

Functional Programming Principles in Scala

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Programming Paradigms

Paradigm: In science, a *paradigm* describes distinct concepts or thought patterns in some scientific discipline.

Main programming paradigms:

- ▶ imperative programming
- ▶ functional programming
- ▶ logic programming

Orthogonal to it:

- ▶ object-oriented programming

Review: Imperative programming

Imperative programming is about

- ▶ modifying mutable variables,
- ▶ using assignments
- ▶ and control structures such as if-then-else, loops, break, continue, return.

The most common informal way to understand imperative programs is as instruction sequences for a Von Neumann computer.

Imperative Programs and Computers

There's a strong correspondence between

Mutable variables	≈	memory cells
Variable dereferences	≈	load instructions
Variable assignments	≈	store instructions
Control structures	≈	jumps

Problem: Scaling up. How can we avoid conceptualizing programs word by word?

Reference: John Backus, Can Programming Be Liberated from the von. Neumann Style?, Turing Award Lecture 1978.

Scaling Up

In the end, pure imperative programming is limited by the “Von Neumann” bottleneck:

One tends to conceptualize data structures word-by-word.

We need other techniques for defining high-level abstractions such as collections, polynomials, geometric shapes, strings, documents.

Ideally: Develop *theories* of collections, shapes, strings, ...

What is a Theory?

A theory consists of

- ▶ one or more data types
- ▶ operations on these types
- ▶ laws that describe the relationships between values and operations

Normally, a theory does not describe mutations!

Theories without Mutation

For instance the theory of polynomials defines the sum of two polynomials by laws such as:

$$(a*x + b) + (c*x + d) = (x+c)*x + (b+d)$$

But it does not define an operator to change a coefficient while keeping the polynomial the same!

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Other example:

The theory of strings defines a concatenation operator ++ which is associative:

$$(a ++ b) ++ c = a ++ (b ++ c)$$

But it does not define an operator to change a sequence element while keeping the sequence the same!

Consequences for Programming

Let's

- ▶ concentrate on defining theories for operators,
- ▶ minimize state changes,
- ▶ treat operators as functions, often composed of simpler functions.

Functional Programming

- ▶ In a *restricted* sense, functional programming (FP) means programming without mutable variables, assignments, loops, and other imperative control structures.
- ▶ In a *wider* sense, functional programming means focusing on the functions.
- ▶ In particular, functions can be values that are produced, consumed, and composed.
- ▶ All this becomes easier in a functional language.

Functional Programming Languages

- ▶ In a *restricted* sense, a functional programming language is one which does not have mutable variables, assignments, or imperative control structures.
- ▶ In a *wider* sense, a functional programming language enables the construction of elegant programs that focus on functions.
- ▶ In particular, functions in a FP language are first-class citizens.

This means

- ▶ they can be defined anywhere, including inside other functions
- ▶ like any other value, they can be passed as parameters to functions and returned as results
- ▶ as for other values, there exists a set operators to compose functions

Some functional programming languages

In the restricted sense:

- ▶ Pure Lisp, XSLT, XPath, XQuery, FP
- ▶ Haskell (without I/O Monad or UnsafePerformIO)

In the wider sense:

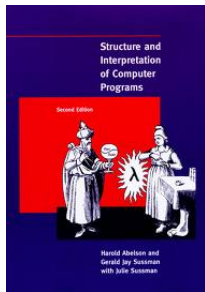
- ▶ Lisp, Scheme, Racket, Clojure
- ▶ SML, Ocaml, F#
- ▶ Haskell (full language)
- ▶ Scala
- ▶ Smalltalk, Ruby (!)

History of FP languages

1959	Lisp
1975-77	ML, FP, Scheme
1978	Smalltalk
1986	Standard ML
1990	Haskell, Erlang
1999	XSLT
2000	OCaml
2003	Scala, XQuery
2005	F#
2007	Clojure

Recommended Book (1)

Structure and Interpretation of Computer Programs. Harold Abelson and Gerald J. Sussman. 2nd edition. MIT Press 1996.

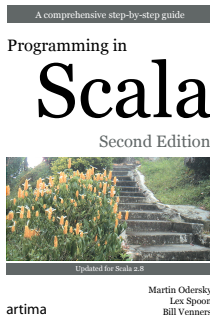


A classic. Many parts of the course and quizzes are based on it, but we change the language from Scheme to Scala.

The full text [can be downloaded here](#).

Recommended Book (2)

Programming in Scala. Martin Odersky, Lex Spoon, and Bill Venners. 2nd edition. Artima 2010.



The standard language introduction and reference.

Recommended Book (3)

Scala for the Impatient



A faster paced introduction to Scala for people with a Java background.

The first part of the book [is available for free download](#)

Why Functional Programming?

Functional Programming is becoming increasingly popular because it offers an attractive method for exploiting parallelism for multicore and cloud computing.

To find out more, see the video of my 2011 Oscon Java keynote

[Working Hard to Keep it Simple](#)

(16.30 minutes).

[The slides for the video](#) are available separately.