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Multi-Mode Radiation Hardened Multi-Core Microprocessors

Integrated circuits (ICs) are used to produce the digital circuits needed for processing binary information. There are two main errors that can occur in ICs. First, hard errors result in permanent failure to the module. Second, soft errors occur when a binary switch within a digital circuit flips to its reverse state causing the IC to receive an incorrect signal. When ICs are in use, particles energized by radiation create "ionizing tracks" within the semiconductor that can cross several circuit nodes and trigger multiple soft-error malfunctions, effectively crippling the design. Currently, if a system encounters an error, the standard fix is to reset the entire system. Therefore, there is a need to overcome these problems in order to create designs with maximum reliability.

Researchers at ASU have developed a number of hardening by design techniques that can be used with little or no changes to the Logic Synthesis Process at the Register Transfer Level (RTL). The approaches taken are modal and have low overhead in hard mode and no overhead in soft mode. Additionally, the designs are mission specific. In hardened mode, any synthesized logic is triplicated (using three processors) and soft errors are repaired by the automatic repair in the Triple Modular Redundancy (TMR) self-correcting system. TMR is a method in which three systems send messages and those results are processed by a majority-voting system to produce a single output, thus eliminating errors. In unhardened mode, the cores run independently for maximum performance. In summary, these approaches are desirable because they allow mission specific or mission portion specific hardening to be achieved with the same hardware.

Potential Applications

- Electrical Components for
 - Space Craft
 - Satellites
 - Nuclear Reactors
- Electronic Design Automation
- Integrated Circuit CAD Software

Benefits and Advantages

- Compatible – Can be used with little to no changes to the RTL.
- Reconfigurable – Allows mission specific (or mission portion specific) hardening with the same hardware.
- Reliable – Uses self-correcting modular redundant design as a safety net.

For more information about the inventor(s) and their research, please see

[Lawrence T. Clark's directory webpage](#)

