



INF [9/5]906: static analysis

Spring 2016

Handout 3

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$$\begin{array}{c}
 [x := a]^l : \Sigma \rightarrow \Sigma \quad \text{ASS} \\
 \\
 [\text{skip}]^l : \Sigma \rightarrow \Sigma \quad \text{SKIP} \\
 \\
 \frac{S_1 : \Sigma \rightarrow \Sigma \quad S_2 : \Sigma \rightarrow \Sigma}{S_1; S_2 : \Sigma \rightarrow \Sigma} \text{SEQ} \\
 \\
 \frac{S : \Sigma \rightarrow \Sigma}{\text{while}[b]^l \text{ do } S : \Sigma \rightarrow \Sigma} \text{WHILE} \\
 \\
 \frac{S_1 : \Sigma \rightarrow \Sigma \quad S_2 : \Sigma \rightarrow \Sigma}{\text{if}[b]^l \text{ then } S_1 \text{ else } S_2 : \Sigma \rightarrow \Sigma} \text{COND}
 \end{array}$$

Figure 1: Trivial types system for while

$$\begin{array}{c}
 \frac{\Gamma(x) = \tau}{\Gamma \vdash x : \tau} \text{VAR} \\
 \\
 \frac{\Gamma, x:\tau_1 \vdash e : \tau_2}{\Gamma \vdash \text{fn } x \Rightarrow e : \tau_1 \rightarrow \tau_2} \text{ABS} \\
 \\
 \frac{\Gamma \vdash e_1 : \tau_1 \rightarrow \tau_2 \quad \Gamma \vdash e_2 : \tau_1}{\Gamma \vdash e_1 e_2 : \tau_2} \text{APP}
 \end{array}$$

Figure 2: Simple type system

$$\frac{\hat{\Gamma}(x) = \hat{\tau}}{\hat{\Gamma} \vdash x : \hat{\tau} \ \& \ \emptyset} \text{VAR}$$

$$\frac{\Gamma, x:\hat{\tau}_1 \vdash e : \hat{\tau}_2 \ \& \ \varphi}{\Gamma \vdash \mathbf{fn}_\pi x \Rightarrow e : \hat{\tau}_1 \xrightarrow{\varphi \cup \{\pi\}} \hat{\tau}_2 \ \& \ \emptyset} \text{ABS}$$

$$\frac{\hat{\Gamma} \vdash e_1 : \hat{\tau}_1 \xrightarrow{\varphi} \hat{\tau}_2 \ \& \ \varphi_1 \quad \hat{\Gamma} \vdash e_2 : \hat{\tau}_1 \ \& \ \varphi_2}{\hat{\Gamma} \vdash e_1 e_2 : \hat{\tau}_2 \ \& \ \varphi \cup \varphi_1 \cup \varphi_2} \text{APP}$$

Table 1: Call tracking

$$[x := a]^{l'} : \text{RD} \rightarrow \text{RD} \setminus \{(x, l) \mid l \in \mathbf{Lab}\} \cup \{(x, l')\} \quad \text{ASS}$$

$$[\text{skip}]^l : \text{RD} \rightarrow \text{RD} \quad \text{SKIP}$$

$$\frac{S_1 : \text{RD}_1 \rightarrow \text{RD}_2 \quad S_2 : \text{RD}_2 \rightarrow \text{RD}_3}{S_1; S_2 : \text{RD}_1 \rightarrow \text{RD}_3} \text{SEQ}$$

$$\frac{S_1 : \text{RD}_1 \rightarrow \text{RD}_2 \quad S_2 : \text{RD}_1 \rightarrow \text{RD}_2}{\text{if}[b]^l \text{ then } S_1 \text{ else } S_2 : \text{RD}_1 \rightarrow \text{RD}_2} \text{IF}$$

$$\frac{S : \text{RD} \rightarrow \text{RD}}{\text{while}[b]^l \text{ do } S : \text{RD} \rightarrow \text{RD}} \text{WHILE}$$

$$\frac{S : \text{RD}'_1 \rightarrow \text{RD}'_2 \quad \text{RD}_1 \subseteq \text{RD}'_1 \quad \text{RD}'_2 \subseteq \text{RD}_2}{S : \text{RD}_1 \rightarrow \text{RD}_2} \text{SUB}$$

Table 2: Annotated base types

$$\begin{array}{c}
[x := a]^l : \Sigma \xrightarrow[\{(x,l)\}]{\{x\}} \Sigma \quad \text{ASS} \\
\\
[\text{skip}]^l : \Sigma \xrightarrow[\emptyset]{\emptyset} \Sigma \quad \text{SKIP} \\
\\
\frac{S_1 : \Sigma \xrightarrow[\text{RD}_1]{X_1} \Sigma \quad S_2 : \Sigma \xrightarrow[\text{RD}_2]{X_2} \Sigma}{S_1; S_2 : \Sigma \xrightarrow[\text{RD}_1 \setminus X_2 \cup \text{RD}_2]{X_1 \cup X_2} \Sigma} \text{SEQ} \\
\\
\frac{S_1 : \Sigma \xrightarrow[\text{RD}]{X} \Sigma \quad S_2 : \Sigma \xrightarrow[\text{RD}]{X} \Sigma}{\text{if}[b]^l \text{ then } S_1 \text{ else } S_2 : \Sigma \xrightarrow[\text{RD}]{X} \Sigma} \text{IF} \\
\\
\frac{S : \Sigma \xrightarrow[\text{RD}]{X} \Sigma}{\text{while}[b]^l \text{ do } S : \Sigma \xrightarrow[\text{RD}]{\emptyset} \Sigma} \text{WHILE} \\
\\
\frac{S : \Sigma \xrightarrow[\text{RD}']{X'} \Sigma \quad X \subseteq X' \quad \text{RD}' \subseteq \text{RD}}{S : \Sigma \xrightarrow[\text{RD}]{X} \Sigma} \text{SUB}
\end{array}$$

Table 3: Annotated constr.

Exercise 1 Remember from the constraint solving part the analysis about CFA. The call-tracking analysis of today is rather similar. Try to formulate a CFA in the style of the call-tracking analysis.

Hint: The CFA can be formulated with judgments of the form

$$\Gamma \vdash e : \hat{\tau} \quad (1)$$

where the annotated types $\hat{\tau}$ are of the same form as in the call tracking analysis, i.e., function types are annotated as

$$\hat{\tau}_1 \xrightarrow{\varphi} \hat{\tau}_2 \quad (2)$$

$$\begin{array}{c}
\frac{?}{\Gamma \vdash X : ?} \text{T-VAR} \\
\\
\frac{? \vdash ?}{\Gamma \vdash \text{fn } X \Rightarrow e : ?} \text{T-ABS} \\
\pi \\
\\
\frac{? \vdash ? \quad ? \vdash ?}{\Gamma \vdash e_1 e_2 : ?} \text{T-APP}
\end{array}$$
