



Degree Project in Technology

First cycle, 15 credits

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Bachelor's Programme in Information and Communication Technology

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Host company: Företaget AB

Swedish title: Detta är den svenska översättningen av titeln

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0.1 Inference Rules

0.1.1 Extension

0.1.1.1 Typing

$$\text{T-TASK} \frac{x : C; \text{ocap} \vdash t : \tau \quad \Gamma; a \vdash b : Q \triangleright \text{Box}[C]}{\Gamma; a \vdash \text{task}(b)\{x \Rightarrow t\} : Q \triangleright \text{Task}[C]}$$

$$\text{T-ASYNC} \frac{\text{Perm}[Q] \in \Gamma \quad \Gamma \setminus \text{Perm}[Q]; a \vdash s : \sigma \quad \Gamma; a \vdash x : Q \triangleright \text{Task}[C]}{\Gamma; a \vdash \text{async}(x)\{s\} : \perp}$$

$$\text{T-FINISH} \frac{\Gamma; \text{ocap} \vdash t : \tau}{\Gamma; a \vdash \text{finish}\{t\} : \text{null}}$$

0.1.1.2 Evaluation

$$\text{E-TASK} \frac{L(b') = b(o, p)}{H, \{(f, \langle L, \text{let } x = \text{task}(b')\{x \Rightarrow t\} \text{ in } s, P \rangle^l)\} \uplus TS} \\ \rightsquigarrow H, \{(f, \langle L[x \rightarrow \text{task}(b(o, p), t)], s, P \rangle^l)\} \uplus TS$$

$$\text{E-ASYNC} \frac{\begin{array}{l} L(y) = \text{task}(b(o, p), t) \quad p \in P \\ T_1 = (f, \langle L, s, P \rangle^\epsilon) \quad T_2 = (f, \langle [x \rightarrow o], t, \emptyset \rangle^\epsilon) \end{array}}{H, \{(f, \langle L, \text{async}(y)\{s\}, P \rangle^l \circ FS)\} \uplus TS} \\ \rightsquigarrow H, \{T_1, T_2\} \uplus TS$$

$$\text{E-FINISH1} \frac{T = (f', \langle L, t, P \rangle^\epsilon) \quad f' \text{ fresh}}{H, \{(f, \langle L, \text{let } x = \text{finish}\{t\} \text{ in } s, P \rangle^l \circ FS)\} \uplus TS} \\ \rightsquigarrow H, \{(f, \langle \text{FINISH } f' \rangle \circ \langle L[x \rightarrow \text{null}], s, P \rangle^l \circ FS)\} \uplus \{T\} \uplus TS$$

$$\text{E-FINISH2} \frac{\nexists (f', FS) \in TS}{H, \{(f, \langle \text{FINISH } f' \rangle \circ FS)\} \uplus TS} \\ \rightsquigarrow H, \{(f, FS)\} \uplus TS$$

$$\text{E-TASK-DONE} \frac{}{H, \{(f, \epsilon)\} \uplus TS \rightsquigarrow TS}$$

0.1.2 LaCasa

0.1.2.1 Well-Formedness

$$\text{WF-VAR} \frac{L(x) = \text{null} \vee L(x) = o \wedge \text{typeof}(H, o) <: \Gamma(x) \vee L(x) = b(o, p) \wedge \Gamma(x) = Q \triangleright \text{Box}[C] \wedge \text{typeof}(H, o) <: C}{H \vdash \Gamma; L; x}$$

$$\text{WF-PERM} \frac{\begin{array}{c} \gamma : \text{permTypes}(\Gamma) \longrightarrow \text{Pinjective} \\ \forall x \in \text{dom}(\Gamma). \\ (\Gamma(x) = Q \triangleright \text{Box}[C] \wedge L(x) = b(o, p) \wedge \text{Perm}[Q] \in \Gamma \vee \\ \Gamma(x) = Q \triangleright \text{Task}[C] \wedge L(x) = \text{task}(b(o, p), t) \wedge \text{Perm}[Q] \in \Gamma) \\ \implies \gamma(Q) = p \end{array}}{\vdash \Gamma; L; P}$$

$$\text{WF-ENV} \frac{\begin{array}{c} \text{dom}(\Gamma) \subseteq \text{dom}(L) \\ \forall x \in \text{dom}(\Gamma). H \vdash \Gamma; L; x \end{array}}{H \vdash \Gamma; L}$$

$$\text{WF-METHOD1} \frac{\Gamma_0, \text{this} : C, x : D; \epsilon \vdash t : E' \quad E' <: E}{C \vdash \text{defm}(x : D) : E = t}$$

$$\text{WF-METHOD2} \frac{\Gamma = \Gamma_0, \text{this} : C, x : Q \triangleright \text{Box}[D], \text{Perm}[Q] \quad Q \text{fresh} \quad \Gamma; \epsilon \vdash t : E' \quad E' <: E}{C \vdash \text{defm}(x : \text{Box}[D]) : E = t}$$

$$\text{WF-PROGRAM} \frac{p \vdash \bar{c}d \quad p \vdash \Gamma_0 \quad \Gamma_0; \epsilon \vdash t : \sigma}{p \vdash \bar{c}d\bar{v}d\bar{t}}$$

$$\text{WF-CLASS} \frac{\begin{array}{c} C \vdash \bar{m}d \quad D = \text{AnyRef} \vee p \vdash \text{class} D \dots \\ \forall (\text{defm} \dots) \in \bar{m}d.\text{override}(m, C, D) \\ \forall \text{var} f : \sigma \in \bar{f}d.f \notin \text{fields}(D) \end{array}}{p \vdash \text{class} C \text{extends} D \{ \bar{f}d \bar{m}d \}}$$

$$\text{WF-OVERRIDE} \frac{\text{mtype}(m, D) \text{notdefined} \vee \text{mtype}(m, D) = \text{mtype}(m, C)}{\text{override}(m, C, D)}$$

0.1.2.2 Typing

$$\text{T-NUL} \frac{}{\Gamma; a \vdash \text{null} : \text{Null}}$$

$$\text{T-VAR} \frac{x \in \text{dom}(\Gamma)}{\Gamma; a \vdash x : \Gamma(x)}$$

T-LET	$\frac{\Gamma; a \vdash e : \tau \quad \Gamma, x : \tau; a \vdash t : \sigma}{\Gamma; a \vdash \text{let } x = e \text{ in } t : \sigma}$
T-SELECT	$\frac{\Gamma; a \vdash x : C \quad \text{ftype}(C, f) = D}{\Gamma; a \vdash x.f : D}$
T-ASSIGN	$\frac{\Gamma; a \vdash x : C \quad \text{ftype}(C, f) = D \quad \Gamma; a \vdash y : D' \quad D' <: D}{\Gamma; a \vdash x.f = y : D}$
T-INVOKE	$\frac{\Gamma; a \vdash x : C \quad \text{mtype}(C, m) = \sigma \rightarrow \tau \quad \Gamma; a \vdash y : \sigma' \quad \sigma' <: \sigma \vee (\sigma = \text{Box}[D] \wedge \sigma' = Q \triangleright \text{Box}[D] \wedge \text{Perm}[Q] \in \Gamma)}{\Gamma; a \vdash x.m(y) : \tau}$
T-NEW	$\frac{a = \text{ocap} \implies \text{ocap}(C) \quad \forall \text{var } f : \sigma \in \bar{f}d. \exists D. \sigma = D}{\Gamma; a \vdash \text{new } C : C}$
T-OPEN	$\frac{\Gamma; a \vdash x : Q \triangleright \text{Box}[C] \quad \text{Perm}[Q] \in \Gamma \quad y : C; \text{ocap} \vdash t : \sigma}{\Gamma; a \vdash x.\text{open}\{y \Rightarrow t\} : Q \triangleright \text{Box}[C]}$
T-BOX	$\frac{\text{ocap}(C) \quad Q \text{fresh} \quad \Gamma; x : Q \triangleright \text{Box}[C]; \text{Perm}[Q]; a \vdash t : \sigma}{\Gamma; a \vdash \text{box}[C]\{x \Rightarrow t\} : \perp}$
T-CAPTURE	$\frac{\Gamma; a \vdash x : Q \triangleright \text{Box}[C] \quad \Gamma; a \vdash y : Q' \triangleright \text{Box}[D] \quad \{\text{Perm}[Q], \text{Perm}[Q']\} \subseteq \Gamma \quad D <: \text{ftype}(C, f) \quad \Gamma \{\text{Perm}[Q']\}, z : Q \triangleright \text{Box}[C]; a \vdash t : \sigma}{\Gamma; a \vdash \text{capture}(x.f, y)\{z \Rightarrow t\} : \perp}$
T-SWAP	$\frac{\Gamma; a \vdash x : Q \triangleright \text{Box}[C] \quad \Gamma; a \vdash y : Q' \triangleright \text{Box}[D] \quad \{\text{Perm}[Q], \text{Perm}[Q']\} \subseteq \Gamma \quad \text{ftype}(C, f) = \text{Box}[D] \quad D' <: D \quad R \text{fresh}}{\Gamma \{\text{Perm}[Q']\}, z : R \triangleright \text{Box}[D], \text{Perm}[R]; a \vdash t : \sigma \quad \Gamma; a \vdash \text{swap}(x.f, y)\{z \Rightarrow t\} : \perp}$
T-EMPFS	$\frac{}{H \vdash \epsilon}$
T-FRAME1	$\frac{\Gamma; a \vdash t : \sigma \quad l \neq \epsilon \implies \sigma <: C \quad H \vdash \Gamma; L \quad H \vdash \Gamma; L; P}{H \vdash \langle L, t, P \rangle^l : \sigma}$
T-FRAME2	$\frac{\Gamma; x : \tau; a \vdash t : \sigma \quad l \neq \epsilon \implies \sigma <: C \quad H \vdash \Gamma; L \quad H \vdash \Gamma; L; P}{H \vdash_x^\tau \langle L, t, P \rangle^l : \sigma}$

$$\text{T-FRAME-NA} \frac{H \vdash F^\epsilon : \sigma \quad H \vdash FS}{H \vdash F^\epsilon \circ FS}$$

$$\text{T-FRAME-NA2} \frac{H \vdash_x^\tau F^\epsilon : \sigma \quad H \vdash FS}{H \vdash_x^\tau F^\epsilon \circ FS}$$

$$\text{T-FRAME-A} \frac{H \vdash F^x : \sigma \quad H \vdash_x^\sigma FS}{H \vdash F^x \circ FS}$$

$$\text{T-FRAME-A2} \frac{H \vdash_x^\tau F^y : \sigma \quad H \vdash_y^\sigma FS}{H \vdash_x^\tau F^y \circ FS}$$

0.1.2.3 Evaluation

$$\text{E-NULL} \frac{}{H, \langle L, \text{let } x = \text{nullint}, P \rangle^l \rightarrow H, \langle L[x \rightarrow \text{null}], t, P \rangle^l}$$

$$\text{E-VAR} \frac{}{H, \langle L, \text{let } x = y\text{int}, P \rangle^l \rightarrow H, \langle L[x \rightarrow L(y)], t, P \rangle^l}$$

$$\text{E-SELECT} \frac{H(L(y)) = \langle C, FM \rangle \quad f \in \text{dom}(FM)}{H, \langle L, \text{let } x = y.f\text{int}, P \rangle^l \rightarrow H, \langle L[x \rightarrow FM(f)], t, P \rangle^l}$$

$$\text{E-ASSIGN} \frac{L(y) = o \quad H(o) = \langle C, FM \rangle \quad H' = H[o \rightarrow \langle C, FM[f \rightarrow L(z)] \rangle]}{H, \langle L, \text{let } x = y.f = z\text{int}, P \rangle^l \rightarrow H', \langle L, \text{let } x = z\text{int}, P \rangle^l}$$

$$\text{E-NEW} \frac{o \notin \text{dom}(H) \quad \text{fields}(C) = \bar{f} \quad H' = H[o \rightarrow \langle C, f \rightarrow \text{null} \rangle]}{H, \langle L, \text{let } x = \text{new } C\text{int}, P \rangle^l \rightarrow H', \langle L[x \rightarrow o], t, P \rangle^l}$$

$$\begin{array}{c}
\text{E-INVOKE} \frac{
\begin{array}{l}
H(L(y)) = \langle C, FM \rangle \quad mbody(C, m) = x \rightarrow t' \\
L' = L_0[this \rightarrow L(y), x \rightarrow L(z)] \\
P' = \emptyset \vee (L(z) = b(o, p) \wedge p \in P \wedge P' = \{p\})
\end{array}
}{
\begin{array}{l}
H, \langle L, letx = y.m(z)int, P \rangle^l \circ FS \\
\Rightarrow H, \langle L', t', P' \rangle^x \circ \langle L, t, P \rangle^l \circ FS
\end{array}
} \\
\text{E-RETURN1} \frac{
\begin{array}{l}
H, \langle L, x, P \rangle^y \circ \langle L', t', P' \rangle^l \\
\rightarrow H, \langle L'[y \rightarrow L(x)], t', P' \rangle^l
\end{array}
}{
} \\
\text{E-RETURN2} \frac{
\begin{array}{l}
H, \langle L, x, P \rangle^\epsilon \circ \langle L', t', P' \rangle^l \\
\rightarrow H, \langle L', t', P' \rangle^l
\end{array}
}{
} \\
\text{E-OPEN} \frac{
\begin{array}{l}
L(y) = b(o, p) \quad p \in P \quad L' = [z \rightarrow o] \\
H, \langle L, letx = y.open\{z \Rightarrow t'\}int, P \rangle^l \circ FS \\
\Rightarrow H, \langle L', t', \emptyset \rangle^\epsilon \circ \langle L[x \rightarrow L(y)], t, P \rangle^l \circ FS
\end{array}
}{
} \\
\text{E-BOX} \frac{
\begin{array}{l}
o \notin dom(H) \quad fields(C) = \bar{f} \\
H' = H[o \rightarrow \langle C, f \rightarrow null \rangle] \quad pfresh
\end{array}
}{
\begin{array}{l}
H, \langle L, box[C]\{x \Rightarrow t\}, P \rangle^l \circ FS \\
\Rightarrow H', \langle L[x \rightarrow b(o, p)], t, P \cup \{p\} \rangle^\epsilon \circ \epsilon
\end{array}
} \\
\text{E-CAPTURE} \frac{
\begin{array}{l}
L(x) = b(o, p) \quad L(y) = b(o', p') \quad \{p, p'\} \subseteq P \\
H(o) = \langle C, FM \rangle \quad H' = H[\rightarrow \langle C, FM[f \rightarrow o'] \rangle]
\end{array}
}{
\begin{array}{l}
H, \langle L, capture(x.f, y)\{z \Rightarrow t\}, P \rangle^l \circ FS \\
\Rightarrow H', \langle L[z \rightarrow L(x)], t, P \setminus \{p'\} \rangle^\epsilon \circ \epsilon
\end{array}
} \\
\text{E-SWAP} \frac{
\begin{array}{l}
L(x) = b(o, p) \quad L(y) = b(o', p') \quad \{p, p'\} \subseteq P \\
H(o) = \langle C, FM \rangle \quad FM(f) = o'' \quad p'' fresh \\
H' = H[o \rightarrow \langle C, FM[f \rightarrow o'] \rangle]
\end{array}
}{
\begin{array}{l}
H, \langle L, swap(x.f, y)\{z \Rightarrow t\}, P \rangle^l \circ FS \\
\Rightarrow H', \langle L[z \rightarrow b(o'', p'')], t, (P \setminus \{p'\}) \cup \{p''\} \rangle^\epsilon \circ \epsilon
\end{array}
}
\end{array}$$

0.1.2.4 Other

$$\text{F-OK} \frac{
\begin{array}{l}
boxSep(H, F) \quad boxObjSep(H, F) \quad boxOcap(H, F) \\
a = ocap \Rightarrow globalOcapSep(H, F) \quad fieldUniqueness(H, F)
\end{array}
}{
H; a \vdash Fok
}$$