Designing of QCA Schemes by Boundary Functions

# Summary

Quantum-dot Cellular Automata (QCA) is one of the most significant technology among the Nano devices for computing at the Nanoscale. The key logic elements in QCA are majority gate and inverter. The majority gates are 3-input majority gate and 5-input majority gate. In earlier designs all the digital logic circuits are implemented using 3-input majority gate based on 2:1 multiplexer. It is called a boundary comparator. This gate implements a Boolean function in its boundary form, as a superposition of elementary boundary functions or as threshold functions having weights equal to integer powers of 2. Microminiaturization complicates the task of checking due to the following two reasons. Firstly, internal poles of the chip are hardly accessible thus decreasing the amount of information, which is required for making conclusions about its workability, presence or absence of faults, and others. Secondly, it becomes more and more difficult to allocate structural elements in the more complex chip. In turn, it hampers the testing, debugging and repairing of the chip. As the result, the traditional optimization criterion steps aside and is presently replaced with criteria of structural simplicity and testability of a scheme, which are more important for modern VLSI schemes.

It includes Logic Synthesis by QCA, Boundary Functions, Quantum comparator and Implementation of QCA by Comparator based Programmable

Arrays.

A majority gate is a primitive gate in QCA that implements the function. The fundamental QCA logic primitives also include a QCA wire and QCA inverter. This comparator being arranged into array structure and called Comparator based Programmable Array (CPA) forms a homogeneous regular structure that can be programmed for implementation of any desired logic function.

In this research paper, here presented a novel universal quantum cellular automata gate - boundary comparator. We introduced a Comparator based Programmable Array (CPA) that is based on this boundary comparator. The CPA is a homogeneous regular structure that can be programmed for implementation of any desired logic function. It is developed theoretical fundamentals of the boundary functions used for representation of logic functions by the boundary comparator. The boundary functions form a functionally complete system in the Boolean algebra. Each of logic function can be implemented by the boundary functions and, consequently, by the boundary comparator. It is demonstrated implementation of the QCA schemes by the proposed CPA structures. The main advantage of the proposed solution is its regularity, which, in turn, provides the testability, a potential reconfigure ability, reparability etc. The array homogeneous structure is also desirable form manufacturing point of view. It is not discussed methods for the optimal synthesis of CPA based QCA schemes. Obviously, this issue is an important direction of the future study. Nevertheless, we believe that even without optimization the proposed CPA structure will be useful in designing QCA logic circuits.