FUNCTIONAL PROGRAMMING

Maths & Natural Sciences (MN) programme at Uppsala University, Sweden

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Chapter 1: Introduction

(Version of 24 September 2004)

1.1. Objectives

Introduction to the *fundamental* principles and methodologies of functional programming, using the programming language Standard ML (SML, or simply ML) as the teaching medium.

Theoretical focus, with many examples, on:

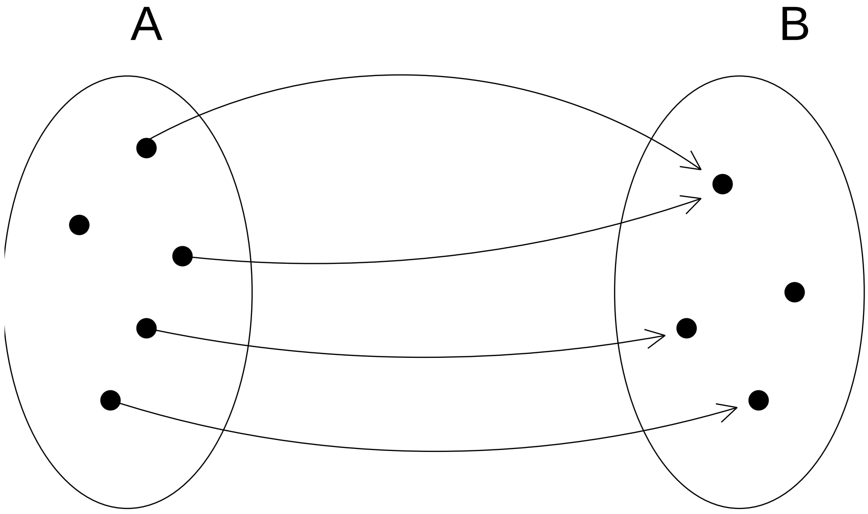
- Algorithms and data structures (**how?**)
- Programming methodology:
  - Importance of *specifications* (**what?**)
  - Importance of *justifications* (**why?**)
  - Importance of other documentation
  - Importance of rigour, explicitness, and elegance
- Complexity of algorithms

Some further *practice* of programming (in ML) is acquired through assignments, which are to be:

1. Prepared at home
2. Tried on the computer in labs under assistant supervision
3. Graded by an assistant

1.2. Functions

A function f is a correspondence between two sets of values:



f : A --> B

To each element a of the set A,
the function f associates at most one value of the set B

Notations

f(a) = b : f associates the value b of B to the element a of A

f(a) = $\perp$ (or f(a) is undefined): f associates no value to a

Total functions and partial functions

Let $\mathsf{f} : \mathsf{A} \rightarrow \mathsf{B}$ be a function:

- f is a *total* function if f is defined for every element of A
- f is a *partial* function if f is not total

Definition of functions

Definition by extension

Give the *graph* of the function: $(a_1, b_1) \quad (a_2, b_2) \quad \ldots$

Example: function double:

(1,2) (2,4) (3,6) (4,8) . . .

Definition by intension (note the '**s**'!)

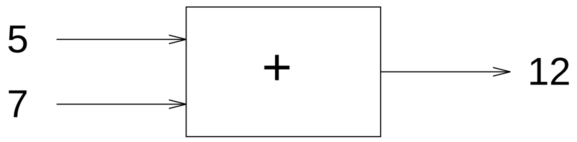
Define the function by a *rule* describing its graph

Example: function double:

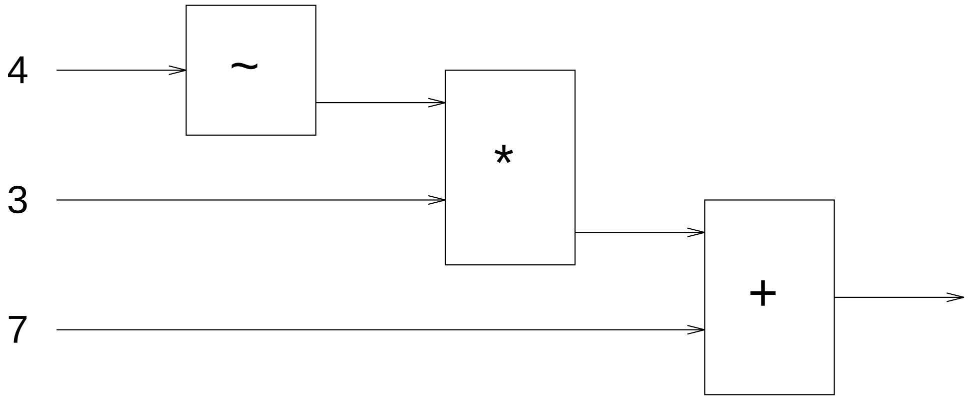
double(n) = 2 ∗ n

Expressions

5 + 7

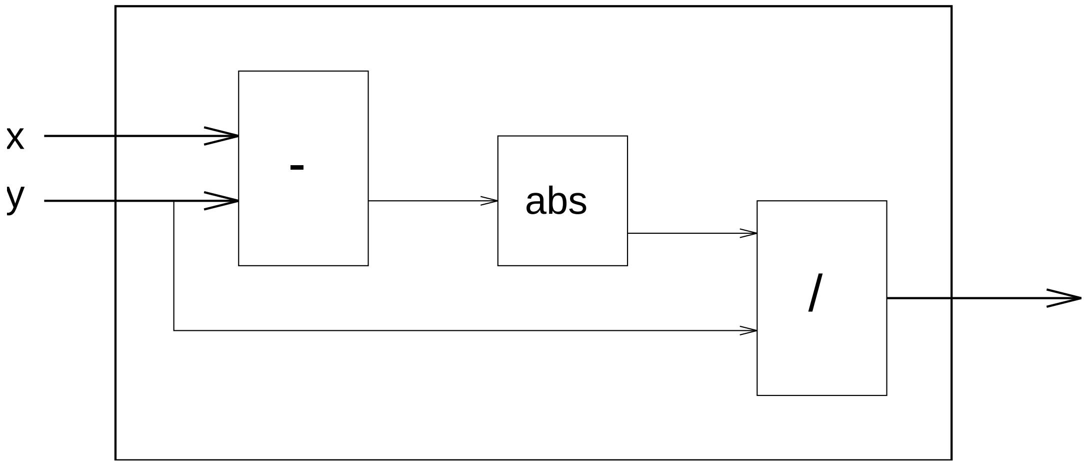


3 * ~ 4 + 7



Definition of new functions

relative_error (x,y) = abs(x - y) / y



1.3. Functional programming languages

Fundamental principles

- Execution by evaluation of expressions
- Declaration of functions
- Application of functions
- Recursion

Existing functional programming languages

- Lisp (Mc Carthy, 1962), Scheme
- FP (J. Backus, 1978)
- Miranda (D. Turner, 1986)
- Haskell (P. Hudack, 1990)
- LCF, ML (Meta Language) (Edinburgh, 1977)
- CAML (France, 1990)
- SML (Standard ML) (1990)