Australian National University

COMP3610/6361
Principles of Programming Languages

Peter Höfner

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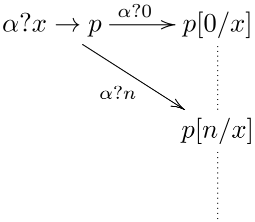
Section 1

Pure CCS

Towards a more basic language

aim: removal of variables to reveal symmetry of input and output

- transitions for value-passing carry labels τ, $a?n$, $a!n$



- this suggests introducing *prefix* $\alpha?n.p$ (as well as $\alpha!n.p$) and view $\alpha?x \to p$ as a *(infinite) sum* $\sum_n \alpha?n.p[n/x]$
- view $\alpha?n$ and $\alpha!n$ as *complementary* actions
- synchronisation can only occur on complementary actions

Pure CCS

- Actions: a, b, c, ...
- Complementary actions: $\bar{a}$, $\bar{b}$, $\bar{c}$,...
- Internal action: τ
- Notational convention: $\bar{\bar{a}} = a$
- Processes:

p ::= $\lambda.p$	prefix	λ ranges over $\tau, a, \bar{a}$ for any action
$\mid\ \sum_{i \in I} p_i$	sum	I is an index set
$\mid\ p_0 \parallel p_1$	parallel	
$\mid\ p \backslash L$	restriction	L a set of actions
$\mid\ p[f]$	relabelling	f a relabelling function on actions
$\mid\ P$		process identifier

- Process definitions:

$$P \overset{\text{def}}{=} p$$

Pure CCS – Semantics

Guarded processes (prefixing)

$$\lambda.p \xrightarrow{\lambda} p$$

Sum

$$\frac{p_j \xrightarrow{\lambda} p'}{\sum_{i \in I} p_i \xrightarrow{\lambda} p'} \quad j \in I$$

Parallel composition

$$\frac{p_0 \xrightarrow{\lambda} p_0'}{p_0 \parallel p_1 \xrightarrow{\lambda} p_0' \parallel p_1} \qquad \frac{p_1 \xrightarrow{\lambda} p_1'}{p_0 \parallel p_1 \xrightarrow{\lambda} p_0 \parallel p_1'}$$

$$\frac{p_0 \xrightarrow{a} p_0' \qquad p_1 \xrightarrow{\bar{a}} p_1'}{p_0 \parallel p_1 \xrightarrow{\tau} p_0' \parallel p_1'}$$

Pure CCS – Semantics

Restriction

$$\frac{p \xrightarrow{\lambda} p'}{p \backslash L \xrightarrow{\lambda} p' \backslash L} \; \lambda \notin L \cup \overline{L}$$

where $\overline{L} = \{\bar{a} \mid a \in L\}$

Relabelling

$$\frac{p \xrightarrow{\lambda} p'}{p[f] \xrightarrow{\lambda} p'[f]}$$

where f is a function such that $f(\tau) = \tau$ and $f(\bar{a}) = \overline{f(a)}$

Identifiers

$$\frac{p \xrightarrow{\lambda} p'}{P \xrightarrow{\lambda} p'} \; P \stackrel{\text{def}}{=} p$$

From Value-passing to Pure CCS

translation from a value-passing CCS *closed* term p to a pure CCS term $\widehat{p}$

p	$\widehat{p}$	
nil	**nil**	
$(\tau \to p)$	$\tau.\widehat{p}$	
$(\alpha!a \to p)$	$\overline{\alpha m}.\widehat{p}$	where a evaluates to m
$(\alpha?x \to p)$	$\sum_{m \in \text{int}} \alpha m.\widehat{p[m/x]}$	
$(b \to p)$	$\widehat{p}$ **nil**	if b evaluates to true if b evaluates to false
$p_0 + p_1$	$\widehat{p}_0 + \widehat{p}_1$	
$p_0 \parallel p_1$	$\widehat{p}_0 \parallel \widehat{p}_1$	
$p \backslash L$	$\widehat{p} \backslash \{\alpha m \mid \alpha \in L \wedge m \in \text{int}\}$	
$P(a_1, \ldots, a_k)$	$P_{m_1,\ldots,m_k}$	where a_i evaluates to m_i

For every definition $P(x_1, \ldots, x_k)$ we have a collection of definitions $P_{m_1,\ldots,m_k}$ indexed by $m_1,\ldots,m_k \in$ int

Correspondence

Theorem

$$p \xrightarrow{\lambda} p' \quad \textit{iff} \quad \widehat{p} \xrightarrow{\widehat{\lambda}} \widehat{p'}$$