Domain of a HASKELL-program

Least solution of

$$\text{Dom} = \text{Functions} \oplus \text{Tuples} \oplus \text{Constructions}_0 \oplus \text{Constructions}_1 \oplus \ \ldots$$

where
$$\begin{aligned}
\text{Functions} &= \langle \text{Dom} \to \text{Dom} \rangle_\perp \\
\text{Tuples} &= \{\perp, (\,)\} \oplus (\text{Dom} \times \text{Dom}) \oplus (\text{Dom} \times \text{Dom} \times \text{Dom}) \oplus \ldots \\
\text{Constructions}_n &= (\text{Con}_n \times \text{Dom}^n)_\perp
\end{aligned}$$

Environment

$\rho : \text{Var} \to \text{Dom}$ with $\rho = \{\underline{\text{var}}_1, \ldots, \underline{\text{var}}_n \,/\, d_1, \ldots, d_n\}$

$$(\rho_1 + \rho_2)(\underline{\text{var}}) = \begin{cases} \rho_2(\underline{\text{var}}), & \text{if } \rho_2(\underline{\text{var}}) \text{ is defined} \\ \rho_1(\underline{\text{var}}), & \text{otherwise.} \end{cases}$$

Initial environment ω

for all pre-defined variables in HASKELL

Simple HASKELL-Programs

- no type synonyms, no type classes, no pre-defined lists
- only one declaration of the form $\underline{\text{var}} = \underline{\text{exp}}$

$$
\begin{array}{rcl}
\underline{\text{exp}} & \rightarrow & \underline{\text{var}} \\
& | & \underline{\text{constr}} \\
& | & \underline{\text{integer}} \\
& | & \underline{\text{float}} \\
& | & \underline{\text{char}} \\
& | & (\underline{\text{exp}}_1, \ldots, \underline{\text{exp}}_n), \quad n \geq 0 \\
& | & (\underline{\text{exp}}_1\ \underline{\text{exp}}_2) \\
& | & \texttt{if}\ \underline{\text{exp}}_1\ \texttt{then}\ \underline{\text{exp}}_2\ \texttt{else}\ \underline{\text{exp}}_3 \\
& | & \texttt{let}\ \underline{\text{var}} = \underline{\text{exp}}\ \texttt{in}\ \underline{\text{exp}} \\
& | & \backslash\ \underline{\text{var}} \rightarrow \underline{\text{exp}}
\end{array}
$$

Semantics of HASKELL-Programs

$$\mathcal{V}al\,[\![\underline{\mathsf{var}}]\!]\,\rho \quad = \quad \rho(\underline{\mathsf{var}})$$

$$\mathcal{V}al\,[\![\underline{\mathsf{constr}}_0]\!]\,\rho \quad = \quad \underline{\mathsf{constr}}_0 \; in \; \mathsf{Constructions}_0 \; in \; \mathsf{Dom}$$

$$\mathcal{V}al\,[\![\underline{\mathsf{constr}}_n]\!]\,\rho \quad = \quad f \; in \; \mathsf{Functions} \; in \; \mathsf{Dom}, \text{ where } f\,d_1\,d_2\,\ldots\,d_n = (\underline{\mathsf{constr}}_n, d_1, \ldots, d_n) \; in \; \mathsf{Constructions}_n \; in \; \mathsf{Dom}$$

$$\mathcal{V}al\,[\![(\underline{\mathsf{exp}}_1, \; \ldots, \; \underline{\mathsf{exp}}_n)]\!]\,\rho \quad = \quad (\,\mathcal{V}al\,[\![\underline{\mathsf{exp}}_1]\!]\,\rho, \ldots, \mathcal{V}al\,[\![\underline{\mathsf{exp}}_n]\!]\,\rho\,) \; in \; \mathsf{Tuples} \; in \; \mathsf{Dom}, \text{ where } n = 0 \text{ or } n \geq 2$$

$$\mathcal{V}al\,[\![(\underline{\mathsf{exp}})]\!]\,\rho \quad = \quad \mathcal{V}al\,[\![\underline{\mathsf{exp}}]\!]\,\rho$$

$$\mathcal{V}al\,[\![(\underline{\mathsf{exp}}_1 \; \underline{\mathsf{exp}}_2)]\!]\,\rho \quad = \quad f(\,\mathcal{V}al\,[\![\underline{\mathsf{exp}}_2]\!]\,\rho\,), \text{ where } \mathcal{V}al\,[\![\underline{\mathsf{exp}}_1]\!]\,\rho = f \; in \; \mathsf{Functions} \; in \; \mathsf{Dom}$$

$$\mathcal{V}al \left[\!\!\left[\begin{array}{l} \texttt{if}\ \underline{\mathsf{exp}}_1\ \texttt{then}\ \underline{\mathsf{exp}}_2 \\ \qquad\quad\ \texttt{else}\ \underline{\mathsf{exp}}_3 \end{array} \right]\!\!\right] \rho \quad = \begin{cases} \mathcal{V}al\,[\![\underline{\mathsf{exp}}_2]\!]\,\rho, & \text{if } \mathcal{V}al\,[\![\underline{\mathsf{exp}}_1]\!]\,\rho = \texttt{True} \\ & \quad\ \mathit{in}\ \mathsf{Constructions}_0\ \mathit{in}\ \mathsf{Dom} \\ \mathcal{V}al\,[\![\underline{\mathsf{exp}}_3]\!]\,\rho, & \text{in } \mathcal{V}al\,[\![\underline{\mathsf{exp}}_1]\!]\,\rho = \texttt{False} \\ & \quad\ \mathit{in}\ \mathsf{Constructions}_0\ \mathit{in}\ \mathsf{Dom} \\ \bot, & \text{otherwise} \end{cases}$$

$$\mathcal{V}al \left[\!\!\left[\begin{array}{l} \texttt{let}\ \underline{\mathsf{var}} = \underline{\mathsf{exp}} \\ \qquad\ \texttt{in}\ \underline{\mathsf{exp}'} \end{array} \right]\!\!\right] \rho \ = \ \mathcal{V}al\,[\![\underline{\mathsf{exp}'}]\!]\,(\rho + \{\underline{\mathsf{var}}\,/\,\mathrm{lfp}\ f\}),$$

where $f : \mathsf{Dom} \to \mathsf{Dom}$ and $f(d) = \mathcal{V}al\,[\![\underline{\mathsf{exp}}]\!]\,(\rho + \{\underline{\mathsf{var}}/d\})$

$$\begin{aligned} \mathcal{V}al\,[\![\texttt{\textbackslash}\ \underline{\mathsf{var}}\ \texttt{->}\ \underline{\mathsf{exp}}]\!]\,\rho \quad &= \quad f\ \mathit{in}\ \mathsf{Functions}\ \mathit{in}\ \mathsf{Dom} \\ &\quad\ \ \text{where } f(d) = \mathcal{V}al\,[\![\underline{\mathsf{exp}}]\!]\,(\rho + \{\underline{\mathsf{var}}\,/\,d\}) \end{aligned}$$