

Side Effects

$f(1+2, 3+4)$

$f(1+2)(3+4)$

Side effect: behavior visible through some means other than argument passing, returned values, or similar data flow.

- variable/value mutation
- graphical rendering (I/O)
- exceptions

`void sortInPlace(int*)`

↑
side-effecting

`int* makeSorted(int*)`

↑
not
side-effecting

FbS ← state

$e ::= \dots \mid \text{Ref } c \mid e := e \mid !e$

$v ::= \dots \mid c$

$c ::= (\text{reference cells}) \quad \# \mathbb{N} \quad \langle S, e \rangle \Rightarrow \langle S, v \rangle$

$S ::= \{c \mapsto v, \dots\}$

$\langle S_0, e \rangle \Rightarrow \langle S_1, c \rangle \quad (c \mapsto v) \in S_1$

$\langle S_0, !e \rangle \Rightarrow \langle S_1, v \rangle$

$\langle S_0, e \rangle \Rightarrow \langle S_1, v \rangle \quad c \notin S_1 \quad S_2 = S_1 \{c \mapsto v\}$

$\langle S_0, \text{Ref } e \rangle \Rightarrow \langle S_2, c \rangle$

$\langle S_0, e_1 \rangle \Rightarrow \langle S_1, c \rangle \quad \langle S_1, e_2 \rangle \Rightarrow \langle S_2, v \rangle \quad S_3 = S_2 \{c \mapsto v\}$

$\langle S_0, e_1 := e_2 \rangle \Rightarrow \langle S_3, v \rangle$

$\langle S_0, e \rangle \Rightarrow \langle S_1, v' \rangle \quad v \text{ is bool neg of } v'$

$\langle S_0, \text{Not } e \rangle \Rightarrow \langle S_1, v \rangle$

$!(\text{Ref } 4) \Rightarrow 4$

$!(\text{Let } a = \text{Ref } 3 \text{ In } a) \Rightarrow 3$

$!(\text{Let } a = \text{Ref } 2 \text{ In } \text{Let } _ = a := 7 \text{ In } _ \Rightarrow 7$
 $a)$

$\text{Let } c = \text{Ref } 2 \text{ In } c \Rightarrow \left(\begin{smallmatrix} \text{Ref cell} \\ \text{containing} \\ 2 \end{smallmatrix} \right)$

$b = a = 0$