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Improved Partitioned Queue Scheduling in Multiprocessor Soft Real Time Systems

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Abstract: Multiprocessor scheduling in real time systems follows global queue and partitioned queue methods. Partitioned queue scheduling technique organised with dedicated queues and tasks are scheduled to corresponding processor, based on Earliest Deadline First (EDF) algorithm. EDF is an optimal technique to schedule aperiodic, periodic and sporadic tasks in Real Time Systems (RTS). Deadline of the task is a major objective of EDF and resource maintenances are negligible. It increases task migration and switching between jobs to achieve the need. Context switching reduces the system quality of services and also increases overhead. In our paper we propose D-EDF (Desirable EDF) technique with 'claim ' value μ(t), which schedules aperiodic tasks feasibly, as well as reducing the context switching and improving the efficiency of system performance apart from reducing overheads.

Key words: Real Time Systems · Deadline · EDF · Context Switching · Task Scheduling

INTRODUCTION

In Real time systems, system performance is based not only on producing correct results but also in which instance of time results are produced. Finishing a task before its deadline is the major goal of scheduling algorithms of RTS. In soft real time systems, missing deadline leads to inefficient or wrong output but in Hard RTS it causes catastrophic events. Scheduling a task using suitable algorithm improves the system performance. Rate-monotonic, EDF, PREC and LST are some important algorithms. In multiprocessor scheduling, global queuing and partitioned queuing are the mostly used scheduling techniques. Global queuing is designed with common queue which is shared among number of processors. Cluster of CPU can execute any task which waits in a queue. Partitioned queuing dedicated with separate local queue and processing in each queue are allotted to specific CPU based only on EDF algorithm (i.e.) which is having earliest deadline and can utilise CPU for its execution. In EDF algorithm, before scheduling a task-set, utility factor will be calculated to find whether EDF is feasible to schedule a given set. Equation (1) shows the utility factor calculation formula.

$$\sum_{i=1}^{n} C_i / D_i = \sum_{i=1}^{n} U_i <= 1 \qquad (1)$$

(C = Execution Time, D=Deadline, U=Utility Factor)

EDF algorithm makes tasks to meet deadline but ignores system power and other criteria like throughput, context switching, waiting time and turnaround time which are essential to maintain a system performance. In our paper we propose a new technique to improve the feasibility of EDF algorithm which reduces context switching, task migration as well as improving the system performance by enhancing the throughput of the multiprocessor system.

Related Work: Review of literature shows that lots of contributions are given from researcher's side to achieve the feasibility of multiprocessor scheduling. To improve the system performance number of techniques designed by various authors. Power aware scheduling algorithm in paper [1] motivates this work. In this paper Scheduling Component (SC) is joined with Dynamic Voltage and Frequency Scaling (DVFS) of the system and reduces

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the response time. Here each processor is assigned with single task and next tasks are splitted in to cycles and executed in more than one processor. But for huge number of tasks splitting and task migration between the processors increases the system overheads and context switching. In paper [2], changes made in global EDF method by calculating laxity time which combines EDF and already existing LST algorithm. But with most of the times EFDF which proposed by author gives same result which produced by EDF algorithm.

Constrained deadlines based sporadic tasks scheduling in partitioned queuing technique focused in paper [3]. Static priority based allocation followed and simulated annealing technique to reduce the WCRT (Worst Case Run Time) overrun faults. Increasing the laxity value to improve the schedulability in partitioned scheduling with fork-join model to overcome task migrations which designed for Linux Kernel proposed in paper [4-7]. Scheduling the task set based on processor afficinity and feasibility with virtual laxity in [4] derives the laxity value by subtracting deadline with remaining burst time of the process.

In paper [8] an algorithm is designed to reduce the task migration in semi-partitioned fixed-priority queuing of sporadic processes on multiprocessors. Restricted pre-emption allotted to the given tasks to control the migration in paper [9]. True-time box maintenance to improve the feasibility of EDF algorithm in NCS derived by Mr. Bo Chen and his group Fuzzy set based EDF algorithm introduced in [10] to maintain the critical situation in unsteadiness and unpredictability environment.

AED heuristics [11] with feedback control technique to find and modify the packet priority arrangements in real time systems to overcome the overloaded problems happens in EDF Algorithm. Handling EDF algorithm in overloaded situation and distributing the missed deadline ratios among all real time tasks using fuzzy control discussed in paper [12]. Two level EDF heuristic to execute the given task set in feasible manner with complex constraints given by Mr.isovic in his research [13].

Proposed Method: The main aim of this research is to improve the system performance by reduces number of context switching happens between aperiodic tasks and reduces overhead of multiprocessor systems. To prove the efficiency of the proposed method partitioned queue with 'N' processors are taken and each processor designed with dedicated local queue. Task set is given as input to multiprocessor system. Local queue size is considered as 'S'. When tasks enter in to system based on arrival time, tasks are allotted to local queue in FCFS manner.

Using EDF algorithm dynamic priority is assigned to the task and the task in queue enters in to processor for execution. When any new process enters in to queue, comparison of deadline between Ti and Tj happens and task with least earliest deadline can pre-empt another task. In proposed method instead of using EDF algorithm we used D-EDF technique. It allows the task which is in local queue to utilise CPU. If new task enter into queue, comparisons starts by calculating 'Claim' value $\mu(t)$ shown in equation 2.

$$\mu(t)=C(j)+c'(i)+ \acute{\Gamma} \quad (2)$$

Next executed Task [ŋ (ţ)] chosen by comparing μ (t) value with Ď (j) which is the deadline of next job. Equation 3 gives the formula to fix Next executed task [ŋ (ţ)].

[ŋ (þ)]= { $Þ_i$ μ (t) <=Ď (j)

$Þ_j$ μ (t)> Ď (j) (3)

Given task set in local queue scheduled in processors based on this heuristic until the queue become empty. Observation of the algorithm gives less number of context switching between tasks and also it satisfies the scheduling criteria of conventional operating systems like less turnaroundtime, waiting time and high throughput compare to global EDF method.

Pseudo Code:

Input: Task set ($Þ_0$... $Þ_n$), Burst time(C_0..C_n), Absolute Deadline($Ď_0$... $Ď_n$)

Initialize: N=Number of processor, LQ ($_{0 \ldots N}$) = {ø},

I = currently executed task
c' = remaining burst time
Set j = i++
ŋ (þ) = Next task to be scheduled
Ѓ = current CPU time

Assign $Þ_0$... $Þ_n$ to LQ_0...LQ_N based on FCFS algorithm

While $((LQ_0...L_N) \neq \{\emptyset\})$
{Burst task ($Þ_0$... $Þ_n$) in processor (0...N) based on earliest deadline

C' (i) =C (i) -Ѓ
µ (t) =C (j) +c' (i) + Ѓ
ŋ (ţ) = {$Þ_i$ µ (t) <= Ď (j)
$Þ_j$ µ (t) > Ď (j) }

Experimental Anaysis: To elaborate the efficiency of proposed techniques, task-set with 9 processes ($Þ_1$... $Þ_9$) shown in table 1 assigned to multiprocessor real time systems organised based on partitioned queue technique. Number of processors assumed as 3 (N=3). Queues (LQ ($_{1...3}$)) assigned with the process based on FCFS algorithm. For given example LQ1={ $Þ_1$, $Þ_4$, $Þ_7$}, LQ2=={ $Þ_2$, $Þ_5$, $Þ_8$}, LQ3={ $Þ_3$, $Þ_6$, $Þ_9$}.]. Tasks are Aperiodic and load balancing with checking the utility factor of each processor is negligible. From queue process are dispatched to corresponding CPU based on proposed heuristic.

Comparative analysis in Table 2 shows the efficiency of proposed technique D-EDF which reduce context switching and improves system performance compared to global EDF and EFDF proposed in [1]. Csc gives context switching count, At gives Average waiting time and Att gives Average turnaround time.

Table 1: Process-set with Nine Tasks

Þ	$A_{t(ARRIVAL\ TIME)}$	C	D	U
$Þ_1$	0	3	7	0.429
$Þ_2$	0	4	11	0.3636
$Þ_3$	0	5	13	0.384
$Þ_4$	2	2	5	0.4
$Þ_5$	2	2	8	0.25
$Þ_6$	3	4	9	0.444
$Þ_7$	3	20	29	0.689
$Þ_8$	4	14	21	0.8235
$Þ_9$	5	9	20	0.45

Table 2: Comparison Table

Symmetric multiprocessor system

Criteria	GEDF	EFDF [1]	D-EDF	Units saved
Csc	9	9	6	33.33%
At	11.6	11.6	10.6	8.62%
At	32.99	32.99	31.8	3.6%

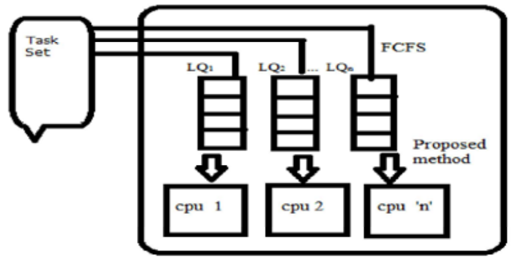

Fig. 1: Partitioned Queue Multiprocessor System Model

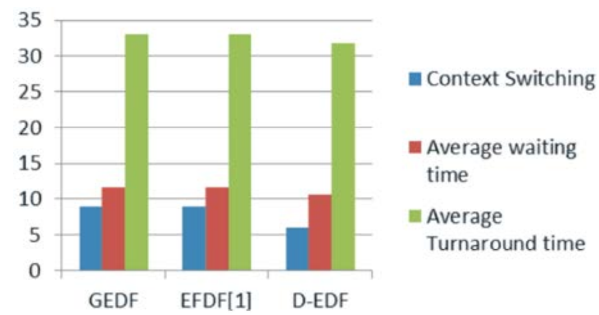

Fig. 2: Comparison of D-EDF with existing technique In reduction of switching

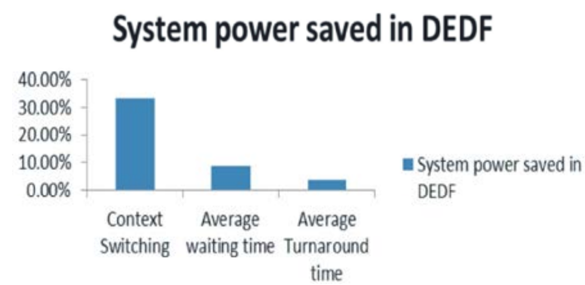

Fig. 3: Units saved with D-EDF algorithm

Context switching occupies more system power resource and increases the overheads. Even average waiting time and turnaround time are not essential criteria of RTS scheduling. System overall performance based on not only finish a task deform its deadline also to improve the throughput of the system. System throughput is inversely propositional to waiting time and turnaround time of the system. Comparative analysis of figure 2 and figure 3 justifies the efficiency of proposed heuristic which improves the system performance by reducing switching, waiting time, turnaround time and increase throughput of the system.

CONCLUSION

In our paper we design a heuristic algorithm D-EDF in multiprocessor partitioned queuing Technique. From our experimental analysis and comparative studies it's concluded that Compare to EDF algorithm which used to dispatch a process from ready state to running state, D-EDF gives better and feasible schedule. Instead of check and concentrates only on deadline values,task switching also considered as a parameter and necessity of task switching decided with a calculated 'Claim' value, which reduce the overheads by unnecessarily migrate the tasks between ready queue and processor. Reduction of context switching automatically reduce all the waiting times and turnaround times of a task set which increases the throughput of multiprocessor system and save a system power in wide manner. Future work of this research may extend with scheduling periodic tasks with proposed technique.

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