

5.304 `soft_cumulative`

	DESCRIPTION	LINKS																
Origin	Derived from <code>cumulative</code>																	
Constraint	<code>soft_cumulative(TASKS, LIMIT, INTERMEDIATE_LEVEL, SURFACE_ON_TOP)</code>																	
Arguments	<table border="0"> <tr> <td style="vertical-align: top;">TASKS</td> <td style="vertical-align: top;">:</td> <td style="vertical-align: top;">collection</td> <td style="vertical-align: middle;"> $\left(\begin{array}{l} \text{origin-dvar,} \\ \text{duration-dvar,} \\ \text{end-dvar,} \\ \text{height-dvar} \end{array} \right)$ </td> </tr> <tr> <td>LIMIT</td> <td>:</td> <td>int</td> <td></td> </tr> <tr> <td>INTERMEDIATE_LEVEL</td> <td>:</td> <td>int</td> <td></td> </tr> <tr> <td>SURFACE_ON_TOP</td> <td>:</td> <td>int</td> <td></td> </tr> </table>		TASKS	:	collection	$\left(\begin{array}{l} \text{origin-dvar,} \\ \text{duration-dvar,} \\ \text{end-dvar,} \\ \text{height-dvar} \end{array} \right)$	LIMIT	:	int		INTERMEDIATE_LEVEL	:	int		SURFACE_ON_TOP	:	int	
TASKS	:	collection	$\left(\begin{array}{l} \text{origin-dvar,} \\ \text{duration-dvar,} \\ \text{end-dvar,} \\ \text{height-dvar} \end{array} \right)$															
LIMIT	:	int																
INTERMEDIATE_LEVEL	:	int																
SURFACE_ON_TOP	:	int																
Restrictions	<pre> require_at_least(2, TASKS, [origin, duration, end]) required(TASKS, height) TASKS.duration ≥ 0 TASKS.origin ≤ TASKS.end TASKS.height ≥ 0 LIMIT ≥ 0 INTERMEDIATE_LEVEL ≥ 0 INTERMEDIATE_LEVEL ≤ LIMIT SURFACE_ON_TOP ≥ 0 </pre>																	
Purpose	<p>Consider a set \mathcal{T} of n tasks described by the TASKS collection, where origin_j, duration_j, end_j, height_j are shortcuts for $\text{TASKS}[j].\text{origin}$, $\text{TASKS}[j].\text{duration}$, $\text{TASKS}[j].\text{end}$, $\text{TASKS}[j].\text{height}$. In addition let α and β respectively denote the earliest possible start over all tasks and the latest possible end over all tasks. The <code>soft_cumulative</code> constraint enforces the three following conditions:</p> <ol style="list-style-type: none"> 1. For each task $\text{TASKS}[j]$ ($1 \leq j \leq n$) of \mathcal{T} we have $\text{origin}_j + \text{duration}_j = \text{end}_j$. 2. At each point in time, the cumulated height of the set of tasks that overlap that point, does not exceed a given limit LIMIT (i.e., $\forall i \in [\alpha, \beta] : \sum_{j \in [1, n] \text{origin}_j \leq i < \text{end}_j} \text{height}_j \leq \text{LIMIT}$). 3. The surface of the profile resource utilisation, which is greater than INTERMEDIATE_LEVEL, is equal to SURFACE_ON_TOP (i.e., $\sum_{i \in [\alpha, \beta]} \max(0, (\sum_{j \in [1, n] \text{origin}_j \leq i < \text{end}_j} \text{height}_j) - \text{INTERMEDIATE_LEVEL}) = \text{SURFACE_ON_TOP}$). 																	
Example	$\left(\left\langle \begin{array}{llll} \text{origin} - 1 & \text{duration} - 4 & \text{end} - 5 & \text{height} - 1, \\ \text{origin} - 1 & \text{duration} - 1 & \text{end} - 3 & \text{height} - 2, \\ \text{origin} - 3 & \text{duration} - 3 & \text{end} - 6 & \text{height} - 2 \end{array} \right\rangle, 3, 2, 3 \right)$																	

Figure 5.546 shows the cumulated profile associated with the example. To each

task of the `cumulative` constraint corresponds a set of rectangles coloured with the same colour: the sum of the lengths of the rectangles corresponds to the duration of the task, while the height of the rectangles (i.e., all the rectangles associated with a task have the same height) corresponds to the resource consumption of the task. The `soft_cumulative` constraint holds since:

1. For each task we have that its end is equal to the sum of its origin and its duration.
2. At each point in time we do not have a cumulated resource consumption strictly greater than the upper limit $LIMIT = 3$ enforced by the second argument of the `soft_cumulative` constraint.
3. The surface of the cumulated profile located on top of the intermediate level $INTERMEDIATE_LEVEL = 2$ is equal to $SURFACE_ON_TOP = 3$.

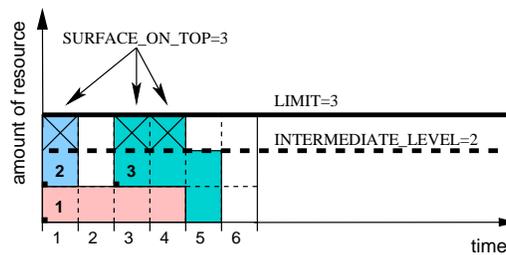


Figure 5.546: Resource consumption profile associated with the 3 tasks of the example, where parts on top of the intermediate level 2 are marked by a cross

Symmetries

- Items of TASKS are [permutable](#).
- One and the same constant can be [added](#) to the origin and end attributes of all items of TASKS.
- LIMIT can be [increased](#).

Remark

The `soft_cumulative` constraint was initially introduced in [CHIP \[112\]](#) as a variant of the `cumulative` constraint. An extension of this constraint where one can restrict the surface on top of the intermediate level on different time intervals was proposed in [\[279\]](#).

See also

[hard version: cumulative](#).

Keywords

constraint type: [soft constraint](#), [scheduling constraint](#), [resource constraint](#), [temporal constraint](#), [relaxation](#).