

Normalized Core Language

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November 22, 2014

1 Introduction

2 Syntax

$v ::= ()$	$f ::= \lambda x.e$	$e ::= v$
$n \in \mathbb{N}$	$v v$	let $x = f$ in e
$b \in \mathbb{B}$	$\text{ref } v$	if v then e_1 else e_2
x	$!v$	
	$v := v$	

3 Transforming to NCL

4 An Abstract Machine

4.1 computation

Let $\kappa' = \langle \mathbf{frame} \Gamma, y, e', \kappa \rangle$.

- $\langle \Gamma, \sigma, (\lambda x.e), y, e', \kappa \rangle \mapsto \langle \sigma, \gamma(\Gamma, \sigma, \lambda x.e), \kappa' \rangle$
- $\langle \Gamma, \sigma, (v_1 v_2), y, e', \kappa \rangle \mapsto \langle \Gamma'', \sigma', e'', \kappa' \rangle$ where
 - $\langle \mathbf{cl} \Gamma', x', e'' \rangle = \gamma(\Gamma, \sigma, x)$
 - $l \notin \text{dom}(\sigma)$
 - $\Gamma'' = \Gamma'[x' \mapsto l]$
 - $\sigma' = \sigma[l \mapsto \gamma(\Gamma, \sigma, v)]$
- $\langle \Gamma, \sigma, (\text{ref } v), y, e', \kappa \rangle \mapsto \langle \sigma', \langle \mathbf{ref } l \rangle, \kappa' \rangle$, where
 - $l \notin \text{dom}(\sigma)$
 - $\sigma' = \sigma[l \mapsto \gamma(\Gamma, \sigma, v)]$
- $\langle \Gamma, \sigma, (!v), y, e', \kappa \rangle \mapsto \langle \sigma, \sigma(\gamma(\Gamma, \sigma, v)), \kappa' \rangle$
- $\langle \Gamma, \sigma, (v_1 := v_2), y, e', \kappa \rangle \mapsto \langle \sigma', \langle \mathbf{unit} \rangle, \kappa' \rangle$ where
 - $\langle \mathbf{ref } l \rangle = \gamma(\Gamma, \sigma, v_1)$ and $l \in \text{dom}(\sigma)$
 - $\sigma' = \sigma[l \mapsto \gamma(\Gamma, \sigma, v_2)]$

4.2 expressions

- $\langle \Gamma, \sigma, v, \kappa \rangle \mapsto \langle \sigma, \gamma(\Gamma, \sigma, v), \kappa \rangle$
- $\langle \Gamma, \sigma, (\text{let } x = f \text{ in } e), \kappa \rangle \mapsto \langle \Gamma, \sigma, f, x, e, \kappa \rangle$
- $\langle \Gamma, \sigma, (\text{if } v \text{ then } e_1 \text{ else } e_2), \kappa \rangle \mapsto \langle \Gamma, \sigma, e, \kappa \rangle$, where

$$e = \begin{cases} e_1, & \text{if } \gamma(\Gamma, \sigma, v) = \langle \mathbf{bool true} \rangle \\ e_2, & \text{if } \gamma(\Gamma, \sigma, v) = \langle \mathbf{bool false} \rangle \end{cases}$$

4.3 values

- $\langle \sigma, v, \langle \mathbf{frame} \Gamma, x, e, \kappa \rangle \rangle \mapsto \langle \Gamma', \sigma', e, \kappa \rangle$, where
 - $l \notin \text{dom}(\sigma)$
 - $\Gamma' = \Gamma[x \mapsto l]$
 - $\sigma' = \sigma[l \mapsto v]$

The function $\gamma(\Gamma, \sigma, v)$ is defined by

- $\gamma(\Gamma, \sigma, ()) = \langle \mathbf{unit} \rangle$
- $\gamma(\Gamma, \sigma, n) = \langle \mathbf{int } n \rangle$
- $\gamma(\Gamma, \sigma, b) = \langle \mathbf{bool } b \rangle$
- $\gamma(\Gamma, \sigma, x) = \sigma(\Gamma(x))$
- $\gamma(\Gamma, \sigma, \lambda x.e) = \langle \mathbf{cl } \Gamma, x, e \rangle$