

salt1: Immutable References

CS392-M1: *Rust, In Practice and in Theory*

Syntax

x	(variables, \mathcal{V})
n	(integers, \mathbb{Z})
$w ::= x \mid * w$	(place expression, \mathcal{W})
$e ::= () \mid n \mid w \mid \& w \mid x = e$	(expressions, \mathcal{E})
$s ::= \text{let } x = e \mid \text{let mut } x = e \mid e$	(statements, \mathcal{S})
$p ::= e \mid s ; p$	(programs, \mathcal{P})

Typing

$$\begin{array}{ll}
 t ::= \textcolor{red}{()} \mid \textcolor{red}{i32} \mid \& x & (\text{types}, \mathcal{T}) \\
 m ::= \text{imm} \mid \text{mut} & (\text{mutability}) \\
 u ::= \langle t \rangle^m & (\text{slot types}, \mathbb{S}_{\mathcal{T}})
 \end{array}$$

$$\Gamma \in \mathcal{V} \mapsto \mathbb{S}_{\mathcal{T}} \quad (\text{contexts})$$

$$\begin{array}{ll}
 \Gamma \vdash w : u & (\text{place expressions}) \\
 \Gamma \vdash \text{writable}(x) & (\text{writability}) \\
 \Gamma \vdash t \approx t & (\text{type compatibility}) \\
 \Gamma \vdash e : t \dashv \Gamma & (\text{expressions}) \\
 \Gamma \vdash s \dashv \Gamma & (\text{statements}) \\
 \Gamma \vdash p : t \dashv \Gamma & (\text{programs})
 \end{array}$$

$$\begin{array}{c}
 \frac{(x \mapsto t^m) \in \Gamma}{\Gamma \vdash x : \langle t \rangle^m} \text{ (var)} \\[10pt]
 \frac{\Gamma \vdash w : \langle \& x \rangle^{m_1} \quad \Gamma \vdash x : \langle t \rangle^{m_2}}{\Gamma \vdash * w : \langle t \rangle^{m_2}} \text{ (deref)} \\[10pt]
 \frac{}{\Gamma \vdash \textcolor{red}{()} : \textcolor{red}{()} \dashv \Gamma} \text{ (unit)} \\[10pt]
 \frac{n \in \mathbb{Z}}{\Gamma \vdash n : \textcolor{red}{i32} \dashv \Gamma} \text{ (int)} \\[10pt]
 \frac{\Gamma \vdash w : \langle t \rangle^m}{\Gamma \vdash w : t \dashv \Gamma} \text{ (place)} \\[10pt]
 \frac{\Gamma \vdash x : \langle t \rangle^m}{\Gamma \vdash \& x : \& x \dashv \Gamma} \text{ (ref-var)}
 \end{array}$$

$$\begin{array}{c}
\frac{\Gamma \vdash w : \langle \& x \rangle^m}{\Gamma \vdash \& * w : \& x \dashv \Gamma} \text{ (ref-drf)} \\
\frac{}{\Gamma \vdash () \approx ()} \text{ (}\approx\text{-unit)} \\
\frac{}{\Gamma \vdash \textcolor{red}{i32} \approx \textcolor{red}{i32}} \text{ (}\approx\text{-int)} \\
\frac{\Gamma \vdash x_1 : \langle t_1 \rangle^m \quad \Gamma \vdash x_2 : \langle t_2 \rangle^m \quad \Gamma \vdash t_1 \approx t_2}{\Gamma \vdash \& x_1 \approx \& x_2} \text{ (}\approx\text{-ref)} \\
\frac{\nexists y. (y \mapsto \& x) \in \Gamma}{\Gamma \vdash \text{writable}(x)} \text{ (writable)} \\
\frac{\Gamma_1 \vdash x : \langle t_1 \rangle^{\text{mut}} \quad \Gamma_1 \vdash e : t_2 \dashv \Gamma_2 \quad \Gamma_2 \vdash t_1 \approx t_2 \quad \Gamma_2 \vdash \text{writable}(x)}{\Gamma_1 \vdash x = e : () \dashv \Gamma_2[x \mapsto t_2^{\text{mut}}]} \text{ (assign)} \\
\frac{\Gamma_1 \vdash e : t \dashv \Gamma_2 \quad x \notin \text{dom}(\Gamma_2)}{\Gamma_1 \vdash \text{let } x = e \dashv \Gamma_2[x \mapsto t^{\text{imm}}]} \text{ (let)} \\
\frac{\Gamma_1 \vdash e : t \dashv \Gamma_2 \quad x \notin \text{dom}(\Gamma_2)}{\Gamma_1 \vdash \text{let mut } x = e \dashv \Gamma_2[x \mapsto t^{\text{mut}}]} \text{ (let-mut)} \\
\frac{\Gamma_1 \vdash e : t \dashv \Gamma_2}{\Gamma_1 \vdash e \dashv \Gamma_2} \text{ (expr-stmt)} \\
\frac{\Gamma_1 \vdash s \dashv \Gamma_2 \quad \Gamma_2 \vdash p : t \dashv \Gamma_3}{\Gamma_1 \vdash s ; p : t \dashv \Gamma_3} \text{ (prog)}
\end{array}$$

Evaluation

$$\begin{array}{ll} \ell ::= \ell_x & (\text{locations}, \mathcal{L}) \\ v ::= \textcolor{red}{()} \mid n \mid \ell & (\text{values}, \mathbb{V}) \end{array}$$

$$S \in \mathcal{L} \mapsto \mathbb{V} \quad (\text{store})$$

$$\begin{array}{ll} w \rightsquigarrow \ell & (\text{place locations}) \\ \langle S, e \rangle \Downarrow \langle S, v \rangle & (\text{expressions}) \\ \langle S, s \rangle \Downarrow S & (\text{statements}) \\ \langle S, p \rangle \Downarrow \langle S, v \rangle & (\text{programs}) \end{array}$$

$$\overline{x \rightsquigarrow \ell_x} \quad (\text{loc-var})$$

$$\frac{w \rightsquigarrow \ell_x \quad (\ell_x \mapsto \ell_y) \in S}{* w \rightsquigarrow \ell_y} \quad (\text{loc-drf})$$

$$\overline{\langle S, \textcolor{red}{()} \rangle \Downarrow \langle S, \textcolor{red}{()} \rangle} \quad (\text{unit})$$

$$\overline{\langle S, n \rangle \Downarrow \langle S, n \rangle} \quad (\text{int})$$

$$\frac{w \rightsquigarrow \ell_x \quad (\ell_x \mapsto v) \in S}{\langle S, w \rangle \Downarrow \langle S, v \rangle} \quad (\text{place})$$

$$\overline{\langle S, \& w \rangle \Downarrow \langle S, \ell_x \rangle} \quad (\text{ref})$$

$$\frac{\langle S_1, e \rangle \Downarrow \langle S_2, v \rangle}{\langle S_1, x = e \rangle \Downarrow \langle S_2[x \mapsto v], \textcolor{red}{()} \rangle} \quad (\text{assign})$$

$$\begin{array}{c}
\dfrac{\langle S_1, e \rangle \Downarrow \langle S_2, v \rangle}{\langle S_1, \text{let } x = e \rangle \Downarrow S_2[x \mapsto v]} \text{ (let)} \\[10pt]
\dfrac{\langle S_1, e \rangle \Downarrow \langle S_2, v \rangle}{\langle S_1, \text{let mut } x = e \rangle \Downarrow S_2[x \mapsto v]} \text{ (let-mut)} \\[10pt]
\dfrac{\langle S_1, e \rangle \Downarrow \langle S_2, v \rangle}{\langle S_1, e \rangle \Downarrow S_2} \text{ (expr-stmt)} \\[10pt]
\dfrac{\langle S_1, s \rangle \Downarrow S_2 \quad \langle S_2, p \rangle \Downarrow \langle S_3, v \rangle}{\langle S_1, s ; p \rangle \Downarrow \langle S_3, v \rangle} \text{ (prog)}
\end{array}$$