        else hcf (ops.Subtract a b) b  
    hcf
```

# Тип функции

## F# Interactive

```
val hcfGeneric : Numeric<'a> -> ('a -> 'a -> 'a)
```

## Примеры использования

```
let intOps = { Zero = 0;  
    Subtract = (-);  
    LessThan = (<) }
```

```
let bigintOps = { Zero = 0I;  
    Subtract = (-);  
    LessThan = (<) }
```

```
let hcfInt = hcfGeneric intOps  
let hcfBigInt = hcfGeneric bigintOps
```

# Результат

## F# Interactive

```
val hcfInt : (int -> int -> int)
```

```
val hcfBigInt : (bigint -> bigint -> bigint)
```

```
> hcfInt 18 12;;
```

```
val it : int = 6
```

```
> hcfBigInt 18102871161622323830395761  
12390281782930928304802390321;;
```

```
val it : bigint = 332241
```

# Повышающий каст

## F# Interactive

```
> let xobj = (1 :> obj);;
```

```
val xobj : obj = 1
```

```
> let sobj = ("abc" :> obj);;
```

```
val sobj : obj = "abc"
```



# Понижающий каст

## F# Interactive

```
> let boxedObject = box "abc";;
```

```
val boxedObject : obj
```

```
> let downcastString = (boxedObject :?> string);;
```

```
val downcastString : string = "abc"
```

```
> let xobj = box 1;;
```

```
val xobj : obj = 1
```

```
> let x = (xobj :?> string);;
```

```
error: InvalidCastException raised at or near stdin:(2,0)
```

## Каст и сопоставление шаблонов

```
let checkObject (x: obj) =  
    match x with  
    | :? string -> printfn "The object is a string"  
    | :? int -> printfn "The object is an integer"  
    | _ -> printfn "The input is something else"
```

```
let reportObject (x: obj) =  
    match x with  
    | :? string as s ->  
        printfn "The input is the string '%s'" s  
    | :? int as d ->  
        printfn "The input is the integer '%d'" d  
    | _ -> printfn "the input is something else"
```

# Гибкие ограничения

## F# Interactive

```
> open System.Windows.Forms
> let setTextOfControl (c : #Control) (s:string) =
    c.Text <- s;;
val setTextOfControl: #Control -> string -> unit

> open System.Windows.Forms;;
> let setTextOfControl (c : 'a when 'a :> Control)
    (s:string) = c.Text <- s;;
val setTextOfControl: #Control -> string -> unit
```

# Гибкие ограничения: пример

```
module Seq =
```

```
...
```

```
val append : #seq<'a> -> #seq<'a> -> seq<'a>
```

```
val concat : #seq<#seq<'a>> -> seq<'a>
```

```
...
```

```
Seq.append [1; 2; 3] [4; 5; 6]
```

```
Seq.append [| 1; 2; 3 |] [4; 5; 6]
```

```
Seq.append (seq { for x in 1 .. 3 -> x }) [4; 5; 6]
```

```
Seq.append [| 1; 2; 3 |] [| 4; 5; 6 |]
```

## Повышающий каст: проблема

```
open System
open System.IO
let textReader =
    if DateTime.Today.DayOfWeek = DayOfWeek.Monday
    then Console.In
    else File.OpenText("input.txt")
```

### F# Interactive

```
else File.OpenText("input.txt")
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
```

error: FS0001: This expression has type StreamReader  
but is here used with type TextReader  
stopped due to error

## Повышающий каст: решение

```
let textReader =  
    if DateTime.Today.DayOfWeek = DayOfWeek.Monday  
    then Console.In  
    else (File.OpenText("input.txt") :> TextReader)
```

# Проблемы в выводе типов, методы и свойства

## F# Interactive

```
> let transformData inp =  
    inp |> Seq.map (fun (x, y) -> (x, y.Length));;
```

```
inp |> Seq.map (fun (x, y) -> (x, y.Length))  
-----^
```

stdin(11,36): error: Lookup on object of indeterminate type. A type annotation may be needed prior to this program point to constrain the type of the object. This may allow the lookup to be resolved.

# Решение

```
let transformData inp =  
    inp |> Seq.map (fun (x, y:string) -> (x, y.Length))
```



# Уменьшение общности

```
let printSecondElements (inp : #seq<'a * int>) =
    inp
    |> Seq.iter (fun (x, y) -> printfn "y = %d" x)
```

## F# Interactive

```
|> Seq.iter (fun (x, y) -> printfn "y = %d" x)
-----^
```

stdin(21,38): warning: FS0064: This construct causes code to be less generic than indicated by the type annotations. The type variable 'a' has been constrained to the type 'int'.

# Уменьшение общности, отладка

```
type PingPong = Ping | Pong
```

```
let printSecondElements (inp : #seq<PingPong * int>) =  
    inp |> Seq.iter (fun (x, y) -> printfn "y = %d" x)
```

## F# Interactive

```
|> Seq.iter (fun (x,y) -> printfn "y = %d" x)
```

```
-----^
```

```
stdin(27,47): error: FS0001: The type 'PingPong' is not  
compatible with any of the types byte, int16, int32,  
int64, sbyte, uint16, uint32, uint64, nativeint,  
unativeint, arising from the use of a printf-style  
format string
```

# Value Restriction

## F# Interactive

```
> let empties = Array.create 100 [];;
```

```
-----^
```

error: FS0030: Value restriction. Type inference has inferred the signature

```
val empties : 'a list []
```

but its definition is not a simple data constant.

Either define 'empties' as a simple data expression, make it a function, or add a type constraint to instantiate the type parameters.

# Корректные определения

```
let emptyList = []  
let initialLists = ([], [2])  
let listOfEmptyLists = [[]; []]  
let makeArray () = Array.create 100 []
```

## F# Interactive

```
val emptyList : 'a list  
val initialLists : ('a list * int list)  
val listOfEmptyLists : 'a list list  
val makeArray : unit -> 'a list []
```

# Способы борьбы

```
let empties : int list [] = Array.create 100 []
```

```
let mapFirst = List.map fst  
( 'a * 'b ) list -> 'a list
```

```
let mapFirst inp = List.map fst inp  
let printFstElements = List.map fst  
    >> List.iter (printf "res = %d")
```

```
let printFstElements inp = inp  
    |> List.map fst  
    |> List.iter (printf "res = %d")
```

## Способы борьбы (2)

```
let empties () = Array.create 100 []  
let intEmpties : int list [] = empties ()  
let stringEmpties : string list [] = empties ()  
  
let emptyLists = Seq.init 100 (fun _ -> [])  
let emptyLists<'a> : seq<'a list> = Seq.init  
    100 (fun _ -> [])
```

# Способы борьбы, результат

## F# Interactive

```
> Seq.length emptyLists;;
```

```
val it : int = 100
```

```
> emptyLists<int>;;
```

```
val it : seq<int list> = seq [[]; []; []; ...]
```

```
> emptyLists<string>;;
```

```
val it : seq<string list> = seq [[]; []; []; ...]
```

# Point-free

```
let fstGt0 xs = List.filter (fun (a, b) -> a > 0) xs
```

```
let fstGt0'1 : (int * int) list -> (int * int) list =  
    List.filter (fun (a, b) -> a > 0)
```

```
let fstGt0'2 : (int * int) list -> (int * int) list =  
    List.filter (fun x -> fst x > 0)
```

```
let fstGt0'3 : (int * int) list -> (int * int) list =  
    List.filter (fun x -> ((<) 0 << fst) x)
```

```
let fstGt0'4 : (int * int) list -> (int * int) list =  
    List.filter ((<) 0 << fst)
```



# Арифметические операторы

```
let twice x = (x + x)
```

```
let threeTimes x = (x + x + x)
```

```
let sixTimesInt64 (x:int64) = threeTimes x + threeTimes x
```

## F# Interactive

```
val twice : x:int -> int
```

```
val threeTimes : x:int64 -> int64
```

```
val sixTimesInt64 : x:int64 -> int64
```