Trabajo Práctico 1
Análisis de Lenguajes de Programación

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Ejercicio 1

Gramática Abstracta

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

Gramática Concreta

Estan mal algunos simbolos

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

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:

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

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

D:

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

$$\dfrac{\langle x = y = 1; \textbf{repeat } x = x - y \textbf{ until } x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow \langle \textbf{skip}; \textbf{repeat } x = x - y \textbf{ until } x == 0,\ [[\sigma|x:1]|y:1]\rangle}{\langle x = y = 1; \textbf{repeat } x = x - y \textbf{ until } x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \textbf{skip}; \textbf{repeat } x = x - y \textbf{ until } x == 0,\ [[\sigma|x:1]|y:1]\rangle}\,\text{T}_1$$

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:

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

DEM:

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

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

$$\overline{\langle x = y = 1; \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{skip}; \mathbf{if}\ x == 0\ \mathbf{then\ skip\ else\ repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:0]|y:1]\rangle}$$

$$\overline{\langle x = y = 1; \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{if}\ x == 0\ \mathbf{then\ skip\ else\ repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:0]|y:1]\rangle}$$

$$\overline{\langle x = y = 1; \mathbf{repeat}\ x = x - y\ \mathbf{until}\ x == 0,\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{skip},\ [[\sigma|x:0]|y:1]\rangle}$$

DEM2:

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{D \quad A}{\langle x = y = 1;\ \mathbf{a},\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{a},\ [[\sigma|x:1]|y:1]\rangle}\,\mathrm{T}_2 \quad B}{\langle x = y = 1;\ \mathbf{a},\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle x = x - y;\ \mathbf{c}\ [[\sigma|x:1]|y:1]\rangle}\,\mathrm{T}_2 \quad C}{\langle x = y = 1;\ \mathbf{a},\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{skip};\ \mathbf{c},\ [[\sigma|x:0]|y:1]\rangle}\,\mathrm{T}_2 \quad E}{\langle x = y = 1;\ \mathbf{a},\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{c}\ [[\sigma|x:0]|y:1]\rangle}\,\mathrm{T}_2 \qquad F}{\langle x = y = 1; \mathbf{a},\ [[\sigma|x:2]|y:2]\rangle \rightsquigarrow^* \langle \mathbf{skip},\ [[\sigma|x:0]|y:1]\rangle}\,\mathrm{T}_2$$

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

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

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

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

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