Second Workshop on Process Algebra and Stochastically Timed Activities (PASTA secondi piatti)

A framework to compare the Mobile Ambient and the π-calculus behaviours

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⟩ *Context* ⟨

global interconnections
global networks (wireless wired)
local free access, firewall, cryptography...

⇓

the connection structure is notflat ⇒

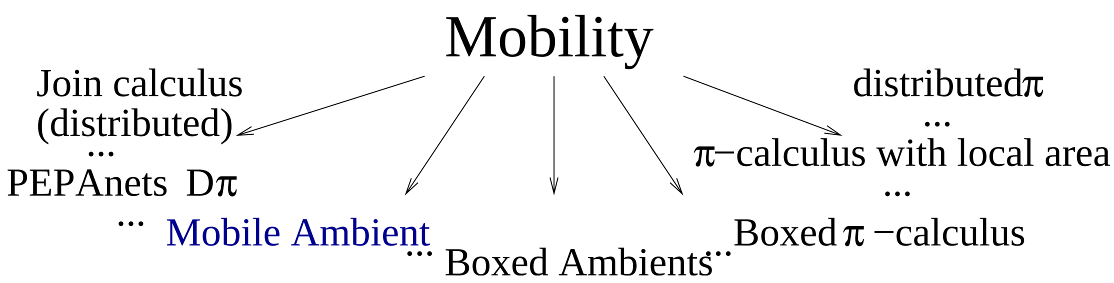
global applications
reachability, security
performance

⇓

communications
depends on locations

other features : location changes | distributed control | partial knowledge

$\rangle$ ***Motivations***$_{1/3}$ $\langle$



locations ambient-abstraction *limiting* shared resources

Encodings:

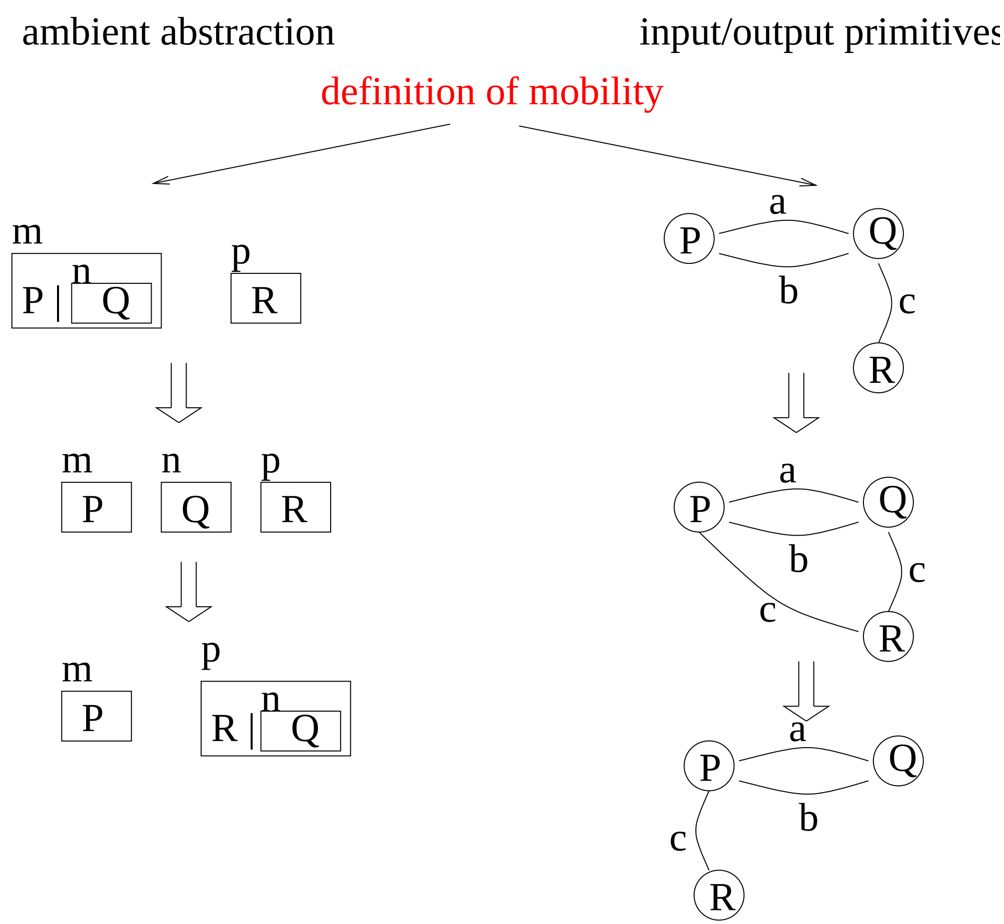
asyn. π-calculus $\rightarrow$ MA; MA $\rightarrow$Join Calculus; MA$\rightarrow$ SA;

...

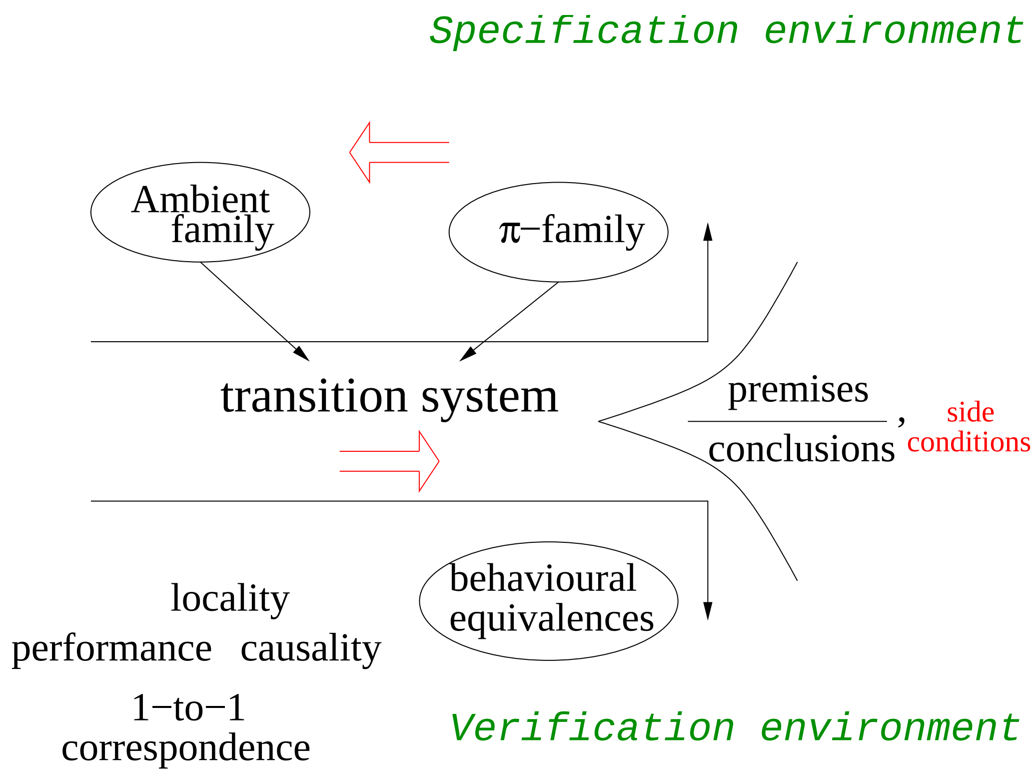
MA $\rightarrow$ π-calculus (?)

investigating expressivity capturing mobility

⟩ *Motivations*$_{2/3}$ ⟨



⟩ *Motivations*$_{3/3}$ ⟨



⟩ *Plan of the presentation* ⟨

background

the technique developed

the operational correctness

results

⟩ *Mobile Ambients* ⟨

		Capabilities			Processes
M	$:= x$	variable	P, Q, R	$:= \mathbf{0}$	inactivity
	$\mid n$	name		$\mid (\nu n)P$	restriction
	$\mid in\ M$	can enter into M		$\mid P\mid Q$	composition
	$\mid out\ M$	can exit out of M		$\mid !P$	replication
	$\mid open\ M$	can open M		$\mid M[P]$	ambient
	$\mid \epsilon$	null		$\mid M.P$	capability action
	$\mid M.M'$	path		$\mid (x).P$	input action
				$\mid \langle M \rangle$	async output action

keeping all processes in ν-form:

in m . ~~ε.0| (ν m)~~ m[P|R]   (ν n) in m.0| n[P | Q]

⟩ π-calculus ($HO\pi$) ⟨

a very limited form of higher order

$$\pi_s ::= \epsilon \mid \pi.\pi_s \qquad T ::= \mathbf{0} \mid \pi_s.T \mid T|T \mid (\nu x)T \mid !T \mid Y$$

$$\pi ::= x(Y) \mid \overline{x}\langle K \rangle$$

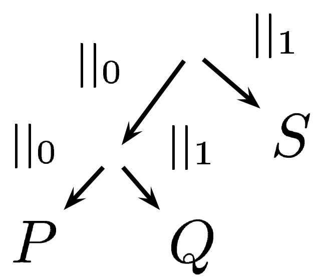
keeping all processes in ν-form:

~~a<x>.b(y)| (νa) a(x)~~.ε.0 (νc) (a<x>.b(y)| c (x).0)

..for convention: $\mathbf{0}_m = (\nu a)\overline{a}\langle m \rangle$

⟩ *EOS labels for π-calculus* ⟨

- Consider π-calculus processes where $|$ is no longer associative and commutative
- $T = (P \mid Q) \mid S$ has the following syntax tree:



- Call a sequence of $||_0$ and $||_1$ address, denoted by ϑ
- Transitions carry rich labels that include addresses

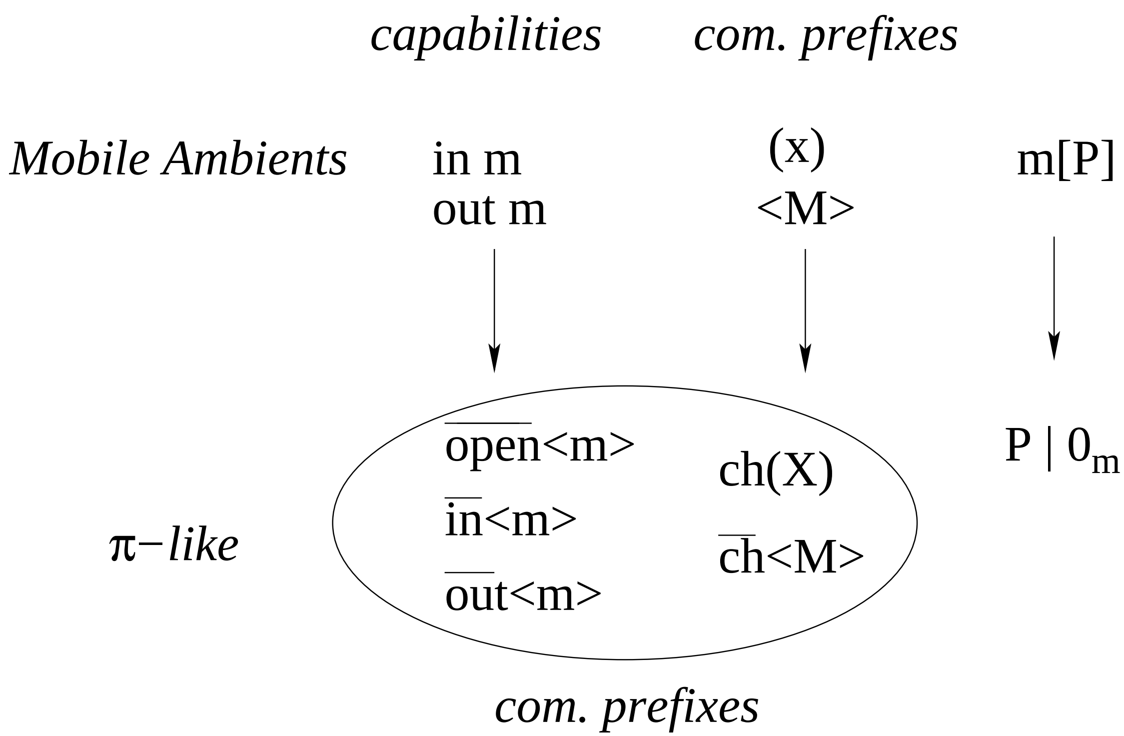
$\rangle$ *The two families* $\langle$

- Mobile Ambients - two kinds of actions: capabilities and communications; (ambient names, anonymous channels)
- π-calculus - only inputs and outputs (a unique set of names)

goal: reflecting the two kinds of actions into pure communication calculus

(there are some works which prove the expressiveness of capability actions)

⟩ The translation MA → π-calculus ⟨



$$\widehat{\mathcal{T}}(P) = (\nu\, I)(\mathcal{T}(P')|\widehat{T}),$$

where $P = (\nu\, I)P'$ and $\widehat{T} = !in(X)\,|\,!out(X)\,|\,!open(X)$

$\rangle$ *The semantics of Mobile Ambients* $\langle$

modifying semantics rules : $\text{Red}\equiv : \dfrac{P \equiv P',\, P' \Rightarrow Q',\, Q' \equiv Q}{P \rightarrow Q}$

imposing an ordering on congruences:

$$\dfrac{\mathbf{A_1},\ \mathbf{A_2},\ \mathbf{A_3},\ \mathbf{A_4},\ \mathbf{C_1},\ \dfrac{\dfrac{n[in\, m.P|\mathbf{0}] \mid m[R] \rightarrow m[n[P|\mathbf{0}] \mid R]}{n[in\, m.P|\mathbf{0}] \mid m[R] \mid P_0 \rightarrow m[n[P|\mathbf{0}] \mid R] \mid P_0}}{n[in\, m.P|\mathbf{0}] \mid m[R] \mid P_0 \mid Q_0 \rightarrow m[n[P|\mathbf{0}] \mid R] \mid P_0 \mid Q_0},\ \mathbf{C_2}}{P_0 \mid n[in\, m.P] \mid m[R] \mid Q_0 \rightarrow m[n[P] \mid R] \mid P_0 \mid Q_0}$$

The two operational semantics coincide

⟩ *The selector @perator on parse trees* ⟨

acts on the parallel strucuture of the terms:

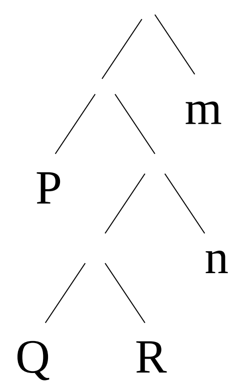
$\text{Proc} = \boxed{P \mid \boxed{Q \mid R}^{n}}^{m}$

$\text{Proc}\ @\|_0 = P \mid \boxed{Q \mid R}^{n}$

$\text{Proc}\ @\|_0\|_0 = P$

$\text{Proc}\ @\|_0\|_1 = \boxed{Q \mid R}^{n}$

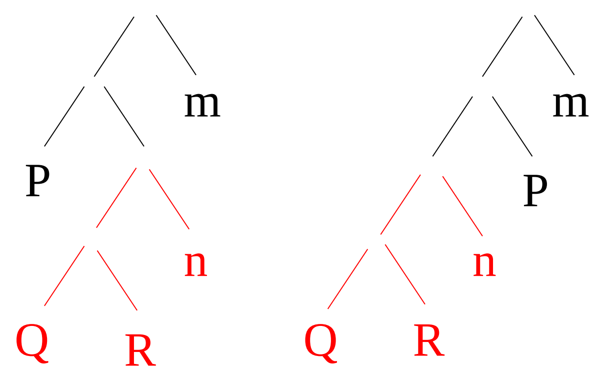
$\text{Proc}\ @\|_1 = m$



$\rangle$ ***notations*** $\langle$

where applying a congruence

$$Proc = m[P|n[Q|R]] \quad \equiv_{comm,||_0} \quad m[n[Q|R]|P]$$

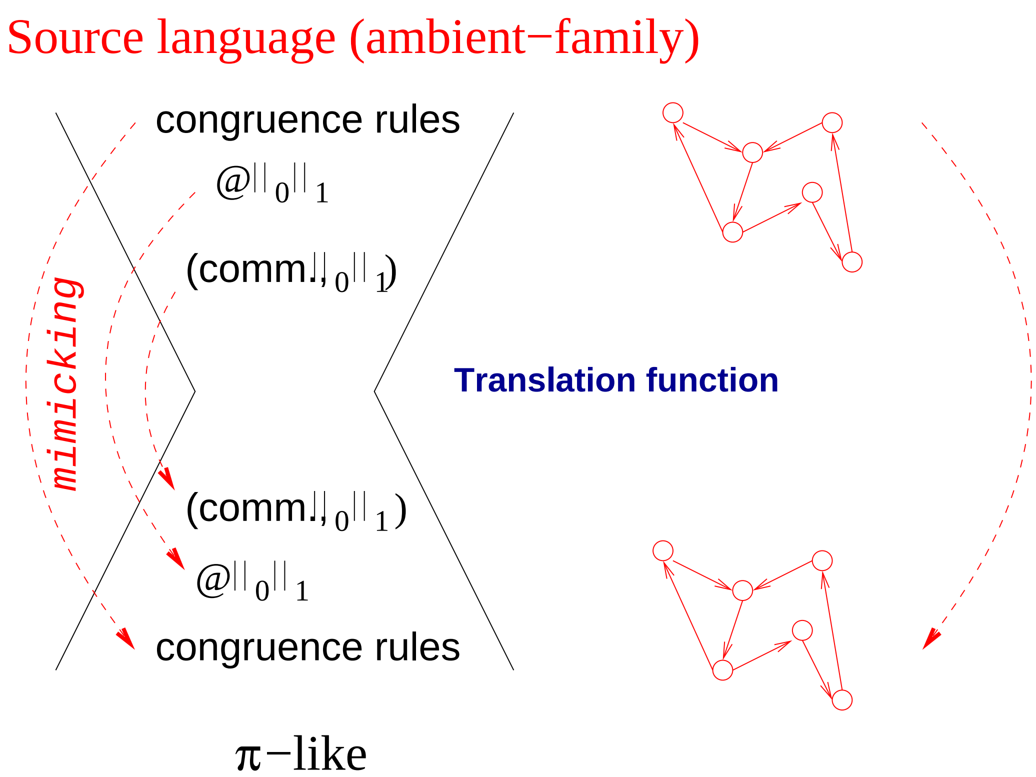


⟩ ***A semantics for the π-calculus*** ⟨

We want to:

- mimic the MA syntactic movements;
- fire an actions under *certain* conditions on the configuration of the terms;
- maintain an *operational* equivalence (MA $\leftrightarrow$ π-calculus);
- investigate the relation between the auxiliary semantics and the *classical* semantics for the π-calculus;

⟩ *The Framework* ⟨



⟩ *Our semantics rules for the π-calculus* ⟨

a standard derivation

HOπ semantic rules

$\longrightarrow_{p}$

$\longrightarrow_{p}$

$\longrightarrow_{p}$

.....

$\Longrightarrow_{\pi}$

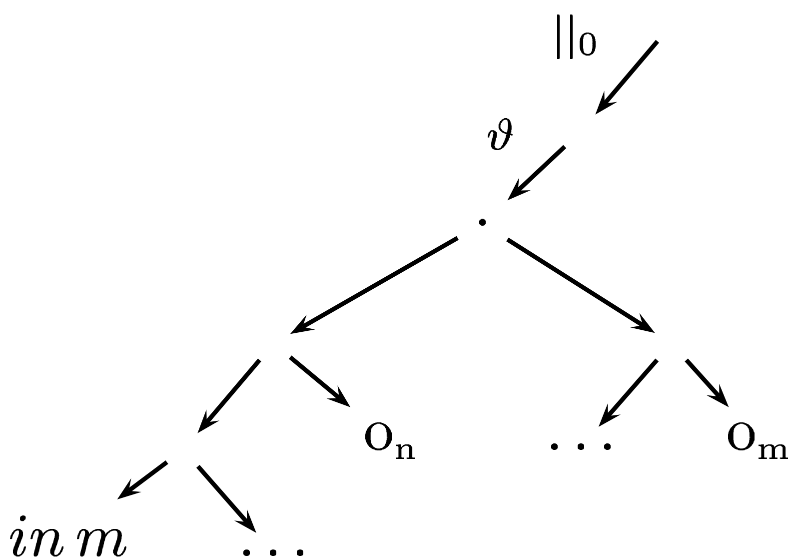
semantics for mimicking ambients

$\Longrightarrow_{\pi}$

No congruence are admitted, but ν-form

$\rangle$ *the rules for "ambients"(part I)* $\langle$

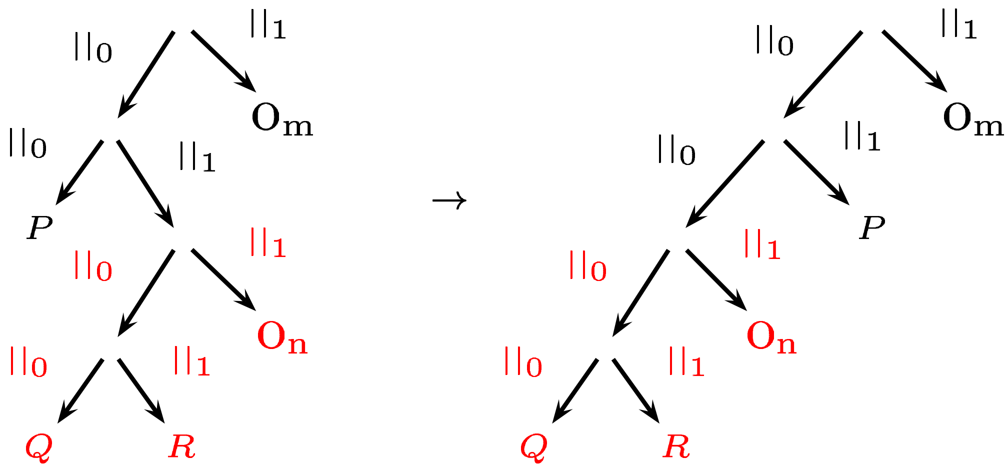
$$\frac{T \xrightarrow{\langle ||_0 \vartheta ||_0 ||_0 ||_0 \overline{in}\langle m \rangle, ||_1 ||_0 in(Y) \rangle}_p T'}{T \Rightarrow_\pi T''}, \text{ side conditions on the labels}$$



$$T@||_0\vartheta||_1||_1 = \mathbf{0}_m \ldots$$

〉 ***The "localized" replacements:*** $T\{||_0 \mapsto T'\}$ 〈

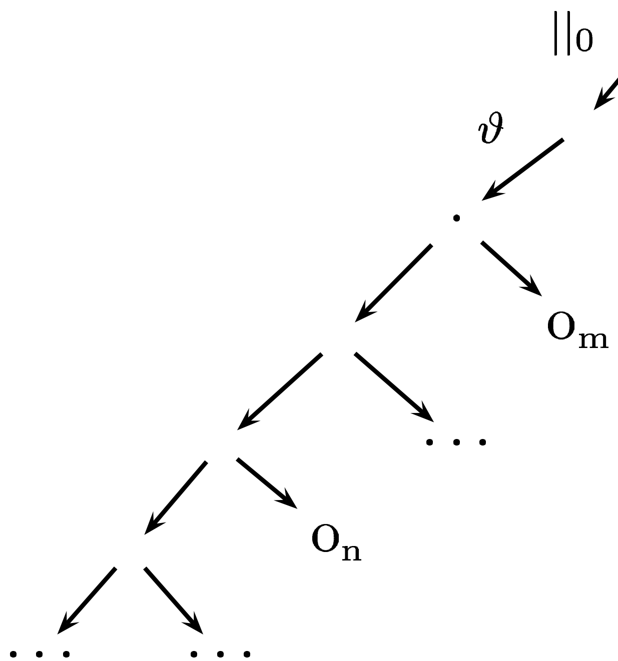
$T_0 = (P|((Q|R)|\mathbf{0}_n))|\mathbf{0}_m$ $\qquad$ $T_1 = (((Q|R)|\mathbf{0}_n)|P)|\mathbf{0}_m$



$$T_1 = T_0\{||_0||_1 \mapsto T_0@||_0||_0\}\{||_0||_0 \mapsto T_0@||_0||_1\}$$

〉 *the rules for "ambients"(part II)* 〈

$$\frac{T \xrightarrow{\langle ||_0 \vartheta ||_0 ||_0 ||_0 \overline{in}\langle m \rangle, ||_1 ||_0 in(Y) \rangle}_p T'}{T \Rightarrow_\pi T'' = (\nu\ I)T \Rightarrow_\pi (\nu\ I)T'\{||_0\vartheta \mapsto (V|W)|Z\}}, \text{ side...}$$



$$V = T'@||_0\vartheta||_0,$$

$$W = T'@||_0\vartheta||_1||_0,$$

$$Z = T'@||_0\vartheta||_1||_1$$

$\rangle$ *summarizing...* $\langle$

- an MA process P as a π-calculus processes T, through the translation function $\widehat{\mathcal{T}}()$
- an ambient $n[P]$ becomes $\mathcal{T}(P) \mid \mathbf{O}_n$, where $\mathbf{O}_n$ is $(\nu a)\overline{a}\langle n\rangle.\mathbf{O}$
- a capability becomes an output on distinguished channels.
(to be read by an auxiliary process on the form
$!in(Y) \; |!out(Y) \; |!open(Y))$
- (implicitly) the tree of ambients of P through the syntactic tree of the EOS π-calculus process $\mathcal{T}(P)$.
Transitions have the form $\mathcal{T}(P) \rightarrow \mathcal{T}(Q)$
(Alternative: explict representation, where a configuration is a pair $\langle \mathcal{T}(P), \mathrm{TREE}$, and TREE is a partial order of addresses)

CAVEAT: structural congruence may *alter* the tree of ambients!!

$\rangle$ ***The results:***$_1$ $\langle$

1 The translation preserves the selectors:
$\mathcal{T}(P@\vartheta) = \mathcal{T}(P)@\vartheta$

2 The translation preserves structural congruence:
$P \equiv_{\phi} Q$ iff $\mathcal{T}(P) \equiv_{\Phi} \mathcal{T}(Q)$
(ϕ is the list (congruence rule applied, MA sub-process affected), and Φ is the corresponding list on π-calculus processes)

3 On rigid transitions:
$P \Rightarrow_{MA} Q$ iff $\mathcal{T}(P) \Rightarrow_{\pi} \mathcal{T}(Q)$

$\rangle$ ***The results:***$_2$ $\langle$

4 On transitions tout court: the following diagram commutes

$$
\begin{array}{ccccccc}
P & \equiv_\phi & P' & \Rightarrow_{MA} & Q' & \equiv_{\phi'} & Q \\
\downarrow & & \downarrow & & \downarrow & & \downarrow \\
\mathcal{T}(P) & \equiv_\Phi & \mathcal{T}(P') & \Rightarrow_\pi & \mathcal{T}(Q') & \equiv_{\Phi'} & \mathcal{T}(Q)
\end{array}
$$

$$\rightarrow_\pi \; = \; \equiv_\Phi \Rightarrow_\pi \equiv_{\Phi'}$$

$\rangle$ ***The results:***$_3$ $\langle$

Theorem

Let $\equiv_M$ be the minimal congruence induced by the standard congruence of the HOπ, and by the rule

P-Par New $(\nu a)\overline{a}\langle m\rangle.\mathbf{0} \equiv_M \mathbf{0}$.

$T_0 \rightarrow_\pi T_1$ implies $T_0 \xrightarrow{\tau}_M T_1$.

Corollary

Let $T_0 = \widehat{\mathcal{T}}(P_0), T_1 = \widehat{\mathcal{T}}(P_1)$ then

$T_0 \rightarrow_\pi T_1$ implies $T_0 \xrightarrow{\tau}_M T_1$.

$\rangle$ ***The results:***$_4$ $\langle$

Therefore, the transition system of the MA is a fragment of the transition system of the π-calculus

(actually one has to get rid of $(\nu a)\overline{a}\langle n\rangle.\mathbf{O}$ which does nothing: add a congruence rule).

The same construction can be applied to other calculi, e.g. variants of MA:

- first define a translation into π,
- then filter the wanted transitions

The basic ingredient: EOS

⟩ ***Acknowledgments*** ⟨

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