



MODELING AND PROCESSING USING REVERSIBLE CONSERVATIVE NOISY ELEMENTARY CELLULAR AUTOMATA CIRCUITS AND THEIR m -ary QUANTUM COMPUTING

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ABSTRACT—Modeling noisy discrete systems utilizing conservative reversible elementary cellular automata (CRECA) is introduced. Reversibility in the ECA evolution rule and reversibility in the ECA circuit implementation are both achieved using a new Swap-based algorithm called Swap-based CRECA (SCRECA). The new method results in adding variable redundancy to counteract the effect of noise. The problem of obtaining a reversible map from an irreversible map is important because quantum circuits are inherently reversible and thus does not consume power, while irreversible circuits (due to either an irreversible mapping or to noise within a reversible mapping) cannot exist in the quantum domain and its circuits consume power. Since noise is an integral part of any real process and since the reduction of power consumption is a main requirement for the circuit design of future technologies such as in quantum computing (QC), the main features of several future technologies will include reversibility, and thus the method for designing noise-incorporating conservative and reversible circuits in the ECA context can play an important role in the design of circuits that consume minimal power for purposes such as low-power efficient simulation of noisy discrete system dynamics, and in several other applications especially that specific types of classical ECA have been already proven to be useful in the VLSI field such as achieving a high VLSI circuit testability. The quantum ECA (QECA) representations of: (1) m -ary orthonormal computational basis states quantum decision trees (QDTs) and (2) m -ary orthonormal composite basis states QDTs are also introduced as possible quantum representations for the modeling and manipulation of the QECA dynamics.

Key Words: Cellular Automata (CA), Elementary Cellular Automata (ECA), Circuits, Bijective Map, Reversible Logic, Conservative Logic, Quantum Logic, Boolean Logic, Many-Valued (m -Valued; m -ary) Logic, Galois field, Quantum Computing, Noise.