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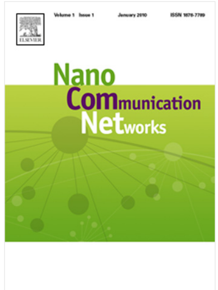

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Computational Fidelity in Reversible Quantum-Dot Cellular Automata Channel Routing Under Thermal Randomness

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***Abstract*—The computational fidelity is the measure, which imposes the knowledge about how far any noisy computational channel resembles the accurate output for the distribution of the same input. The logical operations and signal propagation through semiconductor quantum-dot cellular automata (QCA) having different cell's polarization are affected with environmental noise such as thermal randomness. This paper outlines the computational fidelity in reversible QCA channel routing for noiseless, as well as noisy reversible QCA channels. To show the fidelity for reversible QCA channels, QCA based Feynman gate, Fredkin gate, Peres gate and Toffoli gate have been assumed as a reversible routing channels. Shannon's theory has been applied to measure the fidelity, which confirms the robustness in reversible QCA channel routing. The temperature range at which reversible QCA channels yield trustworthy computation is proposed in this article. It is established that the computational fidelity of the routing channels deteriorates with thermal randomness. On an average, those routing channels have reliable fidelity when perform computation in between *1K* to *10K* temperatures. Hence, all the routing channels yield considerable computational fidelity over the low thermal regions. The evaluation of theoretical values through simulation results establishes the design accuracy for the proposed reversible QCA routing channels.**

***Index Terms*— QCA, Feynman gate, Fredkin gate, Peres gate, Toffoli gate, Information theory, Computational fidelity.**

I. Introduction

Nano-scale design of digital logic circuit with quantum-dot cellular automata (QCA) is upgrading trends by virtue of several advantages like low power consumption, nano-scale device area with high switching speed [1-5]. A new paradigm, i.e., QCA to perform cellular automata based computation at nanoscale level was first projected by C. S. Lent *et. al.* [1]. An adiabatic switching is occurred in QCA computation that helps the QCA clock to control the fundamental components of QCA devices [6-10]. The adiabatic switching is useful in traversing and computation of information to generate the correct outputs. QCA architecture comprises of 3-input majority gate (MV), inverter, and wire [11-15]. This three cellular automata based structures are the fundamental components for QCA devices. Researchers have already demonstrated the experimental establishment of binary wire as well as logic gate with QCA [16-20]. Several general purpose sequential circuits and combinational circuits have been achieved in QCA [20-27]. The summary of logic redundancy design and the conventional fault tolerant techniques for circuit reliability have also been demonstrated [28-33]. The computational fidelity (F_L) is the measure, which shows the quantity about how far any noisy computational channel resembles the accurate output for the distribution of the same input [34-35]. The computational fidelity of such QCA circuits is however, affected by the induced environmental noise like thermal randomness. The fidelity of nano-computing devices can be estimated using Shannon's information theory. In any nanocomputing the most important things are the efficacy for noisy channels to perform complex computations, and statistical exploration of efficacy changes with different physical structures. The information theory based measures inspired by this phenomenon, which statistically define the computational fidelity in noisy channel routing that accumulated through processes. The stated confinement of channel efficacy is usually suitable for all artificial and natural nano-computing channels, which is realized via a structured or random nano-network. Those networks can be modeled as a discrete computation channels. The computational fidelity due to structural randomness, as well as thermal randomness for the QCA full adder circuit through information-theoretic analysis has