Real-Time Syst (2008) 40: 264–289
DOI 10.1007/s11241-008-9061-6

EDZL scheduling analysis

Theodore P. Baker · Michele Cirinei · Marko Bertogna

Published online: 17 September 2008

Abstract A schedulability test is derived for the global Earliest Deadline Zero Laxity (EDZL) scheduling algorithm on a platform with multiple identical processors. The test is sufficient, but not necessary, to guarantee that a system of independent sporadic tasks with arbitrary deadlines will be successfully scheduled, with no missed deadlines, by the multiprocessor EDZL algorithm. Global EDZL is known to be at least as effective as global Earliest-Deadline-First (EDF) in scheduling task sets to meet deadlines. It is shown, by testing on large numbers of pseudo-randomly generated task sets, that the combination of EDZL and the new schedulability test is able to guarantee that far more task sets meet deadlines than the combination of EDF and known EDF schedulability tests.

In the second part of the paper, an improved version of the EDZL-schedulability test is presented. This new algorithm is able to efficiently exploit information on the slack values of interfering tasks, to iteratively refine the estimation of the interference a task can be subjected to. This iterative algorithm is shown to have better performance than the initial test, in terms of schedulable task sets detected.

This is an extended version of the ECRTS'07 paper of Cirinei and Baker (2007), with corrections of some flaws in that original paper and a new iterative schedulability test based on Cirinei (2007).
This material is based upon work supported in part by the National Science Foundation under Grant No. 0509131, and a DURIP grant from the Army Research Office.

T.P. Baker (✉)
Department of Computer Science, Florida State University, Tallahassee, FL 32306-4530, USA
e-mail: baker@cs.fsu.edu

M. Cirinei · M. Bertogna
ReTIS Lab, Scuola Superiore Sant'Anna, Pisa, Italy

M. Cirinei
e-mail: cirinei@gandalf.sssup.it

M. Bertogna
e-mail: marko@sssup.it

Keywords EDF · Earliest deadline first · EDZL · Earliest deadline zero laxity · Multiprocessor · Real time · Scheduling · Symmetric multiprocessing · Schedulability

1 Introduction

EDZL is a hybrid preemptive priority scheduling scheme in which jobs with zero laxity are given highest priority and other jobs are ranked by deadline. In this report we apply demand analysis to Earliest Deadline Zero Laxity (EDZL) scheduling, and derive conditions that are sufficient to guarantee that a system of independent sporadic tasks with arbitrary deadlines will not miss any deadline if scheduled by global EDZL on a platform with m identical processors. We also show through experiments how the new EDZL schedulability tests compare to known schedulability tests for global Earliest-Deadline-First (EDF) scheduling, on large numbers of pseudo-randomly generated task sets.

It was previously shown by Cho et al. (2002) that when EDZL is applied as a global scheduling algorithm for a platform with m identical processors its ability to meet deadlines is never worse than pure global EDF scheduling, and that it is "suboptimal" for the two processor case, meaning that "every feasible set of ready tasks is schedulable" by the algorithm. They propose this weak definition of optimality as being appropriate for on-line scheduling algorithms, which cannot take into account future task arrivals. Cho et al. also provide experimental data, showing that even though EDZL is not "suboptimal" for $m > 2$, it still performs very well. EDZL is a proper extension of EDF, in the sense that both EDZL and EDF make the same scheduling decisions up to a point where a job with zero laxity would not be scheduled by EDF. It follows that EDZL incurs at most one additional preemption overhead over EDF per job, and the additional preemption occurs only for jobs that would fail to meet their deadlines under EDF scheduling.

However, for systems with hard deadlines even optimal scheduling performance is not enough if there is no practical algorithmic way to verify that a task set will be scheduled to meet all its deadlines. In this paper, we address that need, by deriving tests that are sufficient to verify schedulability for sets of independent sporadic task sets under global EDZL scheduling on m identical processors. We describe and prove the correctness of several tests, starting from a simple one and improving the tightness of the schedulability conditions by progressively refining the estimation of the mutual interferences imposed among the various tasks. This allows us to derive schedulability testing algorithms that are proved to detect many more schedulable task sets than existing techniques.

2 Task system model

A *sporadic task* $\tau_i = (e_i, d_i, p_i)$ is an abstraction of a process that generates a potentially infinite sequence of *jobs*. Each job has a *release time*, an *execution time*, and an *absolute deadline*. The execution time of every job of a task τ_i is bounded