Preface

Recent technology advances have provided faster and smaller devices for manufacturing circuits that while more efficient have become more sensitive to the effects of radiation. Smaller transistor dimensions, higher density integration, lower voltage supplies and higher operating frequencies are some of the characteristics that make energized particles an issue when dealing with integrated circuits in harsh environments. These types of particles have a major influence in processors working in such environments, affecting both the program's execution flow by causing incorrect jumps in the program, and the data stored in memory elements, such as data and program memories, and registers. In order to protect processor systems, fault tolerance techniques have been proposed in literature using hardware-based and software-based approaches, which decrease the system's performance, increase its area, and are not able to fully protect the system against such effects. In this context, we proposed a combination of hardware- and software-based techniques to create hybrid techniques aimed at detecting all the faults affecting the system, at low performance degradation and memory overhead. Five techniques are presented and described in detail, from which two are known software-based only techniques and three are new hybrid techniques, to detect all kinds of transient effects caused by radiation in processors. The techniques are evaluated according to execution time, program and data memories, and area overhead and operating frequency degradation. To verify the effectiveness and the feasibility of the proposed techniques, fault injection campaigns are performed by injecting faults by simulation and performing irradiation experiments in different locations with neutrons and a Cobalt-60 sources. Results have shown that the proposed techniques improve the state-of-the-art by providing high fault detection rates at low penalties on performance degradation and memory overhead.

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Hybrid Fault Tolerance Techniques to Detect Transient Faults in Embedded Processors

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