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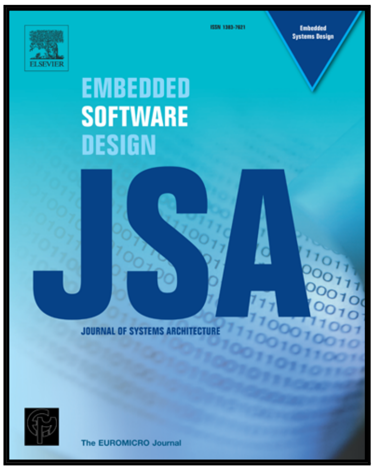

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Job-Shifting: An Algorithm for Online Admission of Non-Preemptive Aperiodic Tasks in Safety Critical Systems

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Abstract

Modern safety critical systems require certification in order to guarantee correct operation before system deployment. The certification process requires rigorous verification and validation, the efforts for which can be greatly reduced by using resource partitioning. However, Lackorzyński et al. demonstrated that bandwidth reservation for event-triggered (ET) activities in partitioned systems may lead to significant bandwidth loss. In contrast, the online admission of ET activities can prevent bandwidth losses. However, the state-of-the-art approaches for online admission of ET activities fail to fulfill the requirements of safety critical systems as they do not support (i) partitioning, (ii) the industrial mixed-criticality task model or (iii) non-preemptive task execution.

In this paper, we present job-shifting algorithm for online admission of non-preemptive aperiodic tasks in partitioned time-triggered environment. Our approach circumvents the bandwidth loss issue with partitioning, and provides guarantees similar to the bandwidth reservation technique such that the certification process of safety critical systems need not be modified. Our approach can be implemented on top of variety of hypervisors and can provide lower response-times for aperiodic tasks. Through evaluation, we demonstrate that our approach efficiently utilizes processor bandwidth and only incurs small scheduling overheads.

Keywords: Real-time systems, Scheduling algorithms, Mixed-criticality, Hierarchic scheduling, Online aperiodic admission

1. Introduction

For safety critical applications, the certification process makes sure that the system will meet the required constraints upon deployment. This process is utilized to define if the product can be safely deployed for the desired application. However, the certification process requires rigorous verification and validation (V&V) of the system, and therefore, the process complexity increases as the system size increases. Partitioning or virtualization enables certification of a sub-system irrespective of the behaviour of other sub-systems, and as a result, reduces the V&V efforts [1].

Depending on the application requirements, a computing system may be required to handle several constraints. In real-time systems, periodic tasks can easily be serviced using time-triggered (TT) mechanisms due to predictable repetitive arrival patterns. However in the case of aperiodic tasks, TT mechanisms like offline bandwidth reservation may lead to over-provisioning, and therefore, may increase cost per feature. The over-provisioning problem becomes increasingly prohibitive with virtualization technologies as these technologies may lead to significant bandwidth loss [2]. Therefore, a new algorithm needs to be developed which provides efficient integration of periodic and aperiodic activities in hierarchic, industrial mixed-critical environments.

Besides bandwidth reservation, a number of techniques are proposed over the last few decades to integrate time-triggered (TT) and event-triggered (ET) activities, for instance, Slack-Stealing [3] and Slot-Shifting [4]. The basic operating principle for both of these approaches is to estimate the information about the amount and distribution of free resources offline and to accommodate aperiodic tasks online. A number of extensions were also proposed for both of these algorithms to compensate for new constraints, e.g., sporadic tasks [5], non-preemptive aperiodic tasks in a preemptive scheduling environment [6] and Vestal's [7] mixed-criticality task model [8]. Although these extensions are viable solutions, they need to frequently keep track of free resources, they are computationally expensive and they cannot be applied on partitioned systems.

In this paper, we present an algorithm which defines availability of free resources in an offline TT scheduling table of non-preemptive tasks, and employs the availability information online to service non-preemptive aperiodic tasks in a partitioned system; we call this algorithm 'Job-

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