On-line Scheduling Of Hard Real-Time Tasks On Multiprocessors

By

M. DOMINIC ANGELO PAULRAJ

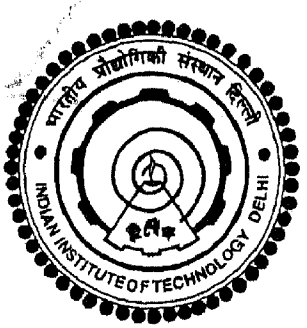
Department of Computer Science and Engineering

Submitted

in fulfillment of the requirements of the degree of

Doctor of Philosophy

to the



Indian Institute of Technology, Delhi

December 1997

CERTIFICATE

This is to certify that the thesis entitled **"On-line Scheduling Of Hard Real-Time Tasks On Multiprocessors"** being submitted by **Mr. M. Dominic Angelo Paulraj** to the Department of Computer Science and Engineering, Indian Institute of Technology, New Delhi for the award of the degree of **"Doctor of Philosophy"** is a record of the bonafide research work carried out by him. Mr. M. Dominic Angelo Paulraj worked under my guidance for the submission of this thesis which to my knowledge has reached the requisite standard.

This thesis or any part thereof has not been submitted to any other university/institution for the award of any degree or diploma.

B.N. JAIN
Professor
Department of Computer Science and Engineering
Indian Institute of Technology,
New Delhi - 110 016

ACKNOWLEDGEMENTS

I wish to take this opportunity to thank all the people who have contributed in making this dissertation possible.

I dedicate this work to my wife Flora Dominic for her patience. She was my constant source of encouragement and without her support, this work would not have been possible.

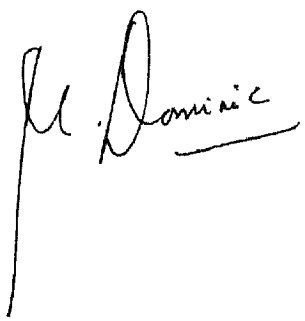
I wish to express my deep sense of gratitude to Prof. B.N.Jain who not only helped supervise this dissertation, but was also a constant source of encouragement. He introduced me to the problem of real-time scheduling on multiprocessors. I am glad to have had the opportunity of having worked under him for this dissertation.

I sincerely thank Dr. Sanjeev Kapoor and Dr. Pankaj Mehra for their valuable suggestions.

I wish to thank my sister Mrs. Catherine Francis and my colleague Mr. Yuvraj Mathur for editing this dissertation (including this page).

I wish to thank my Company directors Mr. Raghavan and Mr. Michael Noronha for their moral and financial support.

The constant support provided by my family members especially my dad Mr. G. Maria Joseph, my mom Mrs. Mary Stella, my wife Flora, and my sons Derrick and Jeff, has been, to say the least, most valuable and critical.



ABSTRACT

We consider the problem of *on-line* scheduling of *hard real-time sporadic* tasks on *multiple* processors. For a given set of ready tasks, one can propose many schedules. These schedules, however, may not necessarily be suitable for on-line scheduling. A suitable schedule for on-line scheduling is one which can accommodate any future task set when it arrives.

The problem in designing an on-line scheduling algorithm is to schedule the ready tasks (with known parameters) in a manner such that future tasks can be scheduled as and when they arrive. However, the decision taken by an on-line scheduler on the set of ready tasks may or may not be suitable for scheduling future tasks. It is, therefore, important that an on-line scheduler schedules the ready tasks in a manner such that adequate resources are available to schedule future tasks.

The traditional approach to solving the on-line scheduling problem is to propose a heuristic and to prove its effectiveness by comparing it with existing heuristics using simulation. No attempt has, however, been made to obtain a condition on the current schedule which when satisfied will permit one to schedule an arbitrary future task.

In this thesis, we aim at developing such a condition on the schedule for ready tasks, which when satisfied can accommodate any future *feasible* task set. The problem is addressed in the context of time-driven schedulers where real-time constraints are expressed in terms of *time units*, and not *priorities*. We consider only feasible sporadic tasks which are pre-emptable and may migrate from one processor to another without incurring any additional cost.

We then propose an on-line scheduler, called MLLA (Modified Least Laxity Algorithm), which results in a schedule that satisfies the above condition for a class of task sets. We prove that a task set, for which the schedule obtained using MLLA does not satisfy the proposed necessary and sufficient condition, cannot be scheduled on-line.

The modified least laxity algorithm was implemented and tested on a large collection of randomly generated task sets. We generate a set of feasible tasks to be scheduled on m (typically 3 or 4) processors. From the simulation results we conclude that the schedule obtained by MLLA is better compared to other known algorithms.

Contents