

*Esquema da mquina:*

$$\langle G, \rho, I, O, M, T_E, N_{MT} \rangle \triangleright \langle G', \rho', I', O', M', T'_E, N'_{MT} \rangle$$

*Operation Call:*

$$\frac{\begin{array}{l} indegree(w) = 0 \quad \bar{a} = Eval_\rho(\bar{E}) \quad A'_c = A_c - \{w \mapsto v \mid v \in V\} \quad A'_d = A_d - \{w \mapsto v \mid v \in V\} \\ G = \langle V[w : S!\bar{E}, w' : S?\bar{X}], A_c[w \mapsto w'], A_d \rangle \quad G' = \langle V[w' : S?\bar{X}], A'_c, A'_d \rangle \end{array}}{\langle G, \rho, I, O, M, T_E, N_{MT} \rangle \triangleright \langle G', \rho, I, O[\langle S, w', \bar{a} \rangle], M[\langle w : S!\bar{E}, w', now(), N_{MT} \rangle], T_E, N_{MT} \rangle}$$

*Operation Response (Success):*

$$\frac{\begin{array}{l} indegree(w') = 0 \\ G = \langle V[w' : S?\bar{X}], A_c, A_d \rangle \quad A'_c = A_c - \{w' \mapsto v \mid v \in V\} \quad A'_d = A_d - \{w' \mapsto v \mid v \in V\} \\ G' = \langle V, A'_c, A'_d \rangle \quad \rho' = \rho[\{(X_i \mapsto t_i) \mid 1 \leq i \leq |\bar{X}|\}] \end{array}}{\langle G, \rho, I[\langle S, w', \bar{t} \rangle], O, M[\langle w : S!\bar{E}, w', T_C, N_T \rangle], T_E, N_{MT} \rangle \triangleright \langle G', \rho', I, O, M, T_E, N_{MT} \rangle}$$

*Operation Response (Failure):*

$$\frac{\begin{array}{l} indegree(w') = 0 \quad now() - T_C > T_E \quad N_T > 0 \quad \forall \bar{t}. \langle S, w', \bar{t} \rangle \notin I \\ G = \langle V[w' : S?\bar{X}], A_c, A_d \rangle \quad \bar{a} = Eval_\rho(\bar{E}) \quad M' = M[\langle w : S!\bar{E}, w', now(), N_T - 1 \rangle] \end{array}}{\langle G, \rho, I, O, M[\langle w : S!\bar{E}, w', T_C, N_T \rangle], T_E, N_{MT} \rangle \triangleright \langle G, \rho, I, O[\langle S, w', \bar{a} \rangle], M', T_E, N_{MT} \rangle}$$

*Rebind*

$$\begin{aligned} \mathcal{T} \llbracket S_1(\bar{E}_1, \bar{X}_1) \% S_2(\bar{E}_2, \bar{X}_2) \% \dots \% S_n(\bar{E}_n, \bar{X}_n) \rrbracket = & \text{let } S = newName(); \\ & K = [S_1!\bar{E}_1, \dots, S_n!\bar{E}_n] \\ & \text{in} \\ & \langle \{w : S!K, w' : S?\bar{X}\}, \{w \mapsto w'\}, \emptyset \rangle \end{aligned}$$

*Operation Call:*

$$\frac{\begin{array}{l} indegree(w) = 0 \quad G = \langle V[w : S!K, w' : S?\bar{X}], A_c[w \mapsto w'], A_d \rangle \\ K = [S_1!\bar{E}_1, \dots, S_n!\bar{E}_n] \quad \bar{a} = Eval_\rho(\bar{E}_1) \\ A'_c = A_c - \{w \mapsto v \mid v \in V\} \quad A'_d = A_d - \{w \mapsto v \mid v \in V\} \quad G' = \langle V[w' : S_1?\bar{X}], A'_c, A'_d \rangle \end{array}}{\langle G, \rho, I, O, M, T_E, N_{MT} \rangle \triangleright \langle G', \rho, I, O[\langle S_1, w', \bar{a} \rangle], M[\langle w : S!K, w', now(), N_{MT} \rangle], T_E, N_{MT} \rangle}$$

*Operation Response (Success):*

$$\frac{\begin{array}{l} indegree(w') = 0 \quad G = \langle V[w' : S?\bar{X}], A_c, A_d \rangle \quad K = [S!\bar{E}, \dots] \\ A'_c = A_c - \{w' \mapsto v \mid v \in V\} \quad A'_d = A_d - \{w' \mapsto v \mid v \in V\} \\ G' = \langle V, A'_c, A'_d \rangle \quad \rho' = \rho[\{(X_i \mapsto t_i) \mid 1 \leq i \leq |\bar{X}|\}] \end{array}}{\langle G, \rho, I[\langle S, w', \bar{t} \rangle], O, M[\langle w : S!K, w', T_C, N_T \rangle], T_E, N_{MT} \rangle \triangleright \langle G', \rho', I, O, M, T_E, N_{MT} \rangle}$$

*Operation Response (Timeout, retry):*

$$\begin{array}{c}
\text{indegree}(w') = 0 \quad \text{now}() - T_C > T_E \quad N_T > 0 \quad \forall \bar{t}. \langle S, w', \bar{t} \rangle \notin I \\
G = \langle V[w' : S? \overline{X}], A_c, A_d \rangle \quad K = [S! \overline{E}, \dots] \\
\overline{a} = \text{Eval}_\rho(\overline{E}) \quad M' = M[\langle w : S'!K, w', \text{now}(), N_T - 1 \rangle] \\
\hline
\langle G, \rho, I, O, M[\langle w : S'!K, w', T_C, N_T \rangle], T_E, N_{MT} \rangle \triangleright \langle G, \rho, I, O[\langle S, w', \overline{a} \rangle], M', T_E, N_{MT} \rangle
\end{array}$$

*Operation Response (Timeout, no-retry, non-empty stack):*

$$\begin{array}{c}
\text{indegree}(w') = 0 \quad \text{now}() - T_C > T_E \quad \forall \bar{t}. \langle S_1, w', \bar{t} \rangle \notin I \\
G = \langle V[w' : S_1? \overline{X}], A_c, A_d \rangle \quad K = [S_1! \overline{E}, S_2! \overline{E}_2, \dots] \quad \overline{a} = \text{Eval}_\rho(\overline{E}_2) \quad K' = [S_2! \overline{E}_2, \dots] \\
M' = M[\langle w : S'!K', w', \text{now}(), N_{MT} \rangle] \quad G' = \langle V[w' : S_2? \overline{X}], A_c, A_d \rangle \\
\hline
\langle G, \rho, I, O, M[\langle w : S'!K, w', T_C, 0 \rangle], T_E, N_{MT} \rangle \triangleright \langle G', \rho, I, O[\langle S_2, w', \overline{a} \rangle], M', T_E, N_{MT} \rangle
\end{array}$$

*Sub-Workflows:*

$$\mathcal{T}[\{P_1 \% P_2 \% \dots \% P_n\}] = \langle \{w : [P_1, P_2, \dots, P_n]\}, \emptyset, \emptyset \rangle$$

*Sub-Workflows: Success!*

$$\begin{array}{c}
\langle \mathcal{T}[P_1], \rho, I, O, M, T_E, N_{MT} \rangle \triangleright^* \langle \langle \emptyset, \emptyset, \emptyset \rangle, \rho', I', O', M', T_E, N_{MT} \rangle \\
A'_c = A_c - \{v \mapsto v' \mid v' \in V\} \quad A'_d = A_d - \{v \mapsto v' \mid v' \in V\} \\
\hline
\langle \langle V[v : [P_1, \dots]], A_c, A_d \rangle, \rho, I, O, M, T_E, N_{MT} \rangle \triangleright \langle \langle V, A'_c, A'_d \rangle, \rho', I', O', M', T_E, N_{MT} \rangle
\end{array}$$

*Sub-Workflows: First alternative failed*

$$\begin{array}{c}
\langle \mathcal{T}[P_1], \rho, I, O, M, T_E, N_{MT} \rangle \triangleright^* \langle \langle V', A'_c, A'_d \rangle, \rho', I', O', M', T_E, N_{MT} \rangle \not\triangleright \\
V' \neq \emptyset \\
\hline
\langle \langle V[v : [P_1, P_2 \dots]], A_c, A_d \rangle, \rho, I, O, M, T_E, N_{MT} \rangle \triangleright \langle \langle V[v : [P_2, \dots]], A_c, A_d \rangle, \rho', I', O', M', T_E, N_{MT} \rangle
\end{array}$$