

Grammar

System Process $::= G \mid \Gamma \mid X \mid R \mid L \mid \Omega$

State $S ::= loc, C, \sigma \mid loc, \sigma$

Mapping σ

Concurrency $C ::= c \mid C \parallel C$

Command $c ::= skip \mid x := t \mid c_1 ; c_2 \mid \text{if } t \text{ pred } t' \text{ then } c_1 \text{ else } c_2 \mid$
 $\text{while } t \text{ pred } t' \text{ do } c \mid \text{await } t \text{ pred } t' \text{ then } d$

Simple commands $d ::= skip \mid x := t \mid d_1 ; d_2 \mid \text{if } t \text{ pred } t' \text{ then } d_1 \text{ else } d_2$

terms $t ::= x \mid n \mid t \text{ op } t' \mid -t$

variables x

numerals $n ::= 0 \mid 1 \mid 2 \mid \dots$

operators $op ::= + \mid \times \mid -$

predicate symbol $\text{pred} ::= = \mid \neq \mid < \mid > \mid \leq \mid \geq$

location $loc ::= () \mid () . n_1 . n_2 \dots n_k$

Gate $G ::= c, \sigma \mid () , c, \sigma \mid \cdot$

Gamma $\Gamma ::= S_1, \dots, S_k \mid \cdot$

Generator $X ::= i ; () \mid i ; j ; () \mid i ; j ; S_1 \dots S_k$

Subscriber $R ::= S_{ij} . \mid \cdot j ; S \mid \cdot j ; S :$

State $L ::= S_1, \dots, S_k \mid \cdot$

Omega $\Omega ::= S_1, \dots, S_k \mid \cdot$

Output $o ::= S_1, \dots, S_k \mid \cdot$

Input $i ::= S_1, \dots, S_k \mid \cdot$

Function CountConcurrent where $\# \text{CountConcurrent } S \#$ is an integer i for the number of " \parallel " in Concurrency C

Function Graph where $\# \text{Graph} \#$ is a visual representation of a graph

Forms of $\mathcal{I}_{\text{gen}} A$

$$G|\Pi|x|R|L|\Omega \rightsquigarrow G|\Pi'|x|R|L|\Omega$$

$$G|\Pi'|x|R|L|\Omega \rightsquigarrow G|\Pi'|x'|R|L'|\Omega$$

$$G|\Pi(x|R|L|\Omega) \rightsquigarrow G|\Pi(x|R|L|\Omega)$$

$$G|\Pi|x|R|L|\Omega \rightsquigarrow G|\Pi'|x|R'|L|\Omega$$

$$G|\Pi|x|R|L|\Omega \rightsquigarrow G|\Pi|x|R|L'|\Omega'$$

more on next page.

Rules

Forms
of
Derivation

$$\frac{G \rightsquigarrow G'}{G | \Gamma | X | R | L | \Omega \rightsquigarrow G' | \Gamma | X | R | L | \Omega}$$

$$\frac{\Gamma \rightsquigarrow \Gamma'}{G | \Gamma | X | R | L | \Omega \rightsquigarrow G | \Gamma' | X | R | L | \Omega}$$

$$\frac{X \rightsquigarrow X'}{G | \Gamma | X | R | L | \Omega \rightsquigarrow G | \Gamma | X' | R | L | \Omega}$$

$$\frac{R \rightsquigarrow R'}{G | \Gamma | X | R | L | \Omega \rightsquigarrow G | \Gamma | X | R' | L | \Omega}$$

$$\frac{L \rightsquigarrow L'}{G | \Gamma | X | R | L | \Omega \rightsquigarrow G | \Gamma | X | R | L' | \Omega}$$

$$\frac{\Omega \rightsquigarrow \Omega'}{G | \Gamma | X | R | L | \Omega \rightsquigarrow G | \Gamma | X | R | L | \Omega'}$$

$$S | \Gamma | X | R | L | \Omega \rightsquigarrow \bullet | S, \Gamma | X | R | L | \Omega \quad \text{Gate push}$$

$$\bullet \rightsquigarrow c, \sigma \quad \text{Gate input} \quad c, \sigma \rightsquigarrow o, c, \sigma \quad \text{Gate process}$$

General
push

$$G | \Gamma | i, j, s_1, \dots, s_{k-1}, s_k | \cdot j \cdot | L | \Omega \rightsquigarrow G | \Gamma | i, j, s_1, \dots, s_{k-1}, s_k | j \cdot | \Omega$$

$$\frac{c, \sigma \rightsquigarrow \sigma}{c, \sigma \rightsquigarrow^* \sigma}$$

$$\frac{c, \sigma \rightsquigarrow d, \sigma'}{c, \sigma \rightsquigarrow^* d, \sigma'}$$

$G \mid s_1, \dots, s_{k-1}, s_k \mid x \mid R \mid L \mid R \leadsto G \mid s_1, \dots, s_k \mid s_{k,j} \mid 0 \mid R \mid s_k, L \mid R$ Generate
push

$G \mid s_1, \dots, s_k \mid x \mid$

$s_k = 0 \quad n_0, 0 \leadsto \dots$

$S_k = 0 \dots n_0, c_j \sigma$

$\llbracket \text{Cont Contain } S_k \rrbracket = j \quad S_k \leadsto 0 \dots n_0, c_j \sigma, \dots, 0 \dots n_0, j, c_j \sigma$

Generate
Process

$s_1, \dots, s_{k-1}, s_k \mid 0 \leadsto s_1, \dots, s_{k-1} \mid s_{k,1}, \dots, s_{k,j}, 0$

$G \mid \Gamma \mid s_1, \dots, s_{k-1}, s_k \mid 0 \mid R \mid L \mid R \leadsto G \mid \Gamma \mid s_1, \dots, s_{k-1} \mid s_{k,1}, \dots, s_{k,j}, 0 \mid R \mid L \mid R$

$G \mid \Gamma \mid s_1, \dots, s_{k-1}, s_k \mid j \mid L \mid R \leadsto G \mid \Gamma \mid s_1, \dots, s_{k-1} \mid s_{k,1}, \dots, s_{k,j}, 0 \mid L \mid R$

$\llbracket \text{Push } +1 \rrbracket \sigma = \text{False}$

Generate focus
exception

$c_i = \text{await} + \text{push} + \text{then } d \quad S_k = 0 \dots n_0, c_{i,1} \parallel \dots \parallel c_{i,j} \parallel \dots \parallel c_{j,j} \sigma$

$\llbracket \text{Cont Contain } S_k \rrbracket = j \mid S_k \leadsto 0 \dots n_0, c_{j,1}, \dots, c_{j,i-1}, c_{j,i}, 0 \dots n_0, i+1, c_{j,i+1}, \dots, 0 \dots n_0, j, c_{j,j} \sigma$

$s_1, \dots, s_{k-1}, s_k \mid j \mid 0 \leadsto s_1, \dots, s_{k-1} \mid s_{k,1}, \dots, s_{k,i-1}, s_{k,i+1}, \dots, s_{k,j}, 0$

$G \mid \Gamma \mid s_1, \dots, s_{k-1}, s_k \mid j \mid R \mid L \mid R \leadsto G \mid \Gamma \mid s_1, \dots, s_{k-1} \mid s_{k,1}, \dots, s_{k,i-1}, s_{k,i+1}, \dots, s_{k,j}, 0 \mid R \mid L \mid R$

Substrate
process to c

$n_k = i \quad c_{i,j} \sigma \leadsto c'_{i,j} \sigma$

$S = 0 \dots n_1 \dots n_k, c_{i,1} \parallel \dots \parallel c_{i,j} \parallel \dots \parallel c_{j,j} \sigma \quad c_{i,1} \parallel \dots \parallel c_{i,j} \parallel \dots \parallel c_{j,j} \sigma \leadsto c_{i,1} \parallel \dots \parallel c'_{i,j} \parallel \dots \parallel c_{j,j} \sigma$

$s_{j,j} \sigma \leadsto s'_{j,j} \sigma$

$G \mid \Gamma \mid x \mid s_{j,j} \mid L \mid R \leadsto G \mid \Gamma \mid x \mid s'_{j,j} \mid L \mid R$

$n_k = i \quad c_{i,j} \sigma \leadsto \sigma'$

Substrate
process
to σ

$S = 0 \dots n_1 \dots n_k, c_{i,1} \parallel \dots \parallel c_{i,j} \parallel \dots \parallel c_{j,j} \sigma \quad c_{i,1} \parallel \dots \parallel c_{i,j} \parallel \dots \parallel c_{j,j} \sigma \leadsto c_{i,1} \parallel \dots \parallel c_{j,j} \sigma$

$s_{j,j} \sigma \leadsto s'_{j,j} \sigma$

$G \mid \Gamma \mid x \mid s_{j,j} \mid L \mid R \leadsto G \mid \Gamma \mid x \mid s'_{j,j} \mid L \mid R$

$\llbracket \text{Push } +1 \rrbracket \sigma = \text{True} \quad d_{j,\sigma} \leadsto^* \sigma'$

$d_{j,\sigma} \leadsto^* d'_{j,\sigma'} \quad d'_{j,\sigma'} \leadsto^* \sigma''$

$\text{await} + \text{push} +1 \quad \text{then } d_{j,\sigma} \leadsto \sigma'$

$d_{j,\sigma} \leadsto^* \sigma''$

Skip, $\sigma \leadsto \sigma$

$x := t, \sigma \leadsto \sigma [x \mapsto [t]\sigma]$

$C_1, \sigma \leadsto \sigma'$

$C_1; C_2, \sigma \leadsto C_2, \sigma'$

$C_1, \sigma \leadsto C_1, \sigma'$

$C_1; C_2, \sigma \leadsto C_1; C_2, \sigma'$

$\llbracket t \text{ push } t' \rrbracket \sigma = \text{True}$

if $t \text{ push } t'$ then a cke $C_2, \sigma \leadsto C_1, \sigma$

$\llbracket t \text{ push } t' \rrbracket \sigma = \text{False}$

if $t \text{ push } t'$ then c, cke $C_2, \sigma \leadsto C_2, \sigma$

$\llbracket t \text{ push } t' \rrbracket \sigma = \text{False}$

cke $t \text{ push } t'$ do c, $\sigma \leadsto \sigma$

$\llbracket t \text{ push } t' \rrbracket \sigma = \text{True}$

cke $t \text{ push } t'$ do c, $\sigma \leadsto C_j$ the $t \text{ push } t'$ do c, σ

$G | \Pi | X | \cdot | j | S | L | R \leadsto G | S, \Pi | X | \cdot | j | \cdot | L | R$

Subtree
push

$G | \Pi | X | R | S_1, \dots, S_k | \cdot \leadsto G | \Pi | X | R | S_1, \dots, S_k | S_1, \dots, S_k$ Sink push

$\llbracket \text{Graph} \rrbracket$

$S_1, \dots, S_k \leadsto \cdot$

Graph
Generation

$G | \Pi | X | R | L | S_1, \dots, S_k \leadsto G | \Pi | X | R | L | \cdot$