# 並行分散計算特論 (6)

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## Semantics by reaction

Distinguish wheather a reaction is possible or not

Computation

$$P|T \to P_1|T_1 \to \cdots \to P_n|T_n \to \cdots$$

$P = Q$ if $P$ and $Q$ cannot be distinguished by any computation

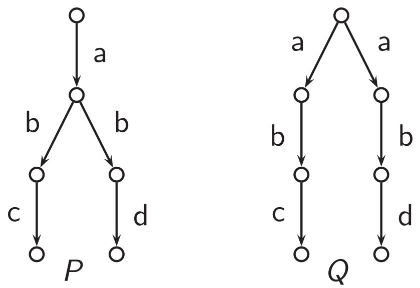
CSP :
Stable Failure Semantics (Brooks et.al. 1984)

CCS :
Testing Semantics (DeNicola, Hennessy, 1988)

Poperly weaker than bisimulation equivalence



## Bisimulation/Reaction




$P = Q$ or $P \neq Q$



## Raction and labelled transtion

Reaction:transition with no label
A step of computation = a reaction

computation by communications

Labelled transtion: labels as observation

A step of computation
= a pair of transitions with complementary labels

When $P \xrightarrow{a} P'$ and $Q \xrightarrow{\overline{a}} Q'$, $P|Q \to P'|Q'$

How do we observe computation?

## Labelled transitions

Labelled Transition: $P \xrightarrow{\alpha} P'$

$$\alpha \in Act = \{a, \overline{a} \mid a \in N\} \cup \{\tau\}$$

$N$ : Set of names

$\{a, \overline{a} | a \in N\}$ : Observable actions

$\tau$ : label for communication

$P$ communicates (with the environment) and becomes $P'$



## LTS for Concurrent Processes

$$\mathrm{SUM}_t : M + \alpha.P + N \xrightarrow{\alpha} P \qquad \mathrm{REACT}_t : \frac{P \xrightarrow{\lambda} P', \ Q \xrightarrow{\overline{\lambda}} Q'}{P|Q \xrightarrow{\tau} P'|Q'}$$

$$\mathrm{L-PAR}_t : \frac{P \xrightarrow{\alpha} P'}{P|Q \xrightarrow{\alpha} P'|Q} \qquad \mathrm{R-PAR}_t : \frac{Q \xrightarrow{\alpha} Q'}{P|Q \xrightarrow{\alpha} P|Q'}$$

$$\mathrm{RES}_t : \frac{P \xrightarrow{\alpha} P'}{\mathrm{new}\ a\ P \xrightarrow{\alpha} \mathrm{new}\ a\ P'} \text{ if } \alpha \notin \{a, \overline{a}\}$$

$$\mathrm{IDENT}_t : \frac{\{\vec{b}/\vec{a}\}P_A \xrightarrow{\alpha} P'}{A\langle\vec{b}\rangle \xrightarrow{\alpha} P'} \text{ if } A(\vec{a}) \stackrel{\mathrm{def}}{=} P_A$$



## Inference of Transition

$$\dfrac{\dfrac{\dfrac{}{\overline{b}.A \xrightarrow{\overline{b}} A}\ \mathrm{SUM}_t}{A' \xrightarrow{\overline{b}} A}\ \mathrm{IDENT}_t \qquad \dfrac{\dfrac{}{b.B' \xrightarrow{b} B'}\ \mathrm{SUM}_t}{B \xrightarrow{b} B'}\ \mathrm{IDENT}_t}{\dfrac{A'|B \xrightarrow{\tau} A|B'}{\mathrm{new}\ b(A'|B) \xrightarrow{\tau} \mathrm{new}\ b(A|B')}\ \mathrm{RES}_t}\ \mathrm{REACT}_t$$



## Compatibility of $\equiv$

**Proposition**

*If $P \xrightarrow{\alpha} P'$ and $P \equiv Q$, then there exists $Q'$ such that $Q \xrightarrow{\alpha} Q'$ and $P' \equiv Q'$*

*If $Q \xrightarrow{\alpha} Q'$ and $P \equiv Q$, then there exists $P'$ such that $P \xrightarrow{\alpha} P'$ and $P' \equiv Q'$*

$\equiv$ is a strong bisimulation

# Reaction and $\tau$-transition

$\xrightarrow{\tau}$ is very similar to $\rightarrow$

**Theorem**

$P \xrightarrow{\tau} \circ \equiv P'$ *if and only if* $P \rightarrow P'$



# Properties of transitions

**Proposition**

*(1) Finite branching*
*Given $P$, there are only finitely many transtions from $P$.*

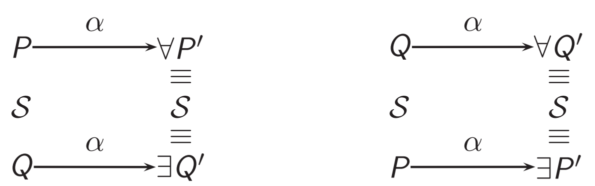
*(2) No free name produced by transitions*
*If $P \xrightarrow{\alpha} P'$, then* $\mathrm{fn}(P', \alpha) \subseteq \mathrm{fn}(P)$

*(3) substitution stability*
*If $p \xrightarrow{\alpha} P'$ and $\sigma$ is any substitution over names, then $\sigma P \xrightarrow{\sigma\alpha} \sigma P'$.*



# Strong Bisimularity for CPE

Expression is usually too fine
Bisimulation up to $\equiv$




up-to bisimulation is also a bisimulation