Accepted Manuscript

Enhancing transient fault tolerance in embedded systems through an OS task level redundancy approach

Seyyed Amir Asghari, Mohammadreza Binesh Marvasti, Amir M. Rahmani

PII: S0167-739X(18)30019-0
DOI: https://doi.org/10.1016/j.future.2018.04.049
Reference: FUTURE 4127

To appear in: *Future Generation Computer Systems*

Received date : 3 January 2018
Revised date : 12 March 2018
Accepted date : 17 April 2018

Please cite this article as: S.A. Asghari, M.B. Marvasti, A.M. Rahmani, Enhancing transient fault tolerance in embedded systems through an OS task level redundancy approach, *Future Generation Computer Systems* (2018), https://doi.org/10.1016/j.future.2018.04.049

Enhancing Transient Fault Tolerance in Embedded Systems through an OS Task Level Redundancy Approach

Seyyed Amir Asghari[1], Mohammadreza Binesh Marvasti[1], and Amir M. Rahmani[2,3]

[1]Department of Electrical and Computer Engineering, Kharazmi University, Tehran, Iran,
[2]Department of Computer Science, University of California, Irvine, USA
[3]Institute for Computer Technology, TU Wien, Vienna, Austria
{asghari,marvasti}@khu.ac.ir, amirr1@uci.edu

Abstract: In numerous safety critical applications, the use of high-reliability or radiation-tolerant equipment may not be a viable option due to the presence of several constraints (such as cost) and the need to utilize Commercial off-the Shelf (COTS) equipment. However, such equipment may not meet reliability requirements, and therefore certain appropriate measures need to be taken to enhance their reliability. In this paper, a fully software-based method is presented to increase the reliability of COTS equipment against transient faults. The reliability of COTS is increased by utilizing a task-level redundancy in operating system. The proposed method is evaluated using a software fault injection method and a full system prototype. The experimental results show that the proposed method increases the fault coverage up to 99.34%. Moreover, the proposed method can be used in embedded systems without any hardware, software, or information redundancy.

Keywords: Embedded system, Fault Tolerance, Operating System, Transient Fault.

1. Introduction

Although the last decade has seen a rapid increase in the use of embedded systems, their reliability in critical missions is still limited. To alleviate the reliability issues, many studies have been done in permanent faults and propose different methods to detect them [1-5]. Transient faults that occur in highly radiated environments have also received a considerable attention. As the probability of SEU (Single Event Upset) occurrence is increased, the dimensions of the problem have been increased. This happens due to reduction in size and increase in the voltage levels of transistors [6-11].
Many techniques presented in literature to enhance fault tolerance require redundant peripheral hardware, which may pose high infrastructure and reconfiguration costs in many applications. As a consequence, many researches endeavor for fully software based techniques to increase fault tolerance in computer systems as well as embedded systems [12-20].

The work done in this paper is motivated by the fact that COTS hardware with COTS operating systems are nowadays widely utilized in embedded systems running critical tasks. Software based techniques that are implemented in operating system level or designed in instruction level, cannot be utilized in many embedded applications and they need specialized operating systems, compilers, and custom preprocessors. These methods usually result in extra overheads in memory and performance. In order to alleviate the foregoing issues, this paper presents a fully software-based method to increase fault tolerance at application level for the real time embedded systems. To the best of our knowledge,