KTH ROYAL INSTITUTE
OF TECHNOLOGY

Degree Project in Technology

First cycle, 15 credits

This is the title in the language of the thesis

A subtitle in the language of the thesis

FAKE A. STUDENT
FAKE B. STUDENT

Stockholm, Sweden, 2024

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FAKE A. STUDENT

FAKE B. STUDENT

Bachelor's Programme in Information and Communication Technology
Date: January 29, 2024

Supervisors: A. Busy Supervisor, Another Busy Supervisor, Third Busy Supervisor
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Swedish title: Detta är den svenska översättningen av titeln
Swedish subtitle: Detta är den svenska översättningen av undertiteln

0.1 Inference Rules

0.1.1 Extension

0.1.1.1 Typing

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

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

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

0.1.1.2 Evaluation

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

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

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

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

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

0.1.2 LaCasa

0.1.2.1 Well-Formedness

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

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

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

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

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

$$\text{WF-PROGRAM}\ \frac{p \vdash \bar{cd} \qquad p \vdash \Gamma_0 \qquad \Gamma_0; \epsilon \vdash t : \sigma}{p \vdash \bar{cd}\bar{v}dt}$$

$$\text{WF-CLASS}\ \frac{\begin{array}{c} C \vdash \bar{md} \qquad D = AnyRef \vee p \vdash classD... \\ \forall (defm...) \in \bar{md}.override(m, C, D) \\ \forall var f : \sigma \in \bar{fd}.f \notin fields(D) \end{array}}{p \vdash classCextendsD\{\bar{fd}\bar{md}\}}$$

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

0.1.2.2 Typing

$$\text{T-FRAME1}\ \frac{\begin{array}{cc} \Gamma; a \vdash t : \sigma \qquad l \neq \epsilon \Longrightarrow \sigma <: C \\ H \vdash \Gamma; L \qquad\qquad H \vdash \Gamma; L; P \end{array}}{H \vdash \langle L,\ t,\ P \rangle^l : \sigma}$$

$$\text{T-FRAME2}\ \frac{\Gamma; x:\tau; a \vdash t:\sigma \qquad l \neq \epsilon \Longrightarrow \sigma <: C \qquad H \vdash \Gamma; L \qquad H \vdash \Gamma; L; P}{H \vdash^{\tau}_{x} \langle L,\ t,\ P\rangle^{l} : \sigma}$$

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

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

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

$$\text{T-FRAME-A2}\ \frac{H \vdash^{\tau}_{x} F^{y} : \sigma \qquad H \vdash^{\sigma}_{y} FS}{H \vdash^{\tau}_{x} F^{y} \circ FS}$$

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

$$\text{T-INVOKE}\ \frac{\Gamma; a \vdash x : C \qquad mtype(C,m) = \sigma \to \tau \qquad \Gamma; a \vdash y : \sigma' \qquad \sigma' <: \sigma \vee \qquad (\sigma = Box[D] \wedge \sigma' = Q \rhd Box[D] \wedge Perm[Q] \in \Gamma)}{\Gamma; a \vdash x.m(y) : \tau}$$

$$\text{T-NEW}\ \frac{a = ocap \Longrightarrow ocap(C) \qquad \forall var f : \sigma \in fd_{w}ith_{l}ine_{a}bove.\exists D.\sigma = D}{\Gamma; a \vdash newC : C}$$

$$\text{T-OPEN}\ \frac{\Gamma; a \vdash x : Q \rhd Box[C] \qquad Perm[Q] \in \Gamma \qquad y : C; ocap \vdash t : \sigma}{\Gamma; a \vdash x.open\{y \Rightarrow t\} : Q \rhd Box[C]}$$

$$\text{T-BOX}\ \frac{ocap(C) \qquad Qfresh \qquad \Gamma; x : Q \rhd Box[C]; Perm[Q]; a \vdash t : sigma}{\Gamma; a \vdash box[C]\{x \Rightarrow t\} : \bot}$$

$$\text{T-CAPTURE}\ \frac{\Gamma; a \vdash x : Q \rhd Box[C] \qquad \Gamma; a \vdash y : Q' \rhd Box[D] \qquad \{Perm[Q], Perm[Q']\} \subseteq \Gamma \qquad D <: ftype(C,f) \qquad \Gamma\ \{Perm[Q']\}, z : Q \rhd Box[C]; a \vdash t : \sigma}{\Gamma; a \vdash capture(x.f, y)\{z \Rightarrow t\} : \bot}$$

$$\text{T-SWAP}\ \frac{\Gamma; a \vdash x : Q \rhd Box[C] \qquad \Gamma; a \vdash y : Q' \rhd Box[D'] \qquad \{Perm[Q], Perm[Q']\} \subseteq \Gamma \qquad ftype(C,f) = Box[D] \qquad D' <: D \qquad Rfresh \qquad \Gamma\ \{Perm[Q']\}, z : R \rhd Box[D], Perm[R]; a \vdash t : \sigma}{\Gamma; a \vdash swap(x.f, y)\{z \Rightarrow t\} : \bot}$$

0.1.2.3 Evaluation

0.1.2.4 Other

$$\text{F-OK}\ \frac{\begin{array}{cc} boxSep(H,F) & boxObjSep(H,F) \qquad boxOcap(H,F) \\ a = ocap \implies globalOcapSep(H,F) & fieldUniqueness(H,F) \end{array}}{H; a \vdash Fok}$$