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Transformation Rules

Appendix A of "Correctness Preserving Transformation"
ESPRIT Project 2304 LOTOSPHERE
task 1.2 Second Deliverable

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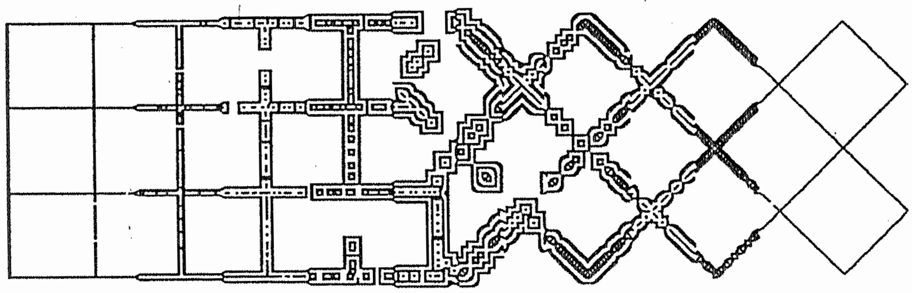
Correctness Preserving Transformation



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Appendix A

Transformation Rules

A.1 Laws for Observational Congruence

In the following a complete set of laws for observational congruence on finite basic LOTOS is listed. This set is not minimal but includes all the laws presented in [2] while for a minimal complete set we refer to [29]. The laws for each operator are grouped together.

Choice []

B1 [] B2 = B2 [] B1

B1 [] (B2 [] B3) = (B1 [] B2) [] B3

B [] stop = B

B [] B = B

Parallel |

(the symbol | stands for any of the following operators: $|[g1, ..., gn]|$, |||, ||)

$B1|B2 = B2|B1$

$B1|(B2|B3) = (B1|B2)|B3$

$B1|[A]|B2 = B1|[A']|B2$ if A' contains the same elements of A

$B1|[A]|B2 = B1|[A']|B2$ $A' = A \cap (L(B1) \cup L(B2))$

$B1|[A]|B2 = B1||B2$ $if A \supseteq (L(B1) \cup L(B2))$

$B1|[\,]|B2 = B1|||B2$

Enabling $>>$

$stop >> B = stop$

$exit >> B = i; B$

$(B1 >> B2) >> B3 = B1 >> (B2 >> B3)$

$B >> stop = B|||stop$

Disabling $[>$

$B1[> (B2[> B3) = (B1[> B2)[> B3$

$B[> stop = B$

$(B1[> B2)[]B2 = B1[> B2$

$stop[> B = B$

$exit[> B = exit[]B$

Hiding hide in

hide A in B = hide A' in B if A' contains the same elements of A

hide A in B = hide A' in B if A' = $A \cap L(B)$

hide A in hide A' in B = hide A" in B if $A'' = A \cup A'$

hide A in B = B if $A \cap L(B) = \emptyset$

hide A in g ; B = g ; (hide A in B) if $name(g) \notin A$

hide A in B1 [] B2 = (hide A in B1) [] (hide A in B2)

hide A in (B1 | [A'] | B2) = (hide A in B1) | [A'] | (hide A in B2) if $A \cup A' = \emptyset$

hide A in (B1 >> B2) = (hide A in B1) >> (hide A in B2)

hide A in (B1 [> B2) = (hide A in B1) [> (hide A in B2)

Relabelling [S]

Note that in LOTOS no explicit operator for relabelling is provided, the effect of relabelling being achieved by means of the gate parameter passing in process instantiation. Therefore, for the sake of simplicity, we give the axioms by using the following notation: $[S] = [a1/g_1, ..., a_n/g_n], S(g_i) = a_i, S(g) = g\ if\ g \neq g_i\ for\ i = 1, .., n$

$stop[S] = stop$

$exit[S] = exit$

$(a; B)[S] = S(a); B[S]$

$(B1[]B2)[S] = B1[S][]B2[S]$

$(B1|[A]|B2)[S] = B1[S]|[S(A)]|B2[S]$ if S is injective on $L(B1) \cup L(B2) \cup A$

$(B1 >> B2)[S] = B1[S] >> B2[S]$

$(B1[> B2)[S] = B1[S][> B2[S]$

(hide A' in B) [S] = hide A in B[S] if S is injective on $L(B) \cup A'$ and S(A') = A

B[S] = B if S = identity on L(B)

B[S1] = B[S2] if S1(a) = S2(a) for every $a \in L(B)$

B[S1] [S2] = B[S2∘S1]

Internal Action i

a ; i ; B = a ; B

B [] i ; B = i ; B

a ; (B1 [] i ; B2) [] a ; B2 = a ; (B1 [] i ; B2)

Expansion Theorems

Notation: $B1[]B2[]....[]Bn = []\{B1, ..., Bn\} = []S$ where $S = \{B1, ..., Bn\}$

Hp. every element of S has the structure $b_i; B_i$.

If $B = []\{b_i; B_i|i \in I\}$ and $C = []\{c_j; C_j|j \in J\}$, then

$B|[A]|C = \quad []\{b_i; (B_i|[A]|C) \mid name(b_i) \notin A, i \in I\}$

$\qquad [] \ []\{c_j; (B|[A]|C_j) \mid name(c_j) \notin A, j \in J\}$

$$[]\ []\{a; (B_i|[A]|C_j) \mid a = b_i = c_j, name(a) \in A, i \in I, j \in J\}$$

$$B[> C = \quad C\ []\ []\{b_i; (B_i[> C)|i \in I\}$$

$$hide\ A\ in\ B = \quad []\{b_i;\ hide\ A\ in\ B_i \mid name(b_i) \notin A, i \in I\}$$

$$[]\ []\{i;\ hide\ A\ in\ B_i \mid name(b_i) \notin A, i \in I\}$$

$$B[S] = []\{S(b_i); B_i[S]|i \in I\}$$

A.2 Recursion

In Lotos no explicit recursive operator is provided. Recursive processes can be defined by means of recursive process definitions. As we have already done for the relabelling operator, we prefer to use an explicit recursive operator to give the related laws [28].

rec x. E = E[rec x.E/x]

If F = E[F/x] then F =rec x.E , provided that x is guarded in E (see section A.3.1)

Note that the addition of these two laws for recursive processes to the ones given before, does not provide a complete set of laws for observational congruence for basic LOTOS.

A.3 Laws for reducing unguarded recursions to guarded recursions

In the following we give the transformation rules that allow to reduce unguarded recursion for the language composed by the action prefix, (explicit) recursion, choice and pure synchronization, preserving the trace congruence.

A.3.1 Definitions

An occurrence of a process variable x in a behaviour expression E is *guarded* in E if it occurs within some subexpression a;F of E, with $a \in Act$. Otherwise it is said to be *unguarded* in E [28].

A recursive process definition rec x.E is said to contain a *guarded recursion* if the process variable x occurs guarded in E. Conversely, it is said to contain an *unguarded recursion* if x occurs unguarded in E.

A.3.2 Trace Congruence Laws

The following laws, in conjunction with the basic ones, form a complete set of axioms for the trace congruence for finite LOTOS.

i;B = B

m;(B1 [] B2) = m;B1 [] m;B2

A.3.3 Unguarded Recursion Laws

The following laws, in conjunction with the trace congruence and the guarded recursion ones, form a complete set of axioms for the trace congruence on the LOTOS subset composed by the action prefix, recursion, choice and pure synchronization [27].

rec x. (U(x)[]B(x)) = rec x. B(x)

rec x. ((U(x)[]B1(x)) || B2(x)) = rec x. (B1(x) || B2(x))

where B(x), B1(x), B2(x) are generic behaviour expressions, and U(x) is an unguarded expression of the form x or x || B(x)

Useful instances of the above axioms are:

rec x. x = stop

rec x. (x [] B(x)) = rec x. B(x)

rec x. (x || B(x)) = stop

The second of these derived laws has been introduced in [28] for the language without synchronization.

A.3.4 More Unguarded Recursion Laws

Another useful transformation, operating on a subset of LOTOS including the interleaving operator, is the following:

rec x. $[]\{a_i; Q_i\}|||x$ = rec x. $[]\{a_i; Q_i|||x\}$

This law preserves strong equivalence, as presented in Chapter 6.