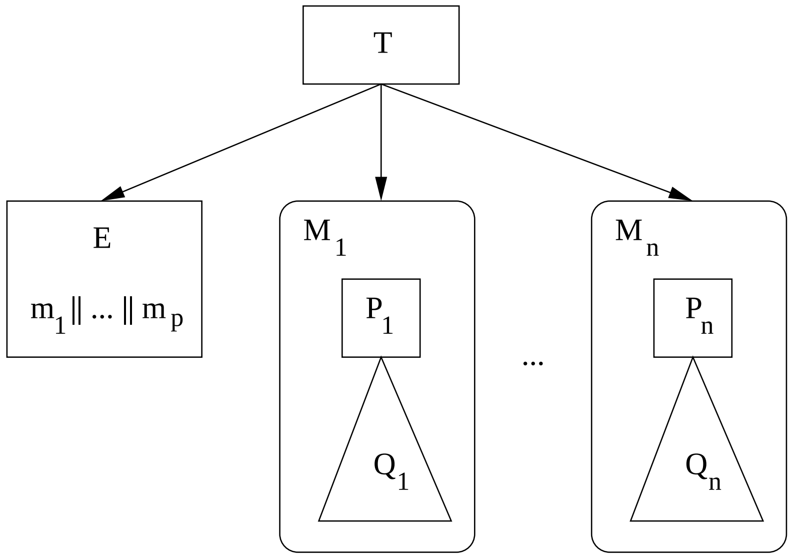
κ-VM : distributed extension

Towards a distributed virtual machine

- In the centralized VM :
  - ⋆ All agents execute inside the same process (VM) / physical machine
  - ⋆ All communication resources are centralized :
    - ◦ Name creation services (channel and location)
    - ◦ Look-up service
- In a distributed VM, these services must be distributed in different processes / physical machines

A simple distribution model

- Structure :
  - ⋆ Machines M_i
  - ⋆ Locations trees P_i, Q_i
  - ⋆ Global ether E
- Global system : $P_1[Q_1] \mid \cdots \mid P_n[Q_n]$



Machine State

$m \ldots$	$\in$	MName	Machine Name
$i \ldots$	$\in$	$\mathsf{IntNm} = \mathsf{MName} \times \mathit{Loc}\mathsf{IntNm}$	Internal Name
$l, \ldots$	$\in$	$\mathsf{LocName} = \mathsf{MName} \times \mathit{Loc}\mathsf{LocName}$	Location Name
$N, \ldots$	$\in$	$\mathsf{NS} = \mathit{Loc}\mathsf{LocName} \cup \mathit{Loc}\mathsf{IntNm}$	Name Creation Service
$t, \ldots$	$\in$	$\mathsf{TimeStamp}$	Timestamp
$O, \ldots$	$\in$	$\mathsf{LocalOracle} =$	Local Lookup Service
		$(\mathsf{IntNm} \mapsto (\mathsf{LocName} \times \mathsf{TimeStamp})) \cup$	
		$(\mathsf{LocName} \mapsto (\mathsf{MName} \times \mathsf{TimeStamp}))$	
$\langle \mathcal{D}, \mathcal{H}, \mathcal{R}, \mathcal{E}, \mathcal{L} \rangle$	$\in$	$\mathsf{Loc} = \mathsf{DefSpace} \times \mathsf{Heap} \times$	Location
		$\mathsf{RQueue} \times \mathsf{Ether} \times \mathsf{SubLoc}$	
$L, \ldots$	$\in$	$\mathsf{MLocs} = \mathsf{LocName} \mapsto \mathsf{Loc}$	Locations Inside a machine
$\mathbb{M}, \ldots$	$\in$	$\mathsf{MState} = \mathsf{MName} \times \mathsf{NS} \times$	State of the
		$\mathsf{LocalOracle} \times \mathsf{MLocs}$	Abstract Machine

Reduction rules

- Sequential, local communication, and domain rules are unchanged (almost)
- Only remote communication and mobility rules are modified.
  - ⋆ INTRUDE , EXTRUDE, and FILTER.OUT are unchanged.
  - ⋆ IN, OUT, and FILTER.IN become D-IN.LOC / D-IN.REM ; D-OUT.LOC / D-OUT.REM ; D-FILTER.IN.LOC / D-FILTER.IN.REM

Local Communication

D-IN.LOC

$$\frac{l' \in \mathcal{L}_0 \quad O(\rho(r)) = \left\langle l', t' \right\rangle \quad \rho(r) \notin \{\mathbf{i}, \mathbf{o}\}}{\begin{array}{c} m : N : O : L\{l_0 \mapsto \left\langle \mathcal{D}_0, \mathcal{H}_0, \mathcal{R}_0, l, \mathcal{L}_0 \right\rangle, l \mapsto \left\langle \mathcal{D}, \mathcal{H}, (\rho, r\widetilde{V}) :: \mathcal{R}, \sharp, \varnothing \right\rangle, l' \mapsto \left\langle \mathcal{D}', \mathcal{H}', \mathcal{R}', \mathcal{E}', \mathcal{L}' \right\rangle\} \longrightarrow \\ m : N : O : L\{l_0 \mapsto \left\langle \mathcal{D}_0, \mathcal{H}_0, \mathcal{R}_0, l, \mathcal{L}_0 \right\rangle, l \mapsto \left\langle \mathcal{D}, \mathcal{H}, \mathcal{R}, \sharp, \varnothing \right\rangle, l' \mapsto \left\langle \mathcal{D}', \mathcal{H}', \mathcal{R}' :: (\rho, r\widetilde{V}), \mathcal{E}', \mathcal{L}' \right\rangle\} \end{array}}$$

D-OUT.LOC

$$\frac{l \in \mathcal{L}_0 \quad O(\rho(r)) = \left\langle l'', t'' \right\rangle \quad l'' \neq l \quad l''.isDesc(l) = 0 \quad \rho(r) \notin \{\mathbf{i}, \mathbf{o}\}}{\begin{array}{c} m : N : O : L\{l_0 \mapsto \left\langle \mathcal{D}_0, \mathcal{H}_0, \mathcal{R}_0, l', \mathcal{L}_0 \right\rangle, l \mapsto \left\langle \mathcal{D}, \mathcal{H}, (\rho, r\widetilde{V}) :: \mathcal{R}, \mathcal{E}, \mathcal{L} \right\rangle, l' \mapsto \left\langle \mathcal{D}', \mathcal{H}', \mathcal{R}', \sharp, \varnothing \right\rangle\} \longrightarrow \\ m : N : O : L\{l_0 \mapsto \left\langle \mathcal{D}_0, \mathcal{H}_0, \mathcal{R}_0, l', \mathcal{L}_0 \right\rangle, l \mapsto \left\langle \mathcal{D}, \mathcal{H}, \mathcal{R}, \mathcal{E}, \mathcal{L} \right\rangle, l' \mapsto \left\langle \mathcal{D}', \mathcal{H}', \mathcal{R}' :: (\rho, r\widetilde{V}), \sharp, \varnothing \right\rangle\} \end{array}}$$

Remote Interaction

D-IN.LOC

$$\frac{l_\top \in \top.\mathcal{L} \quad O(\rho(r)) = \langle l_\top, t\rangle \qquad O' = merge(O, O_0) \quad \rho(r) \notin \{\mathbf{i}, \mathbf{o}\}}{\begin{array}{c} m : N : O : L\{l_\top \mapsto \langle \mathcal{D}, \mathcal{H}, \mathcal{R}, \mathcal{E}, \mathcal{L}\rangle\} \parallel E\{m` \to m \mapsto msg(r, \widetilde{V}, \rho, O_0) :: \mathcal{M}\} \longrightarrow \\ m : N : O' : L\{l_\top \mapsto \left\langle \mathcal{D}, \mathcal{H}, \mathcal{R} :: (\rho, r\widetilde{V}), \mathcal{E}, \mathcal{L}\right\rangle\} \parallel E\{m` \to m \mapsto \mathcal{M}\}\end{array}}$$

D-OUT.LOC

$$\frac{\begin{array}{c} l_\top \in \top.\mathcal{L} \quad O(\rho(r)) = \left\langle l'', t''\right\rangle \quad O(l'') = \left\langle m', t'\right\rangle \quad m' \neq m \quad \rho(r) \notin \{\mathbf{i}, \mathbf{o}\} \\ O' = O\{\forall l \in loc\_identifiers(\widetilde{V}), l \mapsto \left\langle m', t+1\right\rangle, \text{ avec } O(l) = \langle m, t\rangle\}\end{array}}{\begin{array}{c} m : N : O : L\{l_\top \mapsto \left\langle \mathcal{D}, \mathcal{H}, (\rho, r\widetilde{V}) :: \mathcal{R}, \mathcal{E}, \mathcal{L}\right\rangle\} \parallel E\{m \to m' \mapsto \mathcal{M}\} \longrightarrow \\ m : N : O' : L\{l_\top \mapsto \langle \mathcal{D}, \mathcal{H}, \mathcal{R}, \mathcal{E}, \mathcal{L}\rangle\} \parallel E\{m \to m' \mapsto \mathcal{M} :: msg(r, \widetilde{V}, \rho, O')\}\end{array}}$$

From the JAM :

$$merge(O_0, O_1) \quad \stackrel{def}{=} \quad \{\forall i \in \mathsf{dom}\, O_0 \cup \mathsf{dom}\, O_1, i \mapsto best(O_0(i), O_1(i))\}$$

$$best(\langle i_0, t_0\rangle, \langle i_1, t_1\rangle) \quad \stackrel{def}{=} \quad \left| \begin{array}{ll} \langle i_0, t_0\rangle & \text{si } t_0 \geq t_1 \\ \langle i_1, t_1\rangle & \text{si } t_0 \leq t_1 \end{array}\right.$$

Mobility (1)

D-PASS

$$\frac{l \in \mathcal{L}_0 \qquad \left\langle \mathsf{reify}_{\mathsf{control}}(\mathcal{D},\mathcal{H},\mathcal{R}), \mathsf{reify}_{\mathsf{content}}(l_e,\mathcal{L}), L' \right\rangle = extract(l,\mathcal{D},\mathcal{H},\mathcal{R},l_e,\mathcal{L},L)}{\begin{array}{c} m : N : O : L\{l_0 \mapsto \left\langle \mathcal{D}_0, \mathcal{H}_0, \mathcal{R}_0, l', \mathcal{L}_0 \right\rangle, l' \mapsto \left\langle \mathcal{D}', \mathcal{H}', \mathcal{R}', \sharp, \varnothing \right\rangle, \\ l \mapsto \langle \mathcal{D}, \mathcal{H}, (\rho, \mathsf{pass}\, V) :: \mathcal{R}, l_e, \mathcal{L} \rangle\} \longrightarrow m : N : O : L'\{l_0 \mapsto \left\langle \mathcal{D}_0, \mathcal{H}_0, \mathcal{R}_0, l', \mathcal{L}_0 \setminus \{l\} \right\rangle, \\ l' \mapsto \left\langle \mathcal{D}', \mathcal{H}', \mathcal{R}' :: (\rho, V \, \mathsf{reify}_{\mathsf{control}}(\mathcal{D},\mathcal{H},\mathcal{R}) \; \mathsf{reify}_{\mathsf{content}}(l_e,\mathcal{L})), \sharp, \varnothing \right\rangle\} \end{array}}$$

Mobility (2)

D-RCONTROL

$$\frac{\begin{array}{c}\langle \mathcal{D}', H', R' \rangle = insert_{flat}(\mathsf{reify}_{\mathsf{control}}(\mathcal{D}_m, \mathcal{H}_m, \mathcal{R}_m), \mathcal{D}, \mathcal{H}, \mathcal{R}) \\ O' = O\{\forall D \in \mathcal{D}_m \;\; \forall r \in \mathsf{dn}(D), \rho(r) \mapsto \langle l, 0 \rangle\}\end{array}}{\begin{array}{c}m : N : O : L\{l \mapsto \langle \mathcal{D}, \mathcal{H}, (\rho, \mathsf{reify}_{\mathsf{control}}(\mathcal{D}_m, \mathcal{H}_m, \mathcal{R}_m)\ ()) :: \mathcal{R}, \mathcal{E}, \mathcal{L} \rangle \longrightarrow \\ m : N : O' : L\{l \mapsto \langle \mathcal{D}', H', R', \mathcal{E}, \mathcal{L} \rangle\}\end{array}}$$

D-RCONTENT

$$\frac{\begin{array}{c}\langle \mathcal{D}', \mathcal{H}', \mathcal{R}', \mathcal{L}_0', L' \rangle = insert_{sublocs}(\mathsf{reify}_{\mathsf{content}}(l_e, \mathcal{L}), \mathcal{D}, \mathcal{H}, \mathcal{R}, \mathcal{L}_0, L) \\ O' = O\{\forall D \in l_e.\mathcal{D} \;\; \forall r \in \mathsf{dn}(D), \rho(r) \mapsto \langle l, 0 \rangle\} \\ O'' = O'\{\forall l_s \in \mathcal{L} \;\; \forall D \in l_s.\mathcal{D} \;\; \forall r \in \mathsf{dn}(D), \rho(r) \mapsto \langle l_s, 0 \rangle\}\end{array}}{\begin{array}{c}m : N : O : L\{l_0 \mapsto \langle \mathcal{D}_0, \mathcal{H}_0, \mathcal{R}_0, l, \mathcal{L}_0 \rangle, l \mapsto \langle \mathcal{D}, \mathcal{H}, (\rho, \mathsf{reify}_{\mathsf{content}}(l_e, \mathcal{L})\ ()) :: \mathcal{R}, \sharp, \varnothing \rangle\} \longrightarrow \\ m : N : O'' : L'\{l_0 \mapsto \langle \mathcal{D}_0, \mathcal{H}_0, \mathcal{R}_0, l, \mathcal{L}_0' \rangle, l \mapsto \langle \mathcal{D}', \mathcal{H}', \mathcal{R}', \sharp, \varnothing \rangle\}\end{array}}$$