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SPECIAL ISSUE

Real-time embedded systems powered by FPGA dynamic partial self-reconfiguration: a case study oriented to biometric recognition applications

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Abstract This work aims to pave the way for an efficient open system architecture applied to embedded electronic applications to manage the processing of computationally complex algorithms at real-time and low-cost. The target is to define a standard architecture able to enhance the performance-cost trade-off delivered by other alternatives nowadays in the market like general-purpose multi-core processors. Our approach, sustained by hardware/software (HW/SW) co-design and run-time reconfigurable computing, is synthesizable in SRAM-based programmable logic. As proof-of-concept, a run-time partially reconfigurable field-programmable gate array (FPGA) is addressed to carry out a specific application of high-demanding computational power such as an automatic fingerprint authentication system (AFAS). Biometric personal recognition is a good example of compute-intensive algorithm composed of a series of image processing tasks executed in a sequential order. In our pioneer conception, these tasks are partitioned and synthesized first in a series of coprocessors that are then instantiated and executed multiplexed in time on a partially reconfigurable region of the FPGA. The implementation benchmark of the AFAS either as a pure software approach on a PC platform under a dual-core processor (Intel Core 2 Duo T5600 at 1.83 GHz) or as a reconfigurable FPGA co-design (identical algorithm partitioned in HW/SW tasks operating at 50 or 100 MHz on the second smallest device of the Xilinx Virtex-4 LX family) highlights a speed-up of one order of magnitude in favor of the FPGA alternative. These results let point out biometric recognition as a sensible killer application for run-time reconfigurable computing, mainly in terms of efficiently balancing computational power, functional flexibility and cost. Such features, reached through partial reconfiguration, are easily portable today to a broad range of embedded applications with identical system architecture.

Keywords FPGA · Run-time reconfigurable computing · Reconfiguration controller · Dynamic partial self-reconfiguration · Automatic fingerprint authentication system

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1 Introduction

The development of embedded systems, from a purely commercial perspective, is based on manufacturing a product equipped with such an acceptable level of performance to provide a given functionality to the customer at a competitive price. In the last years, however, a new feature has gained significant relevance and claims to be part of the mentioned list of key factors functionality-performance-price: flexibility. It arises as a mandatory characteristic expected in many roadmaps of embedded applications. Commercial products, especially sophisticated embedded electronic systems, are subject to continuous changes: redesigns due to cost-reduction policies and/or to functional improvements to give rise, in the end, to a new generation of such articles are typical scenarios seen day after day in our consumer society. In consequence, today's product must keep alive, in continuous evolution, while it is in the market. This fact, in its turn, lets it survive and extend its life cycle for some more time. This trend towards