5.361 soft_cumulative

DESCRIPTION LINKS

Origin Derived from cumulative

Constraint soft_cumulative(TASKS, LIMIT, INTERMEDIATE_LEVEL, SURFACE_ON_TOP)

Arguments

TASKS	:	collection(origin−dvar, duration−dvar, end−dvar, height−dvar)
LIMIT	:	int
INTERMEDIATE_LEVEL	:	int
SURFACE_ON_TOP	:	dvar

Restrictions

require_at_least(2, TASKS, [origin, duration, end])
required(TASKS, height)
TASKS.duration ≥ 0
TASKS.origin $\leq$ TASKS.end
TASKS.height ≥ 0
LIMIT ≥ 0
INTERMEDIATE_LEVEL ≥ 0
INTERMEDIATE_LEVEL $\leq$ LIMIT
SURFACE_ON_TOP ≥ 0

Purpose

Consider a set $\mathcal{T}$ of n tasks described by the TASKS collection, where $\texttt{origin}_j$, $\texttt{duration}_j$, $\texttt{end}_j$, $\texttt{height}_j$ are shortcuts for TASKS$[j]$.origin, TASKS$[j]$.duration, TASKS$[j]$.end, TASKS$[j]$.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 soft_cumulative constraint forces the three following conditions:

1. For each task TASKS$[j]$ $(1 \leq j \leq n)$ of $\mathcal{T}$ we have $\texttt{origin}_j + \texttt{duration}_j = \texttt{end}_j$.
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., $\forall i \in [\alpha, \beta] : \sum_{j \in [1,n] | \texttt{origin}_j \leq i < \texttt{end}_j} \texttt{height}_j \leq \texttt{LIMIT}$).
3. The surface of the profile resource utilisation, which is greater than INTERMEDIATE_LEVEL, is equal to SURFACE_ON_TOP (i.e., $\sum_{i \in [\alpha, \beta]} \max(0, (\sum_{j \in [1,n] | \texttt{origin}_j \leq i < \texttt{end}_j} \texttt{height}_j) - \texttt{INTERMEDIATE_LEVEL}) = \texttt{SURFACE_ON_TOP}$).

Example

$$\left(\left\langle \begin{array}{llll} \texttt{origin} - 1 & \texttt{duration} - 4 & \texttt{end} - 5 & \texttt{height} - 1, \\ \texttt{origin} - 1 & \texttt{duration} - 1 & \texttt{end} - 2 & \texttt{height} - 2, \\ \texttt{origin} - 3 & \texttt{duration} - 3 & \texttt{end} - 6 & \texttt{height} - 2 \end{array} \right\rangle, 3, 2, 3 \right)$$

Figure 5.703 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` $= 3$.

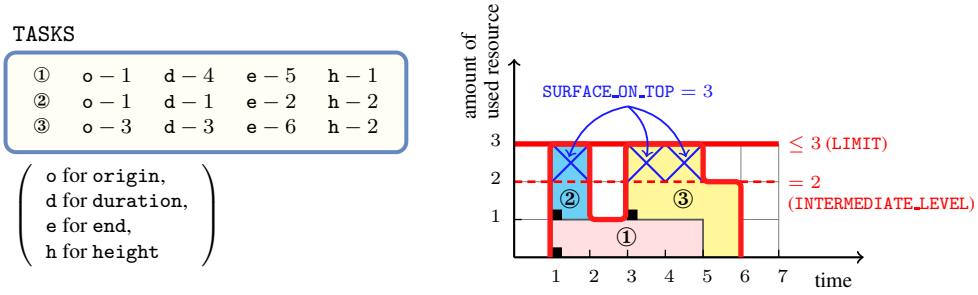

Figure 5.703: Resource consumption profile associated with the three tasks of the **Example** slot, where parts on top of the intermediate level 2 are marked by a cross

Typical

$|\texttt{TASKS}| > 1$
$\texttt{range}(\texttt{TASKS.origin}) > 1$
$\texttt{range}(\texttt{TASKS.duration}) > 1$
$\texttt{range}(\texttt{TASKS.end}) > 1$
$\texttt{range}(\texttt{TASKS.height}) > 1$
$\texttt{TASKS.duration} > 0$
$\texttt{TASKS.height} > 0$
$\texttt{LIMIT} < \texttt{sum}(\texttt{TASKS.height})$
$\texttt{INTERMEDIATE_LEVEL} > 0$
$\texttt{INTERMEDIATE_LEVEL} < \texttt{LIMIT}$
$\texttt{SURFACE_ON_TOP} > 0$

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** [124] 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 first proposed in [311] and was generalised in [118].

See also **hard version:** `cumulative`.

Keywords **constraint type:** predefined constraint, soft constraint, scheduling constraint, resource constraint, temporal constraint, relaxation.