Chapter 12
New Optimal Solutions for Real-Time Reconfigurable Periodic Asynchronous OS Tasks with Minimizations of Response Times

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ABSTRACT

This chapter deals with Reconfigurable Uniprocessor embedded Real-Time Systems to be classically implemented by different OS tasks that we suppose independent, asynchronous, and periodic in order to meet functional and temporal properties described in user requirements. The authors define a schedulability algorithm for preemptable, asynchronous, and periodic reconfigurable task systems with arbitrary relative deadlines, scheduled on a uniprocessor by an optimal scheduling algorithm based on the EDF principles and on the dynamic reconfiguration. Two forms of automatic reconfigurations are assumed to be applied at run-time: Addition-Remove of tasks and just modifications of their temporal parameters: WCET and/or Periods. Nevertheless, when such a scenario is applied to save the system at the occurrence of hardware-software faults, or to improve its performance, some real-time properties can be violated. The authors define a new semantic of the reconfiguration where a crucial criterion to consider is the automatic improvement of the system's feasibility at run-time by using an Intelligent Agent that automatically checks the system's feasibility after any reconfiguration scenario to verify if all tasks meet

DOI: 10.4018/978-1-4666-3922-5.ch012

the required deadlines. Indeed, if a reconfiguration scenario is applied at run-time, then the Intelligent Agent dynamically provides otherwise precious technical solutions for users to remove some tasks according to predefined heuristic (based on soft or hard task), or by modifying the Worst Case Execution Times (WCETs), periods, and/or deadlines of tasks that violate corresponding constraints by new ones, in order to meet deadlines and to minimize their response time. To handle all possible reconfiguration solutions, they propose an agent-based architecture that applies automatic reconfigurations in order to re-obtain the system's feasibility and to satisfy user requirements. Therefore, the authors developed the tool RT-Reconfiguration to support these contributions that they apply to a Blackberry Bold 9700 and to a Volvo system as running example systems and we apply the Real-Time Simulator Cheddar to check the whole system behavior and to evaluate the performance of the algorithm (detailed descriptions are available at the Website: http://beru.univ-brest.fr/~singhoff/cheddar). The authors present simulations of this architecture where they evaluate the agent that they implemented. In addition, the authors present and discuss the results of experiments that compare the accuracy and the performance of their algorithm with others.

INTRODUCTION

Real-Time systems are playing a crucial role in our society, and in the last two decades, there has been an explosive growth in the number of real-time systems being used in our daily lives and in industry production. Systems such as chemical and nuclear plant control, space missions, flight control systems, military systems, telecommunications, multimedia systems, and so on all make use of real-time technologies. The most important attribute of real-time systems is that the correctness of such systems depends on not only the computed results but also on the time at which results are produced. In other words, real-time systems have timing requirements that must be guaranteed. Scheduling and schedulability analysis enables these guarantees to be provided. Common denominators for these embedded systems are real-time constraints. These systems are often safety critical and must react to the environment instantly on an event. Imagine for example the airbag of a car not going off instantly as a crash occurs; reaction time delay would be disastrous (Gharsellaoui et al., 2011). Several interesting academic and industrial research works have been made last years to develop reconfigurable systems. We distinguish in these works two reconfiguration policies: static and dynamic reconfigurations where static reconfigurations are applied off-line to apply changes before the system cold start (Angelov et al., 2005) whereas dynamic reconfigurations are applied dynamically at run-time. Two cases exist in the last policy: manual reconfigurations applied by user (Rooker et al., 2007) and automatic reconfigurations applied by Intelligent Agents (Khalgui, 2010; Al-Safi & Vyatkin, 2007).

Also, today in academy and manufacturing industry, many research works have been made dealing with real-time scheduling of embedded control systems. The new generations of these systems are addressing today new criteria as flexibility and agility. For this reason many reconfigurable embedded control systems have been developed in recent years.

In this book chapter, we are interested in the automatic reconfiguration of embedded real time Systems.

We define at first time a new semantic of this type of reconfiguration where a crucial criterion to consider is the automatic improvement of the system's feasibility at run-time. We propose

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