Translation and *Mobility*

joint work with

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Plan of the talk

PEPA nets & Stochastic π-calculus

C.T.M.C as a property

The translation

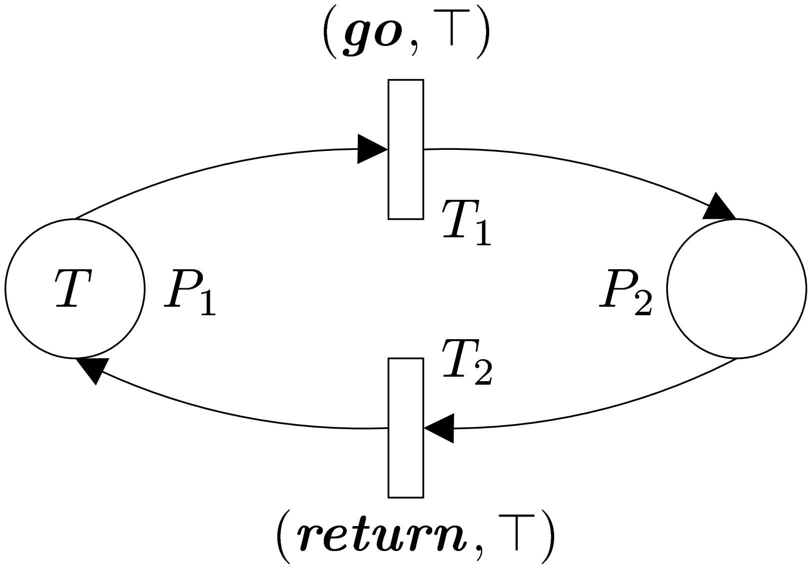
Examples

Conclusions

PEPA nets

PEPA $\qquad \mathrm{P} \underset{\{n,m\}}{\bowtie} \mathrm{Q} \underset{\{c,t\}}{\bowtie} \mathrm{R}$

PEPA nets



PEPA nets

$$\mathit{Cell}: \frac{P' \xrightarrow{(\alpha,\, r)} P''}{P[P'] \xrightarrow{(\alpha,\, r)} P[P'']} \; (P =_a P') \qquad \textit{cell transition}$$

$$\mathit{Tra}: \frac{P_i \xrightarrow{(\alpha,\, r)} P_i' \qquad P_i \overset{(\alpha,\, r')}{\not\longrightarrow\!\Box\!\longrightarrow} P_j}{(\ldots, P_i, \ldots) \xrightarrow{(\alpha,\, r)} (\ldots, P_i', \ldots)} \qquad \textit{local transition}$$

$$\mathit{Fire}: \frac{Q \xrightarrow{(\alpha,\, r_1)} Q' \qquad P_i \overset{(\alpha,\, r_2)}{\longrightarrow\!\Box\!\longrightarrow} P_j}{(P_i[Q], \ldots, P_j[\_]) \xrightarrow{(\alpha, R)} (P_i[\_], \ldots, P_j[Q'])} \; (R = {}^{Q}_{r_1}\langle\alpha\rangle^{P_i}_{r_2}) \qquad \textit{mobility}$$

Stochastic π-calculus

π-calculus

$+$

$$\text{rates} = \frac{r_1}{r_{\overline{x}}(P)} \times \frac{r_2}{r_{\overline{x}}(Q)} \times min(r_{\overline{x}}(P), r_{\overline{x}}(Q))$$

$+$

Enhanced Operational Semantics (?)

Stochastic π-calculus

$$Com_1 : \frac{Q \xrightarrow{\vartheta_0(\overline{x}z, r_1)} Q' \quad P \xrightarrow{\vartheta_1(x(y), r_2)} P'}{Q|P \xrightarrow{(\langle \|_0 \vartheta_0(\overline{x}z, r_1), \|_1 \vartheta_1(x(y), r_2) \rangle, R)} Q'|P'\{z/y\}}$$

the label is not τ

Translation

$$\text{PEPA nets} \quad \cong \quad \text{Stochastic-}\pi\text{-calculus}$$

$$\searrow \qquad\qquad\qquad \swarrow$$

$$\text{C. T. M. C.}$$

$$\text{our} \underset{\not\longleftarrow}{\longrightarrow} \text{work}$$

Some restrictions

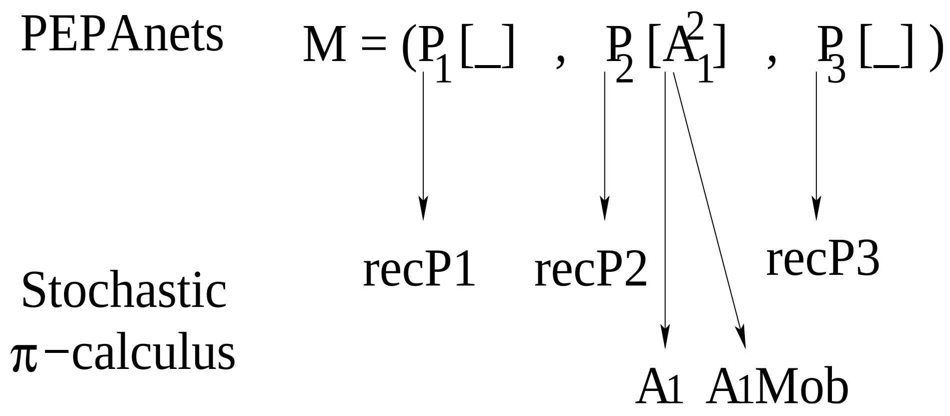
in a PEPA nets $\rightsquigarrow$ also each token

each place is different should be different

$$\begin{tikzcd} & (P_1[A, A],P_2[\_,\_]) \arrow[dl] \arrow[dr] & \\ (P_1[\_, A],P_2[A,\_]) & & (P_1[\_, A],P_2[\_,A]) \end{tikzcd}$$

Also: r, $\top$ to force binary comunications

First tempt...



A1Mob *drives* the token A1 along the *network* sending local names $\rightsquigarrow$ *Warning: two tokens can't comunicate*

(ν operator isn't dynamic)

Example 1

token A1 $\ldots(\boldsymbol{go}(\tilde{x}),\mathrm{r})\ldots$

'driver' A1Mob $\ldots(\overline{\boldsymbol{go}}\langle\text{names of place 2}\rangle,1)\ldots$

$$(P_1[A],P_2[\_]) \xrightarrow{(\mathbf{go},r)} (P_1[\_\ ],P_2\ [A\ ])$$

Adopted technique: working with names

Different names for different localities	*name@12* (place 1 token 2) *name@123* (place 1 tokens 2 and 3)

not for firing names

Example 2: PEPA nets

$$Token \stackrel{def}{=} (on, r_1).(\boldsymbol{go}, r_2).(on, r_3).(\boldsymbol{return}, r_4).$$

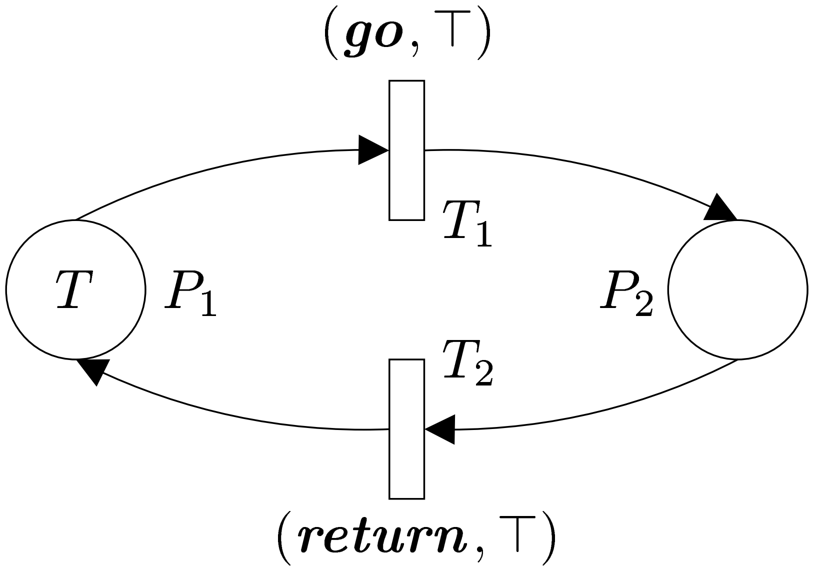
$$(\mathit{off}, r_5).(\boldsymbol{go}, r_6).(\mathit{off}, r_7).(\boldsymbol{return}, r_8).Token$$

$$Switch \stackrel{def}{=} (on, \top).(\mathit{off}, \top).Switch$$

$$P_1[t] \stackrel{def}{=} Switch \underset{\{on, \mathit{off}\}}{\bowtie} Token[t] \;\; P_2[t] \stackrel{def}{=} Switch \underset{\{on, \mathit{off}\}}{\bowtie} Token[t]$$

$$System \stackrel{def}{=} (P_1[Token], P_2[\_])$$

Example 2: pictorially



Example 2: Markov Chains

$$
\begin{tikzcd}
(\bullet^{+}, \bullet) \arrow[r, "r_1"] & (\circ^{+}, \bullet) \arrow[r, "r_2"] & (\circ, \bullet^{+}) \arrow[r, "r_3"] & (\circ, \circ^{+}) \arrow[d, "r_4"] \\
(\bullet, \bullet^{+}) \arrow[u, "r_8"] & (\bullet, \circ^{+}) \arrow[l, "r_7"'] & (\bullet^{+}, \circ) \arrow[l, "r_6"'] & (\circ^{+}, \circ) \arrow[l, "r_5"']
\end{tikzcd}
$$

Example 2: Stochastic π-calculus

$$
\begin{array}{l}
(\nu \quad on@11, \mathit{off}@11, on@21, \mathit{off}@21) \\
\quad ((\nu\ \boldsymbol{go}, \boldsymbol{return}) \\
\qquad (\mathbf{rec}\ \mathit{TokenMob}\ .(\overline{\boldsymbol{go}}, 1).(\overline{\boldsymbol{return}}, 1).\ldots. \qquad \mathit{TokenMob} \\
\qquad | \\
\qquad \mathbf{rec}\ \mathit{Token}\ .(\overline{on@11}, r_1).(\boldsymbol{go}, r_2)\ldots(\boldsymbol{return}, r_8).\mathit{Token} \\
\qquad) \\
\quad |\ \mathbf{rec}\ P1.\ \mathbf{rec}\ \mathit{Switch}.(on@11, 1).(\mathit{off}@11, 1).\mathit{Switch} \\
\quad |\ \mathbf{rec}\ P2.\ \mathbf{rec}\ \mathit{Switch}.(on@21, 1).(\mathit{off}@21, 1).\mathit{Switch})
\end{array}
$$

Compositional Encoding Function

PEPA nets $\langle S, T, F(D, M) \rangle$

S	places
T	firing names
F	$S \times (T \times \mathbb{R})$

$$\mathcal{E}_\sigma[|M|] = P_\pi \qquad \sigma = \langle S, T, F, D \rangle$$

$$\mathcal{E}_\sigma[\![(P_1[A_1^1 \ldots, A_m^1], \ldots, P_N[A_{m+n}^N, \ldots, A_M^N])]\!] =$$

$$(\nu\ names)\ ((\Pi_{i=1}^{N}\ P_{\pi i})\ \mid\ \Pi_{j=1}^{M}\ (\nu\ names_j)(M_{\pi j}\ \mid\ T_{\pi j}))$$

As the function looks like

$$\mathcal{E}S^i_\sigma[\![I[C]]\!] \quad = \quad \mathbf{0}$$

(place)

$$\mathcal{E}T^{(i,j)}_\sigma[\![S_1 + S_2]\!] \quad = \quad \mathcal{E}T^{(i,j)}_\sigma[\![S_1]\!] + \mathcal{E}T^{(i,j)}_\sigma[\![S_2]\!]$$

(token)

$$\mathcal{E}M^i_\sigma[\![(\alpha, r).S]\!] \quad = \quad \begin{cases} \sum_{h=1}^{H}(\overline{\alpha}\ , 1).\mathcal{E}M^{z_h}_\sigma[\![S]\!] & \\ + & \text{if } \alpha \in T \\ \sum_{k=1}^{K}(\overline{\alpha}\ , \lambda_k).\mathcal{E}M^{z_k}_\sigma[\![S]\!] & \\ \mathcal{E}M^i_\sigma[\![S]\!] & \text{o.w.} \end{cases}$$

(driver)

Equivalence

Given $P_n = \langle S, T, F, (D, M)\rangle$ and P_π, P_n is equivalent to P_π, $(P_n \sim P_\pi)$, iff

if $P_n \xrightarrow{(\alpha,r)} P'_n$ $\exists\theta$ s.t. $P_\pi \xrightarrow{\theta} P'_\pi$ with $\ell(\theta) = (\alpha, r)$ and $P'_n \sim P'_\pi$

and

if $P_\pi \xrightarrow{\theta} P'_\pi$ $\exists\alpha, r$ s.t. $P_n \xrightarrow{(\alpha,r)} P'_n$ with $\ell(\theta) = (\alpha, r)$ and $P'_n \sim P'_\pi$

Theorem

Given a PEPA nets process $P_n = \langle S, T, F, (D, M) \rangle$, then the following relation holds:

$$P_n \sim \mathcal{E}_\sigma[\![P_n]\!].$$

Conclusions

- no encoding of multisyncronizations
- encoding locality with names
- no need of *channel passing*
- same performance model (c.t.m.c.)

Future works

The differences between the two models
which implications can have on performance
predictions?

Acknowledgements

This work has been supported by the DEGAS (Design Environments for Global ApplicationS) project IST-2001-32072 funded by the FET Proactive Initiative on Global Computing.