7-1

$M = X \mid \sigma \mid \lambda X.M \mid (\text{deref } M) \mid M\ N \mid (\text{set! } M\ N) \mid b \mid 0^n\ M \mid \ldots$

$E = * \mid E[X \to \sigma]$

$S = * \mid S[\sigma \to V]$

$V = clo(\lambda X.M, E) \mid \sigma \mid \ldots b$

$K = ret \mid fn(N, E, K) \mid ar(V, K) \mid deref(K) \mid set!(N, E, K) \mid set!(\sigma, K)$

$\langle X, E, S, K \rangle \longrightarrow \langle E(x), E, S, K \rangle$

$\langle \lambda X.M, E, S, K \rangle \longrightarrow \langle clo(\lambda X.M, E'), *E, S, K \rangle$ $\quad E' =$ the part of E referenced by M $fv(\lambda X.M)$

$\langle M\ N, E, S, K \rangle \longrightarrow \langle M, E, S, fn(N, E, K) \rangle$

$\langle V, E, S, fn(N, E', K) \rangle \longrightarrow \langle N, E', S, ar(V, K) \rangle$

$\langle V, E, S, ar(clo(\lambda X.M, E'), K) \rangle \longrightarrow \langle M, E'[X \to \sigma], S[\sigma \to V], K \rangle$

σ is fresh

$\langle deref\ M, E, S, K \rangle \Rightarrow \langle M, E, S, deref(K) \rangle$

$\langle \sigma, E, S, deref(K) \rangle \Rightarrow \langle S(\sigma), *E, S, K \rangle$

$\langle set!\ M\ N, E, S, K \rangle \Rightarrow \langle M, E, S, set!(N, E, K) \rangle$

$\langle \sigma, E, S, set!(N, E', K) \rangle \Rightarrow \langle N, E', S, set!(\sigma, K) \rangle$

$\langle V, E, S, set!(\sigma, K) \rangle \Rightarrow \langle V, *E, S[\sigma \to V], K \rangle$

$\langle (\lambda X.\,'X)\ 5, *, *, ret \rangle$

$\langle \lambda X.\,'X, *, *, fn(5, *, ret) \rangle$

$\langle clo(\lambda X.\,'X, *), *, *, fn(5, *, ret) \rangle$

$\langle 5, *, *, ar(clo(\lambda X.\,'X, *), ret) \rangle$

$\langle 'X, *[X \to 0x8], *[0x8 \to 5], ret \rangle$

X: $\langle 0x8, \ldots, ret^K \rangle$

'X: $\langle X, \ldots, deref(ret) \rangle$

$\langle 0x8, \ldots, deref(ret) \rangle$

$\langle 5, *[X \mapsto 0x8], *[0x8 \to 5], ret^K \rangle$

19-2

$\langle M, E, S, K \rangle$

$\rightarrow \langle M, E, S', K \rangle$

$S' = S$ but no junk $\qquad S = S' \cup S''$

S' = referenced stuff

RS_M (rootset) $\quad M \Rightarrow P(\sigma) \qquad RS_E : E \Rightarrow P(\sigma) \qquad RS_K$

$RS\ X = \emptyset \qquad RS\ * = \emptyset$

$RS\ \lambda X.M = RS\ M \qquad RS\ E[X \to \sigma] = RS\ E \cup \{\sigma\}$

$RS\ (M\ N) = RS\ M \cup RS\ N$

$RS\ (\sigma) = \{\sigma\} \qquad RS\ ret = \emptyset$

$RS\ (deref\ M) = RS\ M \qquad RS\ fn(N, E, K) = RS\ N \cup RS\ E \cup RS\ K$

$RS\ (set\ M\ N) = RS\ M \cup RS\ N \qquad RS\ ar(V, K) = RS\ V \cup RS\ K$

$RS\ b = \emptyset$

$RS\ (clo(\lambda X.M, E)) = RS(M) \cup RS(E)$

sort(bool) (*) (void* x, void* y, void* info)(mp), void* info, list<void*> 1)

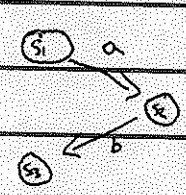
$\langle P(\sigma), P(\sigma), S \rangle$

$\langle \{\sigma_0, \sigma_1, \ldots, \sigma_n\}, \{\sigma'_1, \ldots, \sigma'_m\}, S[\sigma_0 \to V_0] \rangle \rightarrow \langle \{\sigma_1, \ldots, \sigma_n\} \cup RS(V_0) - \{\sigma'_1, \ldots, \sigma'_m\}, \{\sigma_0, \sigma'_1, \ldots, \sigma'_m\}, S[\sigma_0 \to V_0] \rangle$

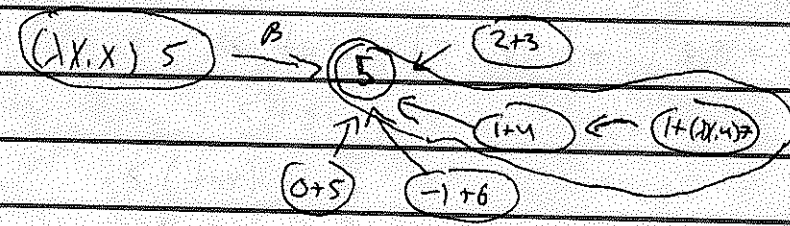
$S' \cup S''$

$\langle RS(M) \cup RS(E) \cup RS(K), \emptyset, S \rangle \longrightarrow^* \langle \emptyset, \{\sigma_0, \ldots, \sigma_n\}, S \rangle$

$= S'$ = referenced stuff



state machine



$(\lambda x.\ 1+x)$?