Генерики в F#

Юрий Литвинов

13.03.2018г

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 181028711616223238303957 6I
   123902817829309283048023903 2I;;
val it : bigint = 33224I
```

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
```