Trabajo Práctico 1
Análisis de Lenguajes de Programación

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Ejercicio 1

Gramática Abstracta

$$
\begin{aligned}
intexp \ &::= nat \mid var \mid \ -_u \ intexp \\
&\mid \ intexp \ + \ intexp \\
&\mid \ intexp \ -_b \ intexp \\
&\mid \ intexp \ \times \ intexp \\
&\mid \ intexp \ \div \ intexp \\
&\mid \ var \ = \ intexp \\
&\mid \ intexp \ , \ intexp \\
boolexp \ &::= \mathbf{true} \mid \mathbf{false} \\
&\mid \ intexp \ == \ intexp \\
&\mid \ intexp \ \neq \ intexp \\
&\mid \ intexp \ < \ intexp \\
&\mid \ intexp \ > \ intexp \\
&\mid \ boolexp \ \wedge \ boolexp \\
&\mid \ boolexp \ \vee \ boolexp \\
&\mid \ \neg \ boolexp \\
comm \ &:= \mathbf{skip} \\
&\mid \ var = intexp \\
&\mid \ comm; \ comm \\
&\mid \ \mathbf{if} \ boolexp \ \mathbf{then} \ comm \ \mathbf{else} \ comm \\
&\mid \ \mathbf{repeat} \ comm \ \mathbf{until} \ boolexp
\end{aligned}
$$

Gramática Concreta

Estan mal algunos simbolos

$$
\begin{array}{rcl}
\mathit{digit} & ::= & \textbf{‘0’} \mid \textbf{‘1’} \mid \ \ldots \ \mid \textbf{‘9’} \\
\mathit{letter} & ::= & \textbf{‘a’} \mid \ \ldots \ \mid \textbf{‘Z’} \\
\mathit{nat} & ::= & \mathit{digit} \mid \mathit{digit}\ \mathit{nat} \\
\mathit{var} & ::= & \mathit{letter} \mid \mathit{letter}\ \mathit{var} \\
\mathit{intexp} & ::= & \mathit{nat} \\
 & \mid & \mathit{var} \\
 & \mid & \textbf{‘-’}\ \mathit{intexp} \\
 & \mid & \mathit{intexp}\ \textbf{‘+’}\ \mathit{intexp} \\
 & \mid & \mathit{intexp}\ \textbf{‘-’}\ \mathit{intexp} \\
 & \mid & \mathit{intexp}\ \textbf{‘*’}\ \mathit{intexp} \\
 & \mid & \mathit{intexp}\ \textbf{‘/’}\ \mathit{intexp} \\
 & \mid & \textbf{‘(’}\ \mathit{intexp}\ \textbf{‘)’} \\
 & \mid & \mathit{var}\ \textbf{‘=’}\ \mathit{intexp} \\
 & \mid & \mathit{intexp}\ \textbf{‘,’}\ \mathit{intexp} \\
\mathit{boolexp} & ::= & \textbf{‘true’} \mid \textbf{‘false’} \\
 & \mid & \mathit{intexp}\ \textbf{‘==’}\ \mathit{intexp} \\
 & \mid & \mathit{intexp}\ \textbf{‘!=’}\ \mathit{intexp} \\
 & \mid & \mathit{intexp}\ \textbf{‘¡’}\ \mathit{intexp} \\
 & \mid & \mathit{intexp}\ \textbf{‘¿’}\ \mathit{intexp} \\
 & \mid & \mathit{boolexp}\ \textbf{‘\&\&’}\ \mathit{boolexp} \\
 & \mid & \mathit{boolexp}\ \textbf{‘——’}\ \mathit{boolexp} \\
 & \mid & \textbf{‘!’}\ \mathit{boolexp} \\
 & \mid & \textbf{‘(’}\ \mathit{boolexp}\ \textbf{‘)’} \\
\mathit{comm} & := & \boldsymbol{\mathit{skip}} \\
 & \mid & \mathit{var}\ \textbf{‘=’}\ \mathit{intexp} \\
 & \mid & \mathit{comm}\ \textbf{‘;’}\ \mathit{comm} \\
 & \mid & \textbf{‘if’}\ \mathit{boolexp}\ \textbf{‘\{’}\ \mathit{comm}\ \textbf{‘\}’} \\
 & \mid & \textbf{‘if’}\ \mathit{boolexp}\ \textbf{‘\{’}\ \mathit{comm}\ \textbf{‘\}’}\ \textbf{‘else’}\ \textbf{‘\{’}\ \mathit{comm} \\
 & \mid & \textbf{‘repeat’}\ \mathit{comm}\ \textbf{‘until’}\ \mathit{boolexp}\ \textbf{‘end’}
\end{array}
$$

Ejercicio 6

Habria que enunciar las nuevas reglas (ejercicio 4) y cambiar el nombre aca, y enunciar las reglas de la clausura transitiva.

A:

$$\dfrac{\dfrac{}{\langle \textbf{skip}; \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle \rightsquigarrow \langle \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle}\,\text{SEQ}_1}{\langle \textbf{skip}; \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle \rightsquigarrow^* \langle \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle}\,\text{T}_1$$

B:

$$\dfrac{\dfrac{}{\langle \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle \rightsquigarrow \langle x = x - y; \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle}\,\text{REPEAT}}{\langle \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle \rightsquigarrow^* \langle x = x - y; \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle}\,\text{T}_1$$

C:

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\langle x,\ [[\sigma|x:1]|y:1]\rangle \Downarrow_{exp} \langle \mathbf{1},\ [[\sigma|x:1]|y:1]\rangle}\,\text{VAR} \quad \dfrac{}{\langle y,\ [[\sigma|x:1]|y:1]\rangle \Downarrow_{exp} \langle \mathbf{1},\ [[\sigma|x:1]|y:1]\rangle}\,\text{VAR}}{\langle x - y,\ [[\sigma|x:1]|y:1]\rangle \Downarrow_{exp} \langle \mathbf{0},\ [[\sigma|x:1]|y:1]\rangle}\,\text{MINUS}}{\langle x = x - y,\ [[\sigma|x:1]|y:1]\rangle \rightsquigarrow \langle \textbf{skip},\ [[\sigma|x:0]|y:1]\rangle}\,\text{ASS}}{\dfrac{\langle x = x - y; \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle \rightsquigarrow \langle \textbf{skip}; \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x ==}{\langle x = x - y; \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle \rightsquigarrow^* \langle \textbf{skip}; \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x ==}}$$

D:

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{}{\langle 1,\ [[\sigma|x:2]|y:2]\rangle \Downarrow_{exp} \langle \mathbf{1},\ [[\sigma|x:2]|y:2]\rangle}\,\text{NVAL}}{\langle y = 1,\ [[\sigma|x:2]|y:2]\rangle \Downarrow_{exp} \langle \mathbf{1},\ [[\sigma|x:2]|y:1]\rangle}\,\text{NASS}}{\langle x = y = 1,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow \langle \textbf{skip},\ [[\sigma|x:1]|y:1]\rangle}\,\text{ASS}}{\langle x = y = 1; \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow \langle \textbf{skip}; \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle}\,\text{SEQ}_2}{\langle x = y = 1; \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \textbf{skip}; \textbf{repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle}\,\text{T}_1$$

E:

$$\dfrac{\dfrac{}{\langle \textbf{skip}; \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:0]|y:1]\rangle \rightsquigarrow \langle \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:0}}{\langle \textbf{skip}; \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:0]|y:1]\rangle \rightsquigarrow^* \langle \textbf{if}\ x == 0\ \textbf{then skip else repeat}\ x = x - y\ \textbf{until}\ x == 0,\ [[\sigma|x:0}$$

F:

$$\dfrac{\dfrac{\dfrac{\dfrac{}{\langle x,\ [[\sigma|x:0]|y:1]\rangle \Downarrow_{exp} \langle \mathbf{0},\ [[\sigma|x:0]|y:1]\rangle}\text{VAR} \quad \dfrac{}{\langle 0,\ [[\sigma|x:0]|y:1]\rangle \Downarrow_{exp} \langle \mathbf{0},\ [[\sigma|x:0]|y:1]\rangle}\text{NVAL}}{\langle x == 0,\ [[\sigma|x:0]|y:1]\rangle \Downarrow_{exp} \langle \mathbf{true},\ [[\sigma|x:0]|y:1]\rangle}\text{EQ}}{\langle \mathbf{if}\ x == 0\ \mathbf{then\ skip\ else\ repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:0]|y:1]\rangle \rightsquigarrow \langle \mathbf{skip},\ [[\sigma|x:0]|y:1]\rangle}\text{IF}_1}{\langle \mathbf{if}\ x == 0\ \mathbf{then\ skip\ else\ repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:0]|y:1]\rangle \rightsquigarrow^* \langle \mathbf{skip},\ [[\sigma|x:0]|y:1]\rangle}\text{T}_1$$

DEM:

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{D \quad A}{\langle x = y = 1; \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle}\text{T}_2 \quad B}{\langle x = y = 1; \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle x = x - y; \mathbf{if}\ x == 0\ \mathbf{then\ skip\ else\ repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:1]|y:1]\rangle}\text{T}_2}{\langle x = y = 1; \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{skip}; \mathbf{if}\ x == 0\ \mathbf{then\ skip\ else\ repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:0]|y:1]\rangle}}{\langle x = y = 1; \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{if}\ x == 0\ \mathbf{then\ skip\ else\ repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:0]|y:1]\rangle}}{\langle x = y = 1; \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{skip},\ [[\sigma|x:0]|y:1]\rangle}$$

Ejercicio 2

```haskell
    -- Expresiones, aritmeticas y booleanas
data Exp a where
  -- Expresiones enteras
  Const  :: Int -> Exp Int
  Var  :: Variable -> Exp Int
  UMinus  :: Exp Int -> Exp Int
  Plus  :: Exp Int -> Exp Int -> Exp Int
  Minus  :: Exp Int -> Exp Int -> Exp Int
  Times  :: Exp Int -> Exp Int -> Exp Int
  Div  :: Exp Int -> Exp Int -> Exp Int
  EAssgn  :: Variable -> Exp Int -> Exp Int
  ESeq  :: Exp Int -> Exp Int -> Exp Int

  -- Expreseiones booleanas
  BTrue  :: Exp Bool
  BFalse  :: Exp Bool
  Lt  :: Exp Int -> Exp Int -> Exp Bool
  Gt  :: Exp Int -> Exp Int -> Exp Bool
  And  :: Exp Bool -> Exp Bool -> Exp Bool
  Or  :: Exp Bool -> Exp Bool -> Exp Bool
  Not  :: Exp Bool -> Exp Bool
  Eq  :: Exp Int -> Exp Int -> Exp Bool
  NEq  :: Exp Int -> Exp Int -> Exp Bool
```

Ejercicio 4

Semántica Operacional Big-Step para Expresiones

$$\frac{}{\langle nv, \sigma \rangle \Downarrow_{exp} \langle \mathbf{nv}, \sigma \rangle}\ \text{NVAL} \qquad \frac{}{\langle x, \sigma \rangle \Downarrow_{exp} \langle \sigma x, \sigma \rangle}\ \text{VAR}$$

$$\frac{\langle e, \sigma \rangle \Downarrow_{exp} \langle n, \sigma' \rangle}{\langle -_u e, \sigma \rangle \Downarrow_{exp} \langle -n, \sigma' \rangle}\ \text{UMINUS} \qquad \frac{\langle e_0, \sigma \rangle \Downarrow_{exp} \langle n_0, \sigma' \rangle \quad \langle e_1, \sigma' \rangle \Downarrow_{exp} \langle n_1, \sigma'' \rangle}{\langle e_0 + e_1, \sigma \rangle \Downarrow_{exp} \langle n_0 + n_1, \sigma'' \rangle}\ \text{PLUS}$$

$$\frac{\langle e_0, \sigma \rangle \Downarrow_{exp} \langle n_0, \sigma' \rangle \quad \langle e_1, \sigma' \rangle \Downarrow_{exp} \langle n_1, \sigma'' \rangle}{\langle e_0 - e_1, \sigma \rangle \Downarrow_{exp} \langle n_0 - n_1, \sigma'' \rangle}\ \text{BMINUS}$$

$$\frac{\langle e_0, \sigma \rangle \Downarrow_{exp} \langle n_0, \sigma' \rangle \quad \langle e_1, \sigma' \rangle \Downarrow_{exp} \langle n_1, \sigma'' \rangle}{\langle e_0 * e_1, \sigma \rangle \Downarrow_{exp} \langle n_0 * n_1, \sigma'' \rangle}\ \text{MULT}$$

$$\frac{\langle e_0, \sigma \rangle \Downarrow_{exp} \langle n_0, \sigma' \rangle \quad \langle e_1, \sigma' \rangle \Downarrow_{exp} \langle n_1, \sigma'' \rangle \quad n_1 \neq 0}{\langle e_0 \div e_1, \sigma \rangle \Downarrow_{exp} \langle n_0 \div n_1, \sigma'' \rangle}\ \text{DIV}$$

$$\frac{\langle e_0, \sigma \rangle \Downarrow_{exp} \langle n_0, \sigma' \rangle \quad \langle e_1, \sigma' \rangle \Downarrow_{exp} \langle n_1, \sigma'' \rangle}{\langle e_0 > e_1, \sigma \rangle \Downarrow_{exp} \langle n_0 > n_1, \sigma'' \rangle}\ \text{GT}$$

$$\frac{\langle e_0, \sigma \rangle \Downarrow_{exp} \langle n_0, \sigma' \rangle \quad \langle e_1, \sigma' \rangle \Downarrow_{exp} \langle n_1, \sigma'' \rangle}{\langle e_0 < e_1, \sigma \rangle \Downarrow_{exp} \langle n_0 < n_1, \sigma'' \rangle}\ \text{LT}$$

$$\frac{\langle e_0, \sigma\rangle \Downarrow_{exp} \langle n_0, \sigma'\rangle \quad \langle e_1, \sigma'\rangle \Downarrow_{exp} \langle n_1, \sigma''\rangle}{\langle e_0\ != e_1, \sigma\rangle \Downarrow_{exp} \langle n_0 \neq n_1, \sigma''\rangle} \text{ NOTEQ}$$

$$\frac{\langle e_0, \sigma\rangle \Downarrow_{exp} \langle n_0, \sigma'\rangle \quad \langle e_1, \sigma'\rangle \Downarrow_{exp} \langle n_1, \sigma''\rangle}{\langle e_0 == e_1, \sigma\rangle \Downarrow_{exp} \langle n_0 = n_1, \sigma''\rangle} \text{ EQ} \qquad \frac{}{\langle bv, \sigma\rangle \Downarrow_{exp} \langle bv, \sigma\rangle} \text{ BVAL}$$

$$\frac{\langle p, \sigma\rangle \Downarrow_{exp} \langle b, \sigma'\rangle}{\langle \neg p, \sigma\rangle \Downarrow_{exp} \langle \neg b, \sigma'\rangle} \text{ NOT} \qquad \frac{\langle p_0, \sigma\rangle \Downarrow_{exp} \langle b_0, \sigma'\rangle \quad \langle p_1, \sigma'\rangle \Downarrow_{exp} \langle b_1, \sigma''\rangle}{\langle e_0 \vee e_1, \sigma\rangle \Downarrow_{exp} \langle b_0 \vee b_1, \sigma''\rangle} \text{ OR}$$

$$\frac{\langle p_0, \sigma\rangle \Downarrow_{exp} \langle b_0, \sigma'\rangle \quad \langle p_1, \sigma'\rangle \Downarrow_{exp} \langle b_1, \sigma''\rangle}{\langle e_0 \wedge e_1, \sigma\rangle \Downarrow_{exp} \langle b_0 \wedge b_1, \sigma''\rangle} \text{ AND}$$

Llamamos IASS a la asignación como expresión y ISEQ a la secuencialización de expresiones con el operador **,**

$$\frac{\langle e, \sigma\rangle \Downarrow_{exp} \langle n, \sigma'\rangle}{\langle v = e, \sigma\rangle \Downarrow_{exp} \langle n, [\sigma'|v : n]\rangle} \text{ IASS}$$

$$\frac{\langle e_0, \sigma\rangle \Downarrow_{exp} \langle n_0, \sigma'\rangle \quad \langle e_1, \sigma'\rangle \Downarrow_{exp} \langle n_1, \sigma''\rangle}{\langle e_0, e_1, \sigma\rangle \Downarrow_{exp} \langle n_1, \sigma''\rangle} \text{ ISEQ}$$

Ejercicio 5

Determinismo de la relación de evaluación en un paso $\rightsquigarrow$

Ejercicio 10

Nueva gramática abstracta

for (intexp;boolexp;intexp) comm

Nueva semántica operacional para comandos

$$\frac{\langle e, \sigma\rangle \Downarrow_{exp} \langle n, \sigma'\rangle}{\langle v = e, \sigma\rangle \rightsquigarrow \langle \mathbf{skip}, [\sigma'|v : n]\rangle} \text{ ASS}$$

$$\frac{}{\langle \mathbf{skip}; c_1, \sigma\rangle \rightsquigarrow \langle c_1, \sigma\rangle} \text{ SEQ1}$$

$$\frac{\langle c_0, \sigma\rangle \rightsquigarrow \langle c_0', \sigma'\rangle}{\langle \mathbf{skip}; c_1, \sigma\rangle \rightsquigarrow \langle c_0'; c_1, \sigma'\rangle} \text{ SEQ2}$$

$$\frac{\langle b,\sigma\rangle \Downarrow_{exp} \langle \textbf{true},\sigma'\rangle}{\langle \textbf{if}\ b\ \textbf{then}\ c_0\ \textbf{else}\ c_1,\sigma\rangle \rightsquigarrow \langle c_0,\sigma'\rangle}\ \text{IF}_1 \qquad \frac{\langle b,\sigma\rangle \Downarrow_{exp} \langle \textbf{false},\sigma'\rangle}{\langle \textbf{if}\ b\ \textbf{then}\ c_0\ \textbf{else}\ c_1,\sigma\rangle \rightsquigarrow \langle c_1,\sigma'\rangle}\ \text{IF}_2$$

$$\frac{}{\langle \textbf{repeat}\ c\ \textbf{until}\ b,\sigma\rangle \rightsquigarrow \langle c;\textbf{if}\ b\ \textbf{then}\ \textbf{skip}\ \textbf{else}\ \textbf{repeat}\ b\ \textbf{until}\ c,\sigma\rangle}\ \text{REPEAT}_1$$

$$\frac{\langle e,\sigma\rangle \Downarrow_{exp} \langle n,\sigma'\rangle}{\langle \textbf{repeat}\ (c;e)\ \textbf{until}\ b,\sigma\rangle \rightsquigarrow}\ \text{REPEAT}_2$$

$$\frac{\langle e_1,\sigma\rangle \Downarrow_{exp} \langle n_1,\sigma'\rangle}{\langle \textbf{for}\ (e_1;e_2;e_3)\ c,\sigma\rangle \rightsquigarrow \langle \textbf{repeat}\ (c;e_3)\ \textbf{until}\ e_2,\sigma'\rangle}\ \text{FOR}$$