

5.50 change_continuity

	DESCRIPTION	LINKS	GRAPH	AUTOMATON
Origin	N. Beldiceanu			
Constraint	change_continuity	$\left(\begin{array}{l} \text{NB_PERIOD_CHANGE,} \\ \text{NB_PERIOD_CONTINUITY,} \\ \text{MIN_SIZE_CHANGE,} \\ \text{MAX_SIZE_CHANGE,} \\ \text{MIN_SIZE_CONTINUITY,} \\ \text{MAX_SIZE_CONTINUITY,} \\ \text{NB_CHANGE,} \\ \text{NB_CONTINUITY,} \\ \text{VARIABLES,} \\ \text{CTR} \end{array} \right)$		
Arguments	<pre> NB_PERIOD_CHANGE : dvar NB_PERIOD_CONTINUITY : dvar MIN_SIZE_CHANGE : dvar MAX_SIZE_CHANGE : dvar MIN_SIZE_CONTINUITY : dvar MAX_SIZE_CONTINUITY : dvar NB_CHANGE : dvar NB_CONTINUITY : dvar VARIABLES : collection(var-dvar) CTR : atom </pre>			
Restrictions	<pre> NB_PERIOD_CHANGE ≥ 0 NB_PERIOD_CONTINUITY ≥ 0 MIN_SIZE_CHANGE ≥ 0 MAX_SIZE_CHANGE ≥ MIN_SIZE_CHANGE MIN_SIZE_CONTINUITY ≥ 0 MAX_SIZE_CONTINUITY ≥ MIN_SIZE_CONTINUITY NB_CHANGE ≥ 0 NB_CONTINUITY ≥ 0 required(VARIABLES, var) CTR ∈ [=, ≠, <, ≥, >, ≤] </pre>			

On the one hand a *change* is defined by the fact that constraint $\text{VARIABLES}[i].\text{var} \text{ CTR } \text{VARIABLES}[i + 1].\text{var}$ holds.
 On the other hand a *continuity* is defined by the fact that constraint $\text{VARIABLES}[i].\text{var} \text{ CTR } \text{VARIABLES}[i + 1].\text{var}$ does not hold.

A *period of change* on variables

$$\text{VARIABLES}[i].\text{var}, \text{VARIABLES}[i + 1].\text{var}, \dots, \text{VARIABLES}[j].\text{var} \quad (i < j)$$

is defined by the fact that all constraints $\text{VARIABLES}[k].\text{var} \text{ CTR } \text{VARIABLES}[k + 1].\text{var}$ hold for $k \in [i, j - 1]$.

A *period of continuity* on variables

$$\text{VARIABLES}[i].\text{var}, \text{VARIABLES}[i + 1].\text{var}, \dots, \text{VARIABLES}[j].\text{var} \quad (i < j)$$

is defined by the fact that all constraints $\text{VARIABLES}[k].\text{var} \text{ CTR } \text{VARIABLES}[k + 1].\text{var}$ do not hold for $k \in [i, j - 1]$.

The constraint *change_continuity* holds if and only if:

- `NB_PERIOD_CHANGE` is equal to the number of periods of change,
- `NB_PERIOD_CONTINUITY` is equal to the number of periods of continuity,
- `MIN_SIZE_CHANGE` is equal to the number of variables of the smallest period of change,
- `MAX_SIZE_CHANGE` is equal to the number of variables of the largest period of change,
- `MIN_SIZE_CONTINUITY` is equal to the number of variables of the smallest period of continuity,
- `MAX_SIZE_CONTINUITY` is equal to the number of variables of the largest period of continuity,
- `NB_CHANGE` is equal to the total number of changes,
- `NB_CONTINUITY` is equal to the total number of continuities.

Purpose

Example

$$\left(\begin{array}{c} \text{var} - 1, \\ \text{var} - 3, \\ \text{var} - 1, \\ \text{var} - 8, \\ \text{var} - 8, \\ \text{var} - 4, \\ \text{var} - 7, \\ \text{var} - 7, \\ \text{var} - 7, \\ \text{var} - 7, \\ \text{var} - 2 \end{array} \right), \neq$$

Figure 5.95 makes clear the different parameters that are associated with the given example for the collection $\text{VARIABLES} = \langle 1, 3, 1, 8, 8, 4, 7, 7, 7, 7, 2 \rangle$. We place character | for representing a change and a blank for a continuity. On top of the solution we represent the different periods of change, while below we show the different periods of continuity. The *change_continuity* constraint holds since:

- Its number of periods of change `NB_PERIOD_CHANGE` is equal to 3 (i.e., the 3 periods depicted on top of Figure 5.95),
- Its number of periods of continuity `NB_PERIOD_CONTINUITY` is equal to 2 (i.e., the 2 periods depicted below Figure 5.95),
- The number of variables of its smallest period of change `MIN_SIZE_CHANGE` is equal to 2 (i.e., the number of variables involved in the third period of change 7 2 depicted on top of Figure 5.95),
- The number of variables of the largest period of change `MAX_SIZE_CHANGE` is equal to 4 (i.e., the number of variables involved in the first period of change 1 3 1 8 depicted on top of Figure 5.95),
- The number of variables of the smallest period of continuity `MIN_SIZE_CONTINUITY` is equal to 2 (i.e., the number of variables involved in the first period 8 8 depicted below Figure 5.95),
- The number of variables of the largest period of continuity `MAX_SIZE_CONTINUITY` is equal to 4 (i.e., the number of variables involved in the second period 7 7 7 7 depicted below Figure 5.95),
- The total number of changes `NB_CHANGE` is equal to 6 (i.e., the number of occurrences of character `|` in Figure 5.95),
- The total number of continuities `NB_CONTINUITY` is equal to 4.

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<-----> <---->      <-->
1|3|1|8 8|4|7 7 7 7|2
          <-->  <----->

```

Figure 5.95: Periods of changes and periods of continuities

Typical

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NB_PERIOD_CHANGE > 0
NB_PERIOD_CONTINUITY > 0
MIN_SIZE_CHANGE > 0
MIN_SIZE_CONTINUITY > 0
NB_CHANGE > 0
NB_CONTINUITY > 0
|VARIABLES| > 1
range(VARIABLES.var) > 1

```

Symmetry

One and the same constant can be [added](#) to the `var` attribute of all items of `VARIABLES`.

Remark

If the variables of the collection `VARIABLES` have to take distinct values between 1 and the total number of variables, we have what is called a permutation. In this case, if we choose the binary constraint `<`, then `MAX_SIZE_CHANGE` gives the size of the longest run of the permutation; A *run* is a maximal increasing contiguous subsequence in a permutation.

See also

[common keyword:](#) [group](#), [group_skip_isolated_item](#), [stretch_path](#) (*timetabling constraint*).

Keywords

characteristic of a constraint: automaton, automaton with counters.

combinatorial object: sequence, run of a permutation, permutation.

constraint network structure: sliding cyclic(1) constraint network(2),
sliding cyclic(1) constraint network(3).

constraint type: timetabling constraint.

final graph structure: connected component, apartition, acyclic, bipartite, no loop.

miscellaneous: obscure.

Arc input(s)	VARIABLES
Arc generator	<i>PATH</i> \mapsto <code>collection</code> (variables1, variables2)
Arc arity	2
Arc constraint(s)	variables1.var CTR variables2.var
Graph property(ies)	<ul style="list-style-type: none"> • NCC= NB_PERIOD_CHANGE • MIN_NCC= MIN_SIZE_CHANGE • MAX_NCC= MAX_SIZE_CHANGE • NARC= NB_CHANGE
Graph class	<ul style="list-style-type: none"> • ACYCLIC • BIPARTITE • NO_LOOP <hr/>
Arc input(s)	VARIABLES
Arc generator	<i>PATH</i> \mapsto <code>collection</code> (variables1, variables2)
Arc arity	2
Arc constraint(s)	variables1.var \neg CTR variables2.var
Graph property(ies)	<ul style="list-style-type: none"> • NCC= NB_PERIOD_CONTINUITY • MIN_NCC= MIN_SIZE_CONTINUITY • MAX_NCC= MAX_SIZE_CONTINUITY • NARC= NB_CONTINUITY
Graph class	<ul style="list-style-type: none"> • ACYCLIC • BIPARTITE • NO_LOOP <hr/>
Graph model	<p>We use two graph constraints to respectively catch the constraints on the period of changes and of the period of continuities. In both case each period corresponds to a connected component of the final graph.</p> <p>Parts (A) and (B) of Figure 5.96 respectively show the initial and final graph associated with the first graph constraint of the Example slot.</p>

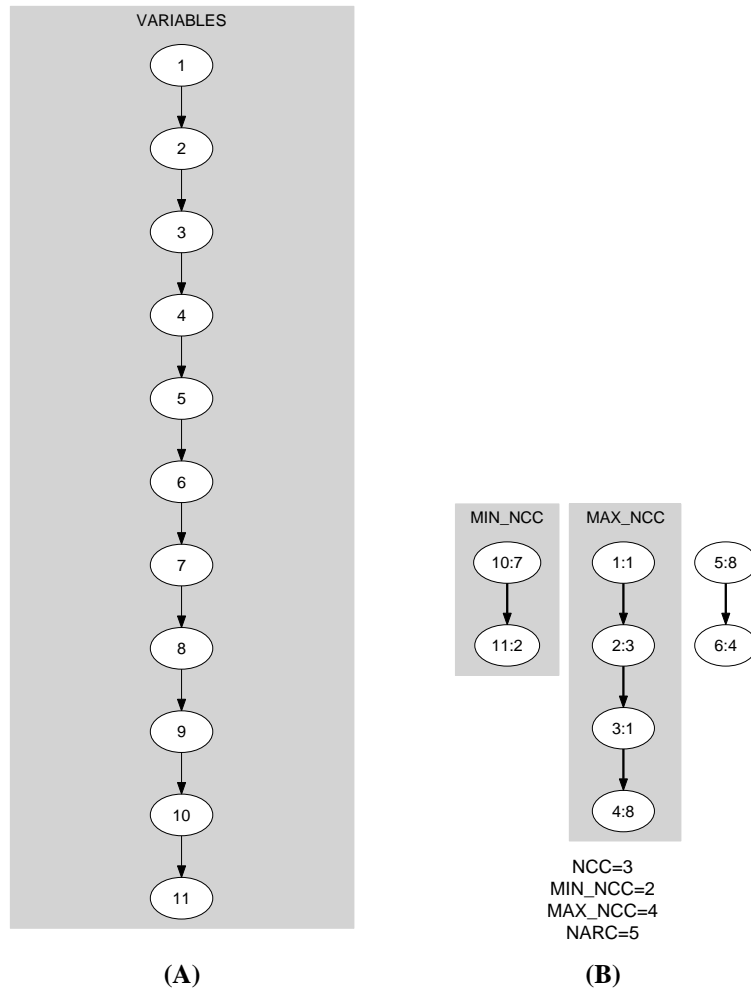


Figure 5.96: Initial and final graph of the change_continuity constraint

Automaton

Figures 5.97 , 5.98 , 5.101 , 5.102 , 5.105 , 5.106 and 5.109 depict the automata associated with the different graph parameters of the change_continuity constraint. For the automata that respectively compute NB_PERIOD_CHANGE, NB_PERIOD_CONTINUITY, MIN_SIZE_CHANGE, MIN_SIZE_CONTINUITY, MAX_SIZE_CHANGE, MAX_SIZE_CONTINUITY, NB_CHANGE and NB_CONTINUITY we have a 0-1 signature variable S_i for each pair of consecutive variables (VAR_i, VAR_{i+1}) of the collection VARIABLES. The following signature constraint links VAR_i , VAR_{i+1} and S_i : $VAR_i \text{ CTR } VAR_{i+1} \Leftrightarrow S_i$.

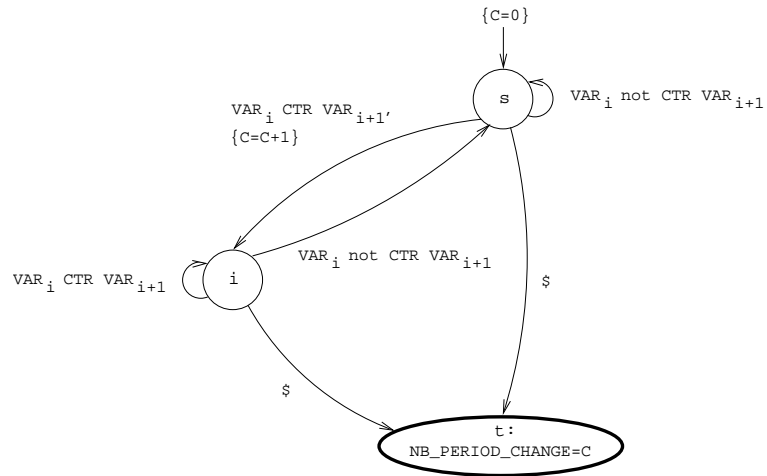


Figure 5.97: Automaton for the NB_PERIOD_CHANGE parameter of the change_continuity constraint

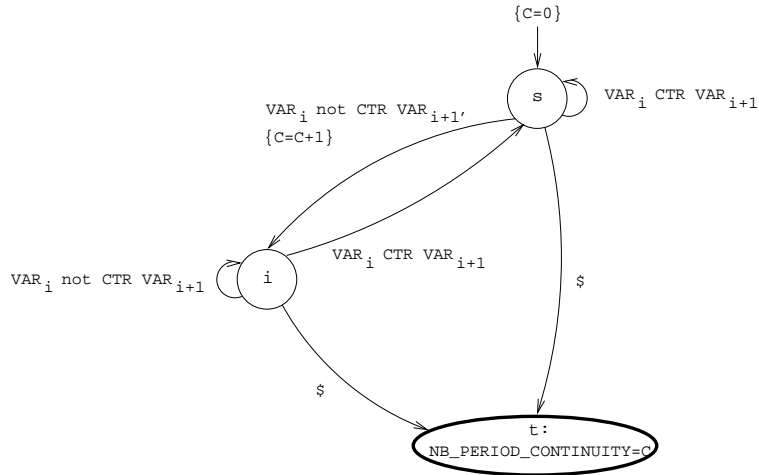


Figure 5.98: Automaton for the NB_PERIOD_CONTINUITY parameter of the change_continuity constraint

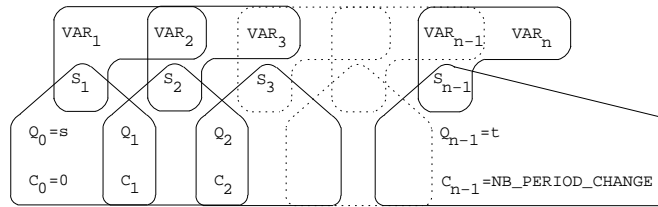


Figure 5.99: Hypergraph of the reformulation corresponding to the automaton of the NB_PERIOD_CHANGE parameter of the change_continuity constraint

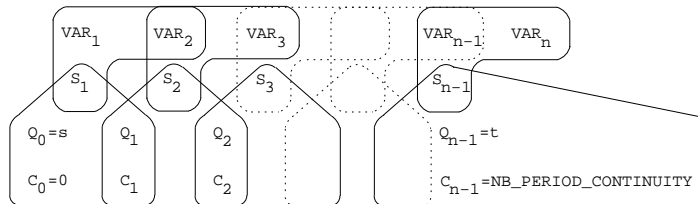


Figure 5.100: Hypergraph of the reformulation corresponding to the automaton of the NB_PERIOD_CONTINUITY parameter of the change_continuity constraint

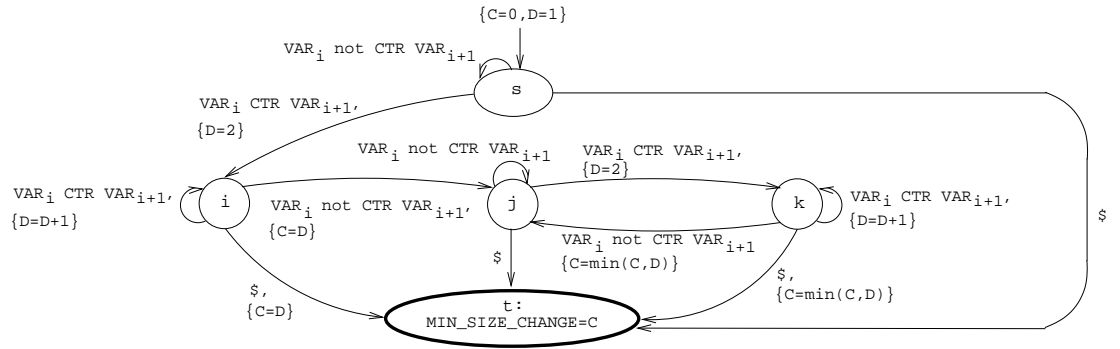


Figure 5.101: Automaton for the MIN_SIZE_CHANGE parameter of the change_continuity constraint

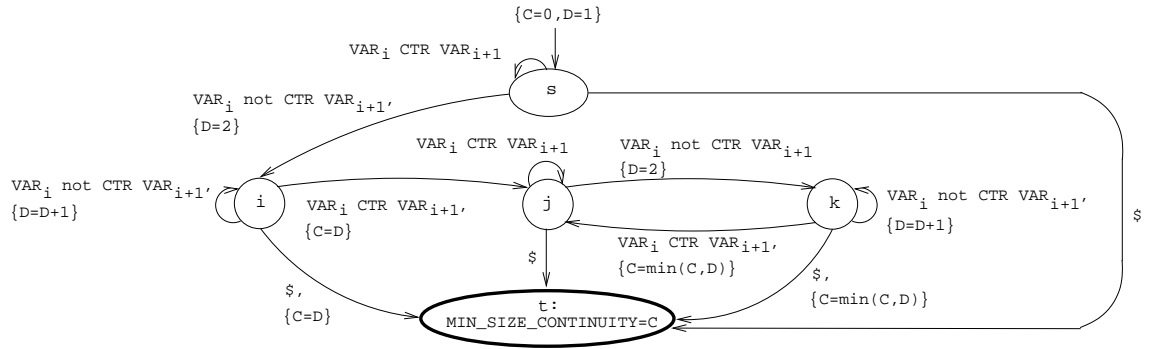


Figure 5.102: Automaton for the MIN_SIZE_CONTINUITY parameter of the change_continuity constraint

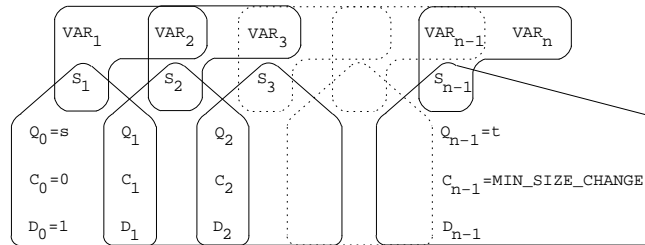


Figure 5.103: Hypergraph of the reformulation corresponding to the automaton of the MIN_SIZE_CHANGE parameter of the change_continuity constraint

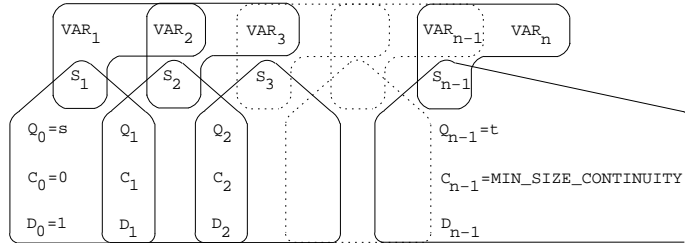


Figure 5.104: Hypergraph of the reformulation corresponding to the automaton of the MIN_SIZE_CONTINUITY parameter of the change_continuity constraint

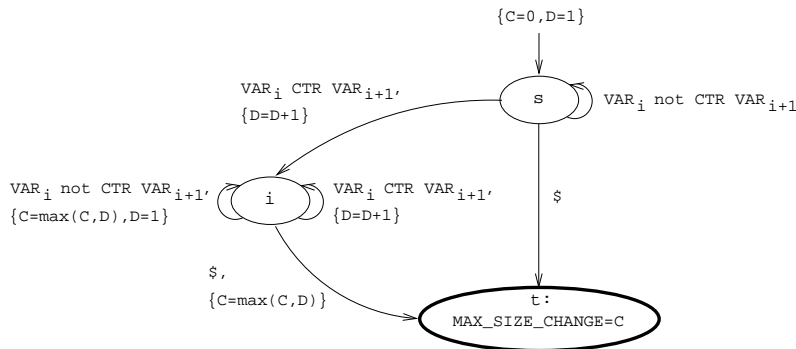


Figure 5.105: Automaton for the MAX_SIZE_CHANGE parameter of the change_continuity constraint

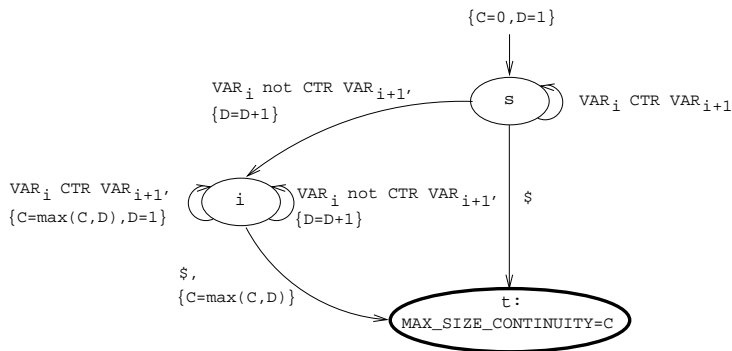


Figure 5.106: Automaton for the MAX_SIZE_CONTINUITY parameter of the change_continuity constraint

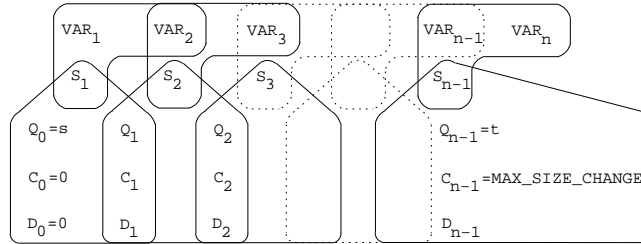


Figure 5.107: Hypergraph of the reformulation corresponding to the automaton of the `MAX_SIZE_CHANGE` parameter of the `change_continuity` constraint

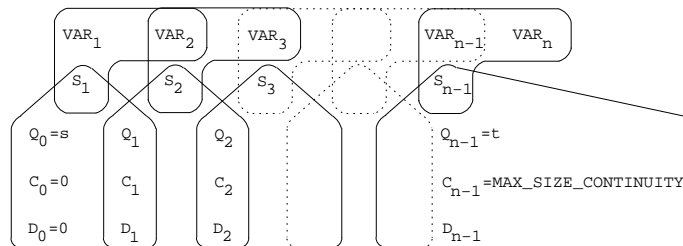


Figure 5.108: Hypergraph of the reformulation corresponding to the automaton of the `MAX_SIZE_CONTINUITY` parameter of the `change_continuity` constraint

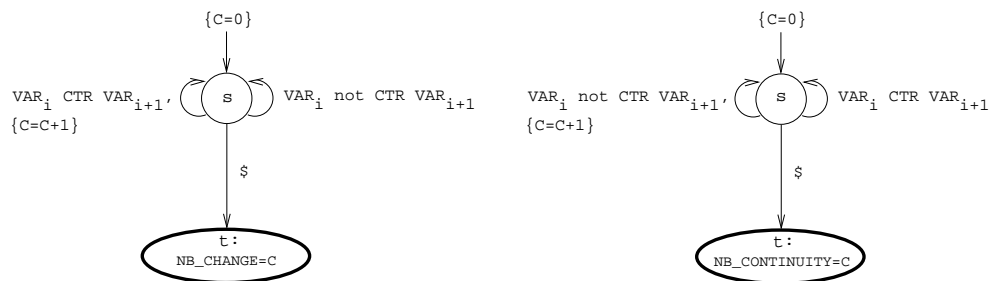


Figure 5.109: Automata for the `NB_CHANGE` and `NB_CONTINUITY` parameters of the `change_continuity` constraint

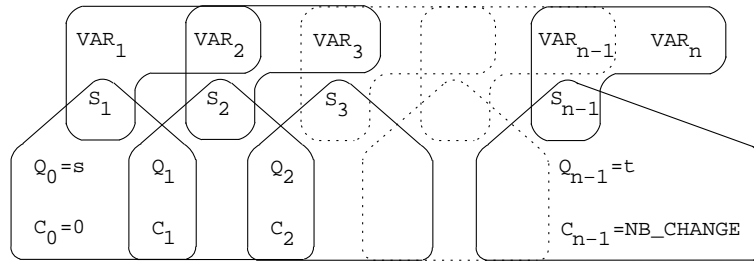


Figure 5.110: Hypergraph of the reformulation corresponding to the automaton of the NB_CHANGE parameter of the change_continuity constraint

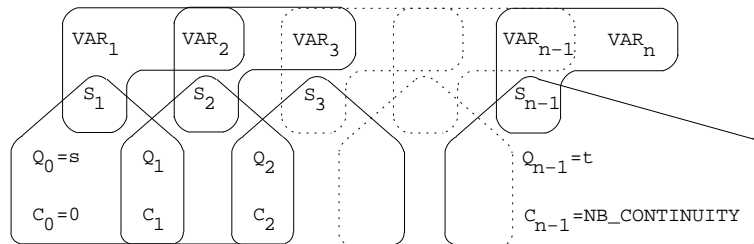


Figure 5.111: Hypergraph of the reformulation corresponding to the automaton of the NB_CONTINUITY parameter of the change_continuity constraint