Bounding Blocking Time for EDF-DVS

{ smohan, vspoojar, hramapr } @unity.ncsu.edu

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We started with a simple task set consisting of two tasks and a single resource, for which both tasks contend. The task set we considered is (ϕ, p, e, d):

A (0, 8, 2, 8) and B (1, 5, 1, 5).

Resource : X

Resource Usage : A requires X for 1 time unit, from 0. B requires X for 1 time unit starting from 0.

Under normal EDF-PIP, the blocking term per resource per task, is calculated as follows:

$b_{i,R_\mathrm{j}} = \max_{1 \leq k \leq n} (\theta_\mathrm{k})$ $\rightarrow$ (1)

[where θ_k is the length of the critical section of every task using the resource $\mathrm{R_j}$]

Now, the blocking term for task i is

$b_\mathrm{i} = \max_{1 \leq l \leq j} (b_{i,R\mathrm{l}})$ $\rightarrow$ (2)

Here,

$b_A = 1$ and $b_\mathrm{B} = 1$.

This task set is schedulable (from the following schedulability test).

$\sum^{\mathrm{n}}{}_{\mathrm{k=1}}\ \mathrm{e}_k/\min(\ \mathrm{d}_k,\ \mathrm{p}_k\ ) + \mathrm{b}_i/\min(\ \mathrm{d}_i,\ \mathrm{p}_i\ ) \leq 1$ $\rightarrow$ (3)

Now, we consider EDF-PIP with DVS. We consider the static DVS mechanism.

We need to find the scaling factor α, such that

$$\mathrm{e}_1 / \mathrm{p}_1 + \mathrm{e}_2 / \mathrm{p}_2 \leq \alpha \qquad \rightarrow (4)$$

The lowest possible value of α is 0.45 in this case. Now, we scale the execution time of each task by this factor. The scaled values for the execution times are:

$\mathrm{e}_1 = 2 / \alpha = 2 / 0.45 = 4.44$

$\mathrm{e}_2 = 1 / \alpha = 1 / 0.45 = 2.22$

Similarly, the blocking times also need to be scaled.

$\mathrm{b}_1 = 1 / \alpha = 1 / 0.45 = 2.22$

$b_2 = 1 / \alpha = 1 / 0.45 = 2.22$

Once the scaling factor has been considered for both the execution and blocking times, the scheduling is exactly like normal EDF-PIP and is schedulable.

The blocking term for n tasks scheduled using EDF-PIP with Static-DVS is the same as the results obtained in equations (1) and (2) above. Care must be taken to ensure that the blocking times thus obtained are also scaled by $1 / \alpha$.

Note: In this particular example, we have used the lowest possible value for α obtained from equation (4). However, this may prove to be an over-optimistic value as blocking has not been considered in the calculation for α. In general, all task sets need not be schedulable if α is calculated in this way.

The correct way to estimate α is by using the following equation in place of equation (4):

$$\sum^{n}_{k=1} e_k/\min(d_k, p_k) + b_i/\min(d_i, p_i) \leq \alpha \qquad \rightarrow (5)$$

Since this is a static algorithm, it might be worthwhile to do the following:
(a) Find the lowest possible value of α using equation (4)
(b) Scale the value of b_i using this value of α
(c) Perform the schedulability test according to equation (3)
(d) If this test fails, find α using equation (5) and proceed.
The value of α calculated in both cases would be significantly different.

Future course of work:
(a) Perform a formal analysis to verify the above results.
(b) Analyse for Cycle-Conserving DVS for EDF-PIP.
(c) Analyse for Look-Ahead DVS for EDF-PIP.

The work presented thus far had equal contributions by all three team members. We intend to continue working together for phase (a) mentioned above and then split the remaining work.