Chapter X
Computational Intelligence to Speed-Up Multi-Objective Design Space Exploration of Embedded Systems

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ABSTRACT

Multi-Objective Evolutionary Algorithms (MOEAs) have received increasing interest in industry, because they have proved to be powerful optimizers. Despite the great success achieved, MOEAs have also encountered many challenges in real-world applications. One of the main difficulties in applying MOEAs is the large number of fitness evaluations (objective calculations) that are often needed before a well acceptable solution can be found. In fact, there are several industrial situations in which both fitness evaluations are computationally expensive and, meanwhile, time available is very low. In this applications efficient strategies to approximate the fitness function have to be adopted, looking for a trade-off between optimization performances and efficiency. This is the case of a complex embedded *system design, where it is needed to define an optimal architecture in relation to certain performance indexes respecting strict time-to-market constraints. This activity, known as Design Space Exploration DSE), is still a great challenge for the EDA (Electronic Design Automation) community. One of the most important bottleneck in the overall design flow of a embedded system is due to the simulation. Simulation occurs at every phase of the design flow and it is used to evaluate a system candidate to be implemented. In this chapter we focus on system level design proposing a hybrid computational intelligence approach based on fuzzy approximation to speed up the evaluation of a candidate system. The methodology is applied to a real case study: optimization of the performance and power consumption of an embedded architecture based on a Very Long Instruction Word (VLIW) microprocessor in a mobile multimedia application domain. The results, carried out on a multimedia benchmark suite, are compared, in terms of both performance and efficiency, with other MOGAs strategies to demonstrate the scalability and the accuracy of the proposed approach.*

INTRODUCTION

Multi-Objective Evolutionary Algorithms (MOEAs) have received increasing interest in industry, because they have proved to be powerful optimizers. Despite the great success achieved, however, MOEAs have also encountered many challenges in real-world applications. One of the main difficulties in applying MOEAs is the large number of fitness evaluations (objective calculations) that are often needed before an acceptable solution can be found. There are, in fact, several industrial situations in which fitness evaluations are computationally expensive and the time available is very short. In these applications efficient strategies to approximate the fitness function have to be adopted, looking for a trade-off between performance and efficiency. This is the case in designing a complex embedded system, where it is necessary to define an optimal architecture in relation to certain performance indexes while respecting strict time-to-market constraints.

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular kind of application device. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines, and toys (as well as the more obvious cellular phone and PDA) are among the myriad possible hosts of an embedded system. In fact, the embedded systems market is without doubt of great economic importance nowadays. The global embedded systems market is expected to be worth nearly US$88 billion in 2009, including US$78 billion of hardware and US$3.5 billion of software, according to a Canadian research firm.

For some years now the market has far exceeded that of PC systems. To have an idea of how embedded systems are pervading our daily lives it is sufficient to recall, for example, that there are more than 80 software programs for driving, brakes, petrol control, street finders and air bags installed in the latest car models. As compared with a general-purpose computing system, embedded systems are much more cost sensitive and have strict time-to-market constraints.

The design flow of an embedded system features the combined use of heterogeneous techniques, methodologies and tools with which an architectural template is gradually refined step by step on the basis of functional specifications and system requirements. Each phase in the design

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