

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

$t ::= () \mid \textcolor{red}{i}32 \mid \& x$	(types, \mathcal{T})
$m ::= \text{imm} \mid \text{mut}$	(mutability)
$u ::= \langle t \rangle^m$	(slot types, $\mathcal{S}_{\mathcal{T}}$)
$\Gamma \in \mathcal{V} \mapsto \mathcal{S}_{\mathcal{T}}$	(contexts)
$\Gamma \vdash \text{writable}(x)$	(writability)
$\Gamma \vdash w : u$	(place expressions)
$\Gamma \vdash t \approx t$	(type compatibility)
$\Gamma \vdash e : t \dashv \Gamma$	(expressions)
$\Gamma \vdash s \dashv \Gamma$	(statements)
$\Gamma \vdash p : t \dashv \Gamma$	(programs)

$$\begin{array}{c}
\frac{(x \mapsto t^m) \in \Gamma}{\Gamma \vdash x : \langle t \rangle^m} \text{VAR} \qquad \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} \qquad \frac{}{\Gamma \vdash () : ()} \text{UNIT} \\
\\
\frac{n \in \mathbb{Z}}{\Gamma \vdash n : \textcolor{red}{i32} \dashv \Gamma} \text{INT} \qquad \frac{\Gamma \vdash w : \langle t \rangle^m}{\Gamma \vdash w : t \dashv \Gamma} \text{PLACE} \qquad \frac{\Gamma \vdash x : \langle t \rangle^m}{\Gamma \vdash \& x : \& x \dashv \Gamma} \text{REFVAR} \\
\\
\frac{\Gamma \vdash w : \langle \& x \rangle^m}{\Gamma \vdash \& * w : \& x \dashv \Gamma} \text{REFDEREF} \qquad \frac{}{\Gamma \vdash () \approx ()} \approx\text{-UNIT} \qquad \frac{}{\Gamma \vdash \textcolor{red}{i32} \approx \textcolor{red}{i32}} \approx\text{-INT} \\
\\
\frac{\Gamma \vdash x_1 : \langle t_1 \rangle^{m_1} \quad \Gamma \vdash x_2 : \langle t_2 \rangle^{m_2} \quad \Gamma \vdash t_1 \approx t_2}{\Gamma \vdash \& x_1 \approx \& x_2} \approx\text{-REF} \qquad \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} \qquad \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{LETMUT} \\
\\
\frac{\Gamma_1 \vdash e : t \dashv \Gamma_2}{\Gamma_1 \vdash e \dashv \Gamma_2} \text{EXPRSTMT} \qquad \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

$\ell ::= \ell_x$ (locations, \mathcal{L})
 $v ::= \textcolor{red}{()} \mid n \mid \ell$ (values, \mathbb{V})

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

$S \vdash w \rightsquigarrow \ell$ (place locations)
 $S \vdash e \Downarrow v \dashv S$ (expressions)
 $S \vdash s \dashv S$ (statements)
 $S \vdash p \Downarrow v \dashv S$ (programs)

$$\begin{array}{c}
 \frac{}{S \vdash x \rightsquigarrow \ell_x} \text{LOCVAR} \qquad \frac{S \vdash w \rightsquigarrow \ell_x \quad (\ell_x \mapsto \ell_y) \in S}{S \vdash * w \rightsquigarrow \ell_y} \text{LOCDEREF} \qquad \frac{}{S \vdash \textcolor{red}{()} \Downarrow \textcolor{red}{()} \dashv S} \text{UNIT} \\
 \\
 \frac{n \in \mathbb{Z}}{S \vdash n \Downarrow n \dashv S} \text{INT} \qquad \frac{S \vdash w \rightsquigarrow \ell_x \quad (\ell_x \mapsto v) \in S}{S \vdash w \Downarrow v \dashv S} \text{PLACE} \qquad \frac{S \vdash w \rightsquigarrow \ell_x}{S \vdash \& w \Downarrow \ell_x \dashv S} \text{REF} \\
 \\
 \frac{\ell_x \in \text{dom}(S) \quad S_1 \vdash e \Downarrow v \dashv S_2}{S_1 \vdash x = e \Downarrow \textcolor{red}{()} \dashv S_2[\ell_x \mapsto v]} \text{ASSIGN} \qquad \frac{S_1 \vdash e \Downarrow v \dashv S_2}{S_1 \vdash \textcolor{red}{let } x = e \dashv S_2[\ell_x \mapsto v]} \text{LET} \\
 \\
 \frac{S_1 \vdash e \Downarrow v \dashv S_2}{S_1 \vdash \textcolor{red}{let mut } x = e \dashv S_2[\ell_x \mapsto v]} \text{LETMUT} \qquad \frac{S_1 \vdash e \Downarrow v \dashv S_2}{S_1 \vdash e \dashv S_2} \text{EXPRSTMT} \\
 \\
 \frac{S_1 \vdash s \dashv S_2 \quad S_2 \vdash p \Downarrow v \dashv S_3}{S_1 \vdash s ; p \Downarrow v \dashv S_3} \text{PROG}
 \end{array}$$