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SURVEY: Reversible Logic Gates Implementation Using QCA

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Abstract: *In this paper we introduced a design and essential learning process basic in Quantum dot cellularautomata(QCA) and Reversible logic gates using QCA. QCA it is nanoscale computing technology that can represents binary information using spatial distribution of electrons.It has features like extremely small feature size, and high clock frequency make QCA an attractive solution for implementing nano-scale architectures. The power dissipation is the main limitation of all Nano electronics including QCA. The Reversible computing is considered as the reliable solution for power dissipation. The realization of quantum computation is not possible without reversible logic also, the Information's are not loss in reversible circuits. Reversal gates are the main building blocks for reversible circuits.*

Keywords: *Cellular Automata(CA), Reversible Gates, Reversible logic ,Quantum Computer(QC),Quantum dotcellular automata(QCA).*

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I. Introduction

As per the MOORE's law, the conventional transistor-based CMOS technology has followed Moore's Law, doubling the number of transistors every 18 months resulting in technology scaling .Scaling comes down to submicron level, many problems occur such as, Non-deterministic behaviour of small currents, Technology limits like power dissipation and design complexity. New paradigms which provides, less area, Minimum complexity, extremely low power consumption, Very high switching speed are needed.[12]

The alternative to CMOS-VLSI, researchers have proposed a new computing paradigm with quantum dots called Quantum dot Cellular Automata (QCA) . The proposed QCA structure designs are optimized by QCA technology. Each cell has four quantum dots. Two electrons remain in a cell. Due to the columbic forces these electrons always try to reside at the diagonal places of the cell in quantum dots. This leads to two polarization state, logic "0" and logic "1".

Now a Days, In digital design ,energy loss is an important consideration. Traditional logic circuits are found irreversible logic circuit and dissipate heat energy in an order KTln2 joules that the loss of per bit of information, where k(K=1.3806505 x 10-23JK-1) is Boltzmann's constant and T is absolute temperature. Bennett shows that in case of reversible logic computation KTln2 joules energy will not be dissipate. Hence reversible logic gets priority to design combinational and also sequential circuit. Information's are not loss in reversible circuits.

Reversible gates are having the some characteristics. Like, A reversible gate has equal input and output in order to have one to one mapping. So that the inputs of a reversible gate can be uniquely find out from its outputs. In a reversible gate fan out of every signal involving primary inputs must be one.[3] Each reversible gate is associated with a cost called quantum cost. The quantum cost of a reversible gate is the number of 2 x 2 reversible gates required in designing .

II. Roots of Quantum Computing

In the classical computer , the most basic building blocks, these bits only exist in two states, a 0 or a 1. When it comes to Quantum computing the computing mechanism based on the quantum mechanical phenomena such as superposition. The quantum computers are different from the digital electronic computer. In quantum computing the rules are changed and it is referred as a 'qubit' which exist in classical states 0 and 1.

The operation on such a qubit effectively acts on both the values at the same time. The 'quantum parallelism' increases when the number of qubits increased .

Now a days, quantum computing becomes more powerful based on strange subatomic rules of quantum mechanics, this makes it very difficult.

1. Progress of Quantum Computing

The quantum mechanics and information theory came about when it was realized that simple properties of quantum systems, such as the unavoidable disturbance involved in measurement, could be put to practical use, in the quantum cryptography (Wiesner 1983, Bennett et al 1982, Bennett and Brassard 1984). Quantum cryptography covers several ideas, of which established in quantum key distribution. This is an inventive method in which transmitted quantum states are used to perform a very particular communication task to establish at two separated locations a pair of identical ,otherwise random, sequences of binary digits, without allowing any other digits to learn the sequence. This is very useful because of such a random sequence can be used as a cryptographic key to permit secure communication. While quantum cryptography was being analyzed and demonstrated, the quantum computer (QC) was undergoing a quiet birth. Since quantum mechanics underlies the behavior of all systems, including those we call classical ('even a screwdriver is quantum mechanical', Landauer (1995))). In order to a quantum-mechanical point of view, the first ideas involved converting the action of a Turing machine into an equivalent reversible process, and then inventing a Hamiltonian which would cause a quantum system to evolve in a way which is a reversible Turing machine.

2. Initialization of Cellular Automata(CA)

During the last years number of software packages for the simulation of CA have been developed. Usually they are not only allow the simulation of the classical two-dimensional deterministic model of von Neumann, but give the user the possibility to make use of extensions. A few of the available software packages, e.g., Cellular, CAMEL and CANL, offer some support for doing the simulations on parallel hardware platforms. Parallel hardware platform means shared memory machines with few processors, large machines with a message passing interface can be used. For the latter the standard parallelization method is a domain decomposition approach. For large ranges of parameters (e.g., the degree of parallelization) have been deduced within which reasonable speed-ups can be achieved. [11]

III. Literature Survey

1. This section deals with the literature survey of A new design and simulation of reversible gates in quantum-dot cellular automata technology. It deals with the reliable solution to lower the power dissipation. It has equal input and output in order to have one to one mapping. So that the inputs of a reversible gate can be uniquely determined from its output . In a reversible gate fan out of every signal containing primary inputs must be one. There are some basics terminology related to reversible logic like Reversible Function , Reversible Logic, Garbage Outputs, Quantum Cost, Flexibility.[3]

2.

3. Reversible Gates

It has wide range of application in low power logical circuit design.

2.1 Feynman gate is 2x2 reversible gate and it is called as controlled NOT.[2]The logical expression between the inputs (A, B) and outputs (P, Q) is represented by:

= and = $\oplus$ [3]

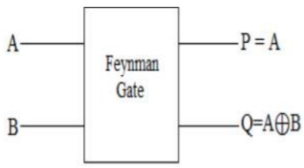

Fig 1: Feynman Gate[3]

2.2 Toffoli gate is 3x3 reversible gate, In this reversible gate, the inputs (A, B, C) are associated with the outputs (P, Q, R) by:

= , = and = $\oplus$ [3].

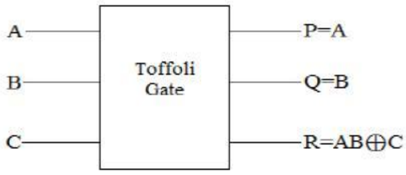

Fig 2: Toffoli Gate

3. Multi-objective synthesis

Addition to objective priorities proposed in which include the gate counts (the number of majority gates), gate levels and the number of NOT gates, another objective namely Control inputs is used. One of the important objectives in creating reversible functions in the QCA technology is reducing of the number of AND/OR gates that need method .

In this synthesis method adding an important objective to previous synthesis flow, a multi-objective synthesis method for reversible functions is presented. In to redundancy constant inputs. As in QCA technology, AND/OR gates are generated using Majority gate and it needs to redundancy constant inputs and because these gates are irreversible, so, these redundancy constant inputs generate extra heat. Because of that, Landauer et al have shown that whenever there is a loss of information during some computation, energy is dissipated in the form of heat.[1]

3.1 converting irreversible functions to reversible functions

A new method for converting irreversible functions to reversible ones is proposed for the QCA technology. The first, common states in outputs are marked, then, input columns are compared with outputs and input column that can remove the most common states in outputs is selected and added as a new column in output.[1]This work is repeated until common states in outputs the deleted fully and the one to one mapping between the outputs and inputs is created. By using this method, each type of reversible functions with the minimum complexity, area, garbage outputs, control inputs and delay can be created while the other methods such as have used popular reversible blocks like Toffoli and Fredkin gates or building of reversible blocks (intermediate reversible blocks) for designing other reversible functions which these methods are not optimal. Finally, the obtained reversible functions are synthesized using the proposed method in Section 3.

4. Evolutionary approaches to synthesis of Quantum arrays

There are two basic methods of designing and drawing quantum circuits. In the first method you draw a circuit from gates and you connect these gates by standard wires.[4] The rules to design a reversible circuit using this approach are the following: (1) no loops allowed in the circuit and no loops internal to gates, (2) fanout of every gate is one (which means, every output of gate can be connected only one input terminal).These rules preserve the reversible characteristics of gate thus the resulting circuit is also completely reversible.

IV. Conclusion

In reversible systems, computation can be carried out in different manner from conventional computer. Reversible logic circuits which are helpful in quantum computing, low power cmos, nanotechnology, quantum dot cellular automata, communication. Reversible logic supports the process should running the system both forward and backward .Using evolutionary approach we found that the importance and mutual relations of four problems: circuit encoding, fitness function, cost function, and local optimizing transformation.

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