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Fuzzy EDF Algorithm for Soft Real Time Systems

[1]P.Vijayakumar, [2]P.Aparna

[1]*Asst.Prof (Sr.G)/E.C.E., SRM University, Kattankulathur, Chennai.*
Vijay_at23@rediffmail.com
[2]*(M.Tech-Embedded Systems) SRM University, Kattankulathur, Chennai.*
aparnapratti@gmail.com.

***Abstract* - EDF is a classic dynamic embedded real-time multi-task scheduling algorithm. In an embedded soft real-time system, the deadline missing ratio is an important metric to evaluate system performance. When an embedded soft real-time system is overloaded, EDF algorithm is not effective. Considering the unsteadiness and unpredictability of a practical task running environment due to the unsteadiness of network communication and the time estimation deviation, it is necessary to introduce Fuzzy concept and theory to the scheduling field of embedded soft real-time application systems. In fuzzy scheduling model, all task's criticality and deadline distance are described with Fuzzy set. In our scheduling algorithm, a task's scheduling priority is gotten by looking up the inference rule table with its Fuzzy deadline distance and Fuzzy criticality patterns. By comparing to traditional EDF algorithm to FUZZY EDF Algorithm FUZZY EDF Algorithm will have the less miss dead line ratio.**

***Key Words* - Fuzzify, Miss dead line ratio, Fuzzy Inference, EDF.**

I. INTRODUCTION

Many real-time applications require periodic activities that have to be cyclically executed at fixed rates and within specific deadlines. Real operating systems have to manage many concurrent applications with varying resource requirements. Typically, each periodic instance is assigned a relative deadline equal to the task period and is treated as a hard job. Applications with such time-dependent resource requirements are often referred to as soft real-time. Schedulability analysis of periodic task sets can easily be performed both under fixed and dynamic priority assignments. EDF (Earliest Deadline First) is one of the most classic dynamic priority scheduling algorithms in which the priority of a task is determined according to its deadline distance. A task which has the shortest deadline distance is allocated the highest priority, and then it is first scheduled. Under certain conditions, Earliest Deadline First (EDF) is an optimal dynamic scheduling algorithm in resource sufficient environments. EDF algorithm has Utilization bound of 100%.the Schedulability test for EDF is:

$$\sum_{i=1}^{n} \frac{ei}{pi} \leq 1 \qquad (1)$$

Where

ei is the worst case execution time of task,

Pi is the respective inter arrival times.

EDF algorithm is a dynamic algorithm that does not require processes to be periodic. Whenever process needs the CPU time, it announces its presence and its dead line. If a soft real-time system is overloaded, the distribution of miss deadline ratio is not rectangular in the EDF scheduling system. The usually scene is some tasks have many miss deadlines and some tasks have not any miss deadlines. Thus, many tasks may have noticeable degradation in quality of service when the real-time system is overloaded. So we should have a mechanism to distribute the miss deadlines uniformly among all tasks.

Fig1: Output Of TRADITIONAL EDF Algorithm

Considering the unsteadiness and unpredictability characteristics of the practical tasks' running environment, it is necessary to employ the fuzzy control theory to dynamically adjust the priority of each task. In the Fig1 the miss dead line ratio of the task is 66.6% under overload conditions.

II. FUZZY INFERENCE SYSTEM

Fuzzy logic is extension of Boolean logic dealing with the concept of partial truth which denotes the extension to which proposition is true. Whereas classic logic holds that everything can be expressed in terms of binary numbers. Fuzzy logic deals with Boolean truth value with degree of truth. Degree of truth is often employed to

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decisions in an environment of uncertainty and imprecision. Fuzzy Inference Systems (FIS) are conceptually very simple. They consist of an input, a processing, and an output stage. The input stage maps the inputs, such as frequency of reference, recency of reference, and so on, to the appropriate membership functions and truth values. The processing stage invokes each appropriate rule and generates a corresponding result. It then combines the results. Finally, the output stage converts the combined result back into a specific output value. The five steps toward a fuzzy inference are as follows:

- Fuzzifying inputs
- Applying fuzzy operators
- Applying implication methods
- Aggregating outputs
- Defuzzifying results

In this paper, we proposed an improved EDF based on fuzzy inference scheduling model which is more suitable for embedded soft real-time systems in an uncertain environment. In our model, the scheduling priority of a task is mainly decided by its Fuzzified deadline distance and Fuzzified criticality.

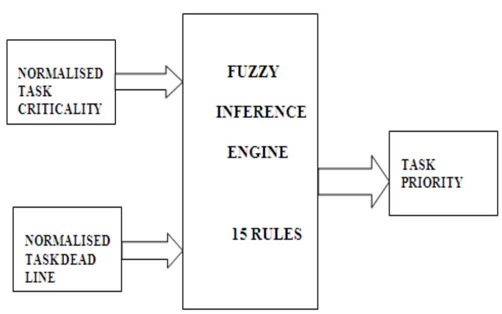

Fig2. Process to Get Scheduling Priority by Fuzzy Inference

This figure illustrates the process to get the scheduling priority by fuzzy inference. A task‘s criticality and deadline distance are fuzzified by their domain transformers and fuzzifiers; after gotten a task’s fuzzy sets of deadline distance and criticality, we match these fuzzy sets with standard fuzzy set patterns to get the inputs of the fuzzy inference rule table; then we may get a task’s final fuzzy scheduling priority by looking up fuzzy inference table.

III. TASK MODEL

In general, most tasks of an embedded soft real-time multi-task system are periodic. Every periodic taskT*i* in an uncertain environment may be described with a 8-tuple:

BCETi < AETi < WCETi < Di, and

BCETi<=EETi <=WCETi<=Di, Di = Ti.

Si is the arrival time of the task *Ti*, and we assume that arriving time of a task is its ready time; *BCETi* is its best case execution time; *WCETi* is its worst case execution time; *EETi* is its estimated average execution time, *AETi* is the actual average execution time which is time varying and unknown to the scheduler in an uncertain environment. *Di* isthe relative deadline of task T*i*; *Pi* is its relative criticality and *Ti* is its period. To the kth (k>=1) execution of T*i*, its absolute ready time is *Si+(k-1)*Ti* and its absolute deadline is *Si+(k-1)*Ti+Di*, respectively. We call one execution of a periodic task as one instance or one execution request. In our paper, a periodic task’s deadline missing ratio is defined as the number of deadline misses divided by the total number of a task’s instances in a sampling time window.

IV. FUZZIFICATION AND FUZZY INFERENCE

In improved EDF scheduling model based on fuzzy inference, we set the fuzzy set domain as follows:

U={0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0}

The fuzzy partition sets of deadline distance *T(Idf) = {very short, short, normal, long , very long}*, and The fuzzy partition sets of the criticality *T(Icf) = {low,normal, high}* and The fuzzy partition sets of final fuzzy scheduling priorities *T(Op ={high, normal, low}*.

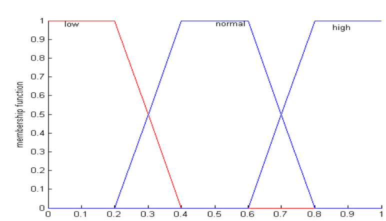

Fig3: Membership Function of Criticality

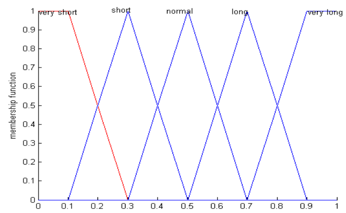

Fig4: Membership Function of Dead Line Distance.

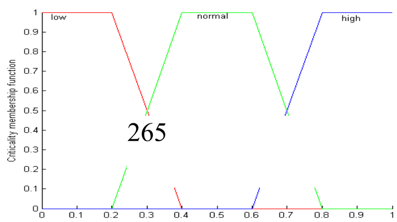

Fig5: Membership Function of Fuzzy Scheduling priority.

To fuzzify the deadline distance, we transform the deadline distance value (*dd* denotes the value) of task Ti into its fuzzy set according to the following steps:

1) Domain transformation: r*ela_deadline_dist = dd* / *D*, *D* is the period of task.
2) Fuzzification: if *rela_deadline_dist* is in *U*, we fuzzify it by singleton method.

V. FUZZY INFERENCE

Fuzzy inference rules, which includes 15 fuzzy inference rules. The rules are as follows:

R1: if (the criticality is *low*) and (the deadline distance is *very short)* then the scheduling fuzzy priority is *low*;

R15: if (the criticality is *high*) and (the deadline distance is *very short)* then the scheduling fuzzy priority is *high*.

Table1: The Fuzzy Inference Rules.

T(Idf)/ T(Op)/ T(Icf)	Very short	short	normal	long	Very long
Low	low	low	low	low	Low
normal	low	normal	normal	normal	high
high	high	high	high	high	high

VI. READY TASK QUEUES AND FUZZY SCHEDULING PRIORITY

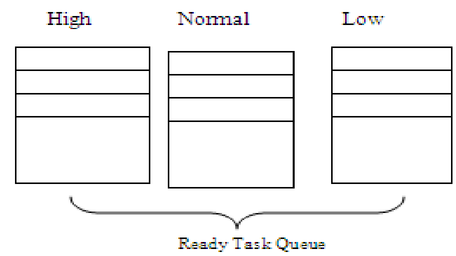

Fig6: Ready Task Queue Model

The above figure shows the ready task queue model which is composed of three sub queues (corresponding to the fuzzy partition sets of fuzzy scheduling priorities T (Op) = {high, normal, low} respectively). All tasks in

priority ready sub queue by its fuzzy scheduling priority.

VII. SCHEDULING POLICY

In our fuzzy EDF scheduling model, the scheduling policy is as the following:

1) To the tasks in different fuzzy priority ready sub queues, the ones which are in the highest fuzzy priority ready sub queue will be scheduled first. So, the ready tasks in the **high** ready sub-queue have highest scheduling priority; only if the **high** ready sub-queue is empty, the ready tasks in **normal** ready sub queue are considered.

Namely the scheduling precedence sequence of ready task sub queues is: **high, normal, low**.

2. To the tasks in the same fuzzy ready priority sub queue, we adopt the EDF scheduling policy, namely the task who has the shortest deadline distance will be scheduled first.
3. in the running of a task, if there is a higher fuzzy priority task is ready, preempt the current task's running right, namely we adopt the preemptive scheduling policy.

CONCLUSION AND FUTURE WORK

The FUZZY EDF algorithm will be developed with this fuzzy inference Rules. So the Miss dead line ratio of the tasks will be reduced compared to traditional EDF algorithm. The Fuzzy EDF algorithm will be implemented in DSP Processor.

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