Article Title

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Abstract

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I. Introduction

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II. Related work

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III. Model

I. Symbol definition

This article considers a shared memory system. The system is modeled as m processors and a task set $\Gamma = \{\tau_0, \tau_1, ..., \tau_{n-1}\}$.

[*]A thank you or further information

Each task τ_i is characterized by its worst-case execution time C_i and its period T_i, both of which are assumed to be integer multiples of a system unit time. We consider real-time tasks with implicit deadlines. That is, T_i is also the relative deadline of task τ_i. The weight for task τ_i is defined as $W_i = \frac{C_i}{T_i}$, and the system utilization is $U_\Gamma = \sum_{i=0}^{n-1} W_i$. We assume that $0 < W_i < 1$, and $0 < U_\Gamma < m$.
A job $J_{i,j}$ is the jth task instance of task τ_i. It arrives at time $JStart_{i,j} = j \cdot T_i$ and need to complete its execution by its deadline at time $JEnd_{i,j} = (j+1) \cdot T_i$. Assuming that the first job of each task arrives at time 0. That is, $\forall \tau_i \in \Gamma, JStart_{i,0} = 0$.
The multiprocessor real-time scheduling problem is to construct a peroidc schedule for the above tasks, which allocates exactly C_i time units of a processor to task τ_i within each interval $[(k-1) \cdot T_i, k \cdot T_i)$ for all $k \in \{1, 2, 3, ...\}$, subject to the following constraints:

- C1: A processor can only be allocated to one task at any time, that is, processors cannot be shared concurrently;
- C2: A task can only be allocated at most one processor at any time, that is, tasks are not parallel and thus cannot occupy more than one processor at any time.

The least common multiple of all tasks' period is H_Γ. Because of the periodic property of the problem, we only consider the schedule from time 0 to time H_Γ. We split the time range $[0, H_\Gamma)$ into $znum$ zones with consecutive deadlines. Each zone Z_i start at time $ZStart_i$ and end at time $ZEnd_i$. $\forall c, \exists (i,j), ZStart_c = j \cdot T_i, ZStart_c < ZEnd_c$ and $ZEnd_c = ZStart_{c+1} (c = 0, ..., znum-2)$.
The scheduling during $[0, H_\Gamma)$ is expressed by a matrix M with n rows and $znum$ columns. Elements in M denoted as $alloc_{i,j}$ represents the execution time units assigned to τ_i in Z_j. The scheduling matrix only specifies the assigned units amount, without concerning the exact time and processor a task is to execute.

Table 1: *Symbol table*

m	number of processors in system
n	number of tasks in system
$znum$	number of zones in system
τ_i	the ith task
C_i	worst case execution time of τ_i
T_i	period of τ_i
W_i	weight of τ_i
Γ	task set, $\{\tau_0, ..., \tau_{n-1}\}$
H_Γ	hyperperiod of Γ
U_Γ	the system utilization
$J_{i,j}$	the jth job of τ_i
$JStart_{i,j}$	the start time of $J_{i,j}$
$JEnd_{i,j}$	the end time of $J_{i,j}$
Z_i	the ith Zone
$ZStart_i$	the start time of Z_i
$ZEnd_i$	the end time of Z_i
$ZWidth_i$	the width of Z_i
Rem_i	unassigned time units in Z_i
L_i	laxity of τ_i
R_i	remaining execution time of τ_i
$alloc_{i,j}$	assigned time units for τ_i in Z_j

All the symbols are listed in 1.

II. Overload effect

Definition 1. *The minimum load of τ_i in Z_k is the minimum units of execution time that must be assigned to τ_i in Z_k to meet the deadline.*

$$Lt_{i,k} = MAX(0, ZWidth_k - L_{i,k})$$

Definition 2. *The maximum load of τ_i in Z_k is the maximum units of execution time that can be assigned to τ_i in Z_k considering the WCET of a job and the width of a Zone(to ensure a task can only be executed in a processor at a time).*

$$Mt_{i,k} = MIN(R_{i,k}, ZWidth_k)$$

Definition 3. *The execution assignment is **rational** in Z_k if execution time assigned to each task is between minimum load and maximum load, and the sum of execution time of tasks in Γ doesn't exceed the capacity of Z_k.*

$$\forall i \in [0, n) : Lt_{i,k} \leq alloc_{i,k} \leq Mt_{i,k}$$

$$\sum_{i=0}^{n-1} alloc_{i,k} \leq m \cdot ZWidth_k$$

Definition 4. ***Overload effect*** *occurs if the total minimum load of tasks in* Γ *is more than the capacity of* Z_k.

$$\sum_{i=0}^{n-1} Lt_{i,k} > m \cdot ZWidth_k$$

IV. Algorithm

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V. Correctness of algorithm

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VI. Assessment

I. Complexity

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II. Simulation

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References

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