Principles of Programming

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Constructs

Five Common Constructs:

- Assignment
- Declaration (Variable and Constant)
- Sequence
- Test
- Loop

Assignment

- The Syntax:
  "$x = t;$"
  - x: a variable identifier
  - t: an expression:
- The Semantics:
  Filling the memory compartment labeled x with the value of the expression t.
- Examples:
  - Valid assignments: $y = 3$; $x = y$; $x = (y + z) * (z - x)$;
  - Invalid ones: $y - 5 = 3$; $z - z = 0$;

Two disjoint syntactic categories: Expressions & Statements

$x + 3$: an expression

$y = x + 3$: a statement

Declaration

- The Syntax:
  "{ *T x; x = v;*}" or "{T x = v;}"
  - ▸ *T*: a type
  - ▸ *x*: a variable
  - ▸ *v*: a value of type *T*

  A type can be :
  - ▸ Scalar: byte, short, int, long, float, double, boolean, char
  - ▸ Compound : Later!

- The Semantics of *T x = t* :

T	x
t	

- Examples: { *int x = 5; x = x + 1;* } { *int x; x = 5;* }
- Constant Declaration:
  final int x = 4;

Sequence

- If p_1 and p_2 are statements, then "$\{\ p_1\ p_2\ \}$" is a statement.
  For simplicity, we write $\{\ p_1\ \{\ p_2\ \{\ p_3\ p_4\ \}\ \}\ \}$ as $\{\ p_1\ p_2\ p_3\ p_4\ \}$
- Alternative view:
  See ; as the sequencing operation!

Test

- The Syntax:
  "if (b) p_1 else p_2"
  - ▸ b is a boolean expression
  - ▸ p_1 and p_2 are statements
- The Semantics: (The initial state: T_0)
  1. Compute b in state T_0
  2. If true, p_1 in state T_1
  3. else p_2 in state T_2

Loop

- The Syntax:
  "*While* (*b*) *S*"
- The Semantics:
  1. Evaluate b in the current state,
  2. If it is false, do nothing (The state changes)
  3. otherwise execute S and repeat (The state changes)

The Semantics of Core - The Concept of a State

The structure consists three universes **Var**, **Val**, and **State** where

- **Var** is a finite set of *variables*
- **Val** is a set of *values* (inhabitants of types)
- **State** is a set of *states*. A state s is a function from a subset of Var, say V, to Val: $s : V \rightarrow Val$
  Example: $[x = 5, \quad y = 6]$
  $ex : x \mapsto 5$ & $y \mapsto 6$

We define the following functions:

- $\oplus : State \times (var = val) \rightarrow State$ (total)
- $\Theta : Expr \times State \rightarrow Val$ (partial)
- $\Sigma : statements \times State \rightarrow State$ (partial)

$$\begin{array}{l} \text{x } 5 \\ \text{y } 6 \end{array} \quad \oplus \quad \text{x} = 3 \quad \rightsquigarrow \quad \begin{array}{l} \text{x } 3 \\ \text{y } 6 \end{array}$$

$$\begin{array}{l} \text{x } 5 \\ \text{y } 6 \end{array} \quad \oplus \quad \text{z} = 3 \quad \rightsquigarrow \quad \begin{array}{l} \text{x } 3 \\ \text{y } 6 \\ \text{z } 3 \end{array}$$

$$\Theta(x + 3, [x = 5, y = 6]) = 8$$
$$\Theta(x + 3, [x = 5, y = 6]) : \text{Error!}$$

$$\Sigma(x = x + 1; , [x = 5]) = [x = 6]$$