Concurrency Semantics
Week 8

Course Notes 2005
EPFL – I&C

Uwe Nestmann
Johannes Borgström

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7.1 Notation (Polyadism) We use the following sets of entities with corresponding meta-variables:

$\mathcal{N}$	*names*	$a, b, c \ldots, x, y, z$
$\mathcal{A}$	*actions*	$\pi \; ::= \; \tau \;\big|\; x(\vec{y}) \;\big|\; \overline{x}\langle\vec{y}\rangle$
$\mathcal{L}$	*labels*	$\pi \; ::= \; \tau \;\big|\; x(\vec{y}) \;\big|\; (\boldsymbol{\nu}\vec{z})\,\overline{x}\langle\vec{y}\rangle$

where in *bound output* $(\boldsymbol{\nu}\vec{z})\,\overline{x}\langle\vec{y}\rangle$, we require $\tilde{z} \subseteq \tilde{y}$. We write $\overline{x}\langle\vec{y}\rangle$ for $(\boldsymbol{\nu}\vec{z})\,\overline{x}\langle\vec{y}\rangle$ when $\vec{z}$ is empty.

7.2 Definition (Operational Semantics)
The LTS $(\mathcal{P}^\pi, \mathcal{T})$ of sequential process expressions over $\mathcal{A}$ has $\mathcal{P}^\pi$ as states, and its transitions $\mathcal{T}$ are precisely generated by the following rules:

$$\text{(TAU)}\; \tau.P \xrightarrow{\tau} P \qquad\qquad \text{(OUT)}\; \overline{a}\langle\vec{b}\rangle.P \xrightarrow{\overline{a}\langle\vec{b}\rangle} P$$

$$\text{(INP)}\; \frac{\vec{b} \subseteq \mathcal{N}}{a(\vec{x}).P \xrightarrow{a\vec{b}} \{^{\vec{b}}\!/_{\vec{x}}\}P} \text{ if } |\vec{b}| = |\vec{x}|$$

$$\text{(RES)}\; \frac{P \xrightarrow{\mu} P'}{(\boldsymbol{\nu}c)\,P \xrightarrow{\mu} (\boldsymbol{\nu}c)\,P'} \text{ if } c \notin \mathrm{n}(\mu)$$

$$\text{(OPEN)}\; \frac{P \xrightarrow{(\boldsymbol{\nu}\vec{b})\,\overline{a}\langle\vec{z}\rangle} P'}{(\boldsymbol{\nu}c)\,P \xrightarrow{(\boldsymbol{\nu}c\vec{b})\,\overline{a}\langle\vec{z}\rangle} P'} \text{ if } \vec{z} \ni c \notin \{a, \vec{b}\}$$

$$\text{(PAR}_1\text{)}\; \frac{P_1 \xrightarrow{\mu} P_1'}{P_1 \,|\, P_2 \xrightarrow{\mu} P_1' \,|\, P_2} \text{ if } \mathrm{bn}(\mu) \cap \mathrm{fn}(P_2) = \emptyset$$

$$\text{(CLOSE)}\; \frac{P_1 \xrightarrow{a\vec{b}} P_1' \qquad P_2 \xrightarrow{(\boldsymbol{\nu}\vec{c})\,\overline{a}\langle\vec{b}\rangle} P_2'}{P_1 \,|\, P_2 \xrightarrow{\tau} (\boldsymbol{\nu}\vec{c})\,(P_1' \,|\, P_2')} \text{ if } \{\vec{c}\} \cap \mathrm{fn}(P_1) = \emptyset$$

$$\text{(SUM}_1\text{)}\; \frac{P_1 \xrightarrow{\mu} P_1'}{P_1 + P_2 \xrightarrow{\mu} P_1'}$$

$$\text{(REP)}\; \frac{P \,|\, !\,P \xrightarrow{\mu} P'}{!\,P \xrightarrow{\mu} P'}$$

$$\text{(ALP)}\; \frac{Q \xrightarrow{\mu} Q'}{P \xrightarrow{\mu} Q'} \text{ if } P =_\alpha Q$$

7.3 Definition (Asynchrony)
The *asynchronous* π-calculus is the subset of the standard (then called *synchronous*) π-calculus given by:

1. constraining sending to the form $\overline{y}\langle\tilde{z}\rangle$ (without any suffix);

2. removing the summation operator

The syntax of $\mathcal{P}^{\mathrm{A}}$ is generated by the BNF-grammar:

$$P \quad ::= \quad \mathbf{0} \;\big|\; \overline{y}\langle\tilde{z}\rangle \;\big|\; y(\tilde{x}).P \;\big|\; P|P \;\big|\; (\boldsymbol{\nu} a)\, P \;\big|\; \mathbf{!}\, P$$

where terms of the form $\overline{y}\langle\tilde{z}\rangle$ are called *messages*.