SPACE SYSTEMS SYMPOSIUM (D1)
Enabling Technologies for Space Systems (2)

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EVOLVING COMPLEX PROGRAMS IN TIERRA-BASED ON-BOARD COMPUTER ON UNITEC-1

Abstract

This paper investigates the effectiveness of our proposed OBC (On-Board Computer) loaded in UNITEC-1, which is developed by the several Japanese universities and will be launched to Venus as the piggyback of the JAXA's satellite named "AKATSUKI" (Planet-C) in 2010. Unlike the conventional approaches that employ the shielded devices, multiplex logic circuit, or CPUs with a thick process rule to protect OBC from the bit inversion (Single-Event Upset: SEU) caused by space radiation, our proposed OBC evolves the software programs (hereafter, we just say it programs) through the bit inversion of DRAM by exposing space radiation. This is a unique approach which changes the weak point of OBC to its strong point. To develop such an OBC, our previous research developed Tierra-based On-Board Computer (OBC) which employed the idea of Tierra, the biological evolution simulator, where digital creatures (implemented by the programs) are evolved through the mutation in a gene. Since Tierra executes problems from the biological viewpoint, the following mechanisms were introduced into Tierra-based OBC to executes problems from the engineering viewpoint (e.g., orbit/attitude control, navigation task, optimization problem): (1) the fitness used in Genetic Algorithm (GA) is employed for each program to evaluate its accomplish degree; and (2) the asynchronous GA was proposed to evaluate the programs independently (i.e., the programs are replicated when their fitnesses exceed a certain threshold). As the hardware architecture, Tierra-based OBC is constructed with the MCU (H8) and the DRAM, and the H8 evolves the programs stored in the DRAM.

The final goal of our mission aims at validating that Tierra-based OBC can evolve the programs through the bit inversion caused by space radiation from its experiment results downlinked from UNITEC-1. Towards this goal, this paper investigates the effectiveness of Tierra-based OBC in complex problems before launching UNITEC-1. In detail, the following experiments are conducted by artificial mutating the programs instead of the bit inversion caused by space radiation: the complexity of the program increases (1) by changing the target (output) of the problem; (2) by changing the initial programand (3) by adding the instructions. Through the intensive experiments of Tierra-based OBC the following implications have been revealed: Tierra-based OBC maintains the correct programs and evolves the programs not depending on (1) the target of the problem and (2) the initial program; and (3) Tierra-based OBC is also applicable to the complex programs added the instructions.