IOSR Journal of Engineering
Apr. 2012, Vol. 2(4) pp: 563-567

A Review on CMOL Cell Assignment Problem

Tanvi Vaidya[1], Er. Abhijeet Kumar[2]
[1]*M.Tech (regular), M. M. Engg. College Mullana (Ambala)*
[2]*Lecturer ECE Deptt. M.M.Engg.College Mullana (Ambala)*

Abstract
- IN RECENT YEARS, nanoelectronics has made tremendous progress, with advances in novel nanodevices, nano-circuits, nano-crossbar arrays , manufactured by nanoimprint lithography, CMOS/nano co-design architectures, and applications. CMOL cell assignment Problem (BP) is a telecommunication problem and this problem is very complex due to its constraint. So this problem needs to be resolved. Cell assignment problem is solved by using many different methods .Recently it is solved by Genetic Algorithm method. Particle Swarm Optimizer algorithm supposed to give better results than Genetic algorithm so the work can be performed in this direction.

Keywords: *programmable gate array (FPGA), nanodevice, reconfigurable computing, Particle swarm optimization(PSO), Genetic algorithm..*

Introduction-

IN RECENT YEARS, nanoelectronics has made tremendous progress, with advances in novel nanodevices, nano-circuits, nano-crossbar arrays , manufactured by nanoimprint lithography, CMOS/nano co-design architectures, and applications. Nanodevices are very small devices which are used in electronic devices. Because of these nanodevices the size of chip is reduced. These nanodevices can be used in many electronic devices to reduce the size of devices. In These technologies the aim is to place these nanodevices in a proper manner. To connect nanodevices, nanowires are used. Nanodevices are connected in such a way so that they follow the shortest path. Due to this the coast of the system is reduced. For this purpose firstly the cell assignment should be done. CMOL cell assignment Problem (BP) is a telecommunication problem and this problem is very complex due to its constraint. So this problem needs to be resolved. Cell assignment problem is solved by using a genetic algorithm proposed by Author Yinshui Xia et.al.[2] PSO algorithm supposed to give better results than Genetic algorithm so the proposed work is in the same direction.

SECTION-I

CMOL nanowire technology

CMOL was originally developed by Likharev and his colleagues. CMOL is a CMOS Molecular Hybrid device. Fig. 1 shows the basic CMOL circuit with the interface between CMOS and nanowires. The nanodevice in CMOL can be any two-terminal nanodevices, e.g., a binary "latching switch" based on molecules with two metastable internal states.

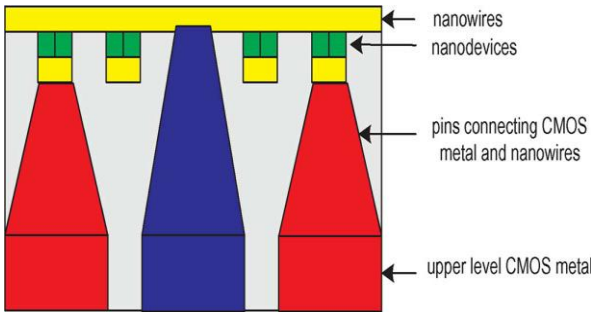


Fig. 1. Generic CMOL circuit schematic side view[4]

Here the nanowires are on top of CMOS circuits, with interface pins connecting CMOS metals and nanowires. The pins (blue) connecting with the upper-layer nanowires could break the lower-layer nanowires to relax the requirements for fabrication and increase interface yield.

SECTION-II

Introduction of PSO

Particle swarm optimization (PSO) is a population based heuristic search technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. PSO has some properties similar with other evolutionary techniques such as Genetic algorithms (GA), like GA PSO also selects initial population randomly from solution search space. PSO does not use the operators like crossover and mutation like GA. As PSO is inspired from bird flocking it uses velocity equation to update the solutions and fly towards the best solution. The power of the technique is its fairly simple computations and sharing of information within the algorithm as it derives its

internal communications from the social behavior of individuals. The individuals, called particles henceforth, are own through the multi-dimensional search space with each particle representing a possible solution to the multi-dimensional optimization problem. Each solution's fitness is based on a performance function related to the optimization problem being solved.

SECTION-III

Literature Survey

Zhu-Fei Chu et.al.[1] Presented a genetic algorithm (GA) based method for Cmos/nanowire/Molecular hybrid (CMOL).Their approach is capable of solving larger circuits with less CPU time, smaller area and shorter delay. Yinshui Xia et.al.[2] Explained a Genetic Algorithm for cell assignment of CMOL, a hybrid CMOS/molecular circuit architecture.They had developed a Genetic Algorithm based approach to solve large circuits with less CPU runtimes, smaller area usage and delay. Amir Aavani et.al.[3] Introduced a new algorithm for translating Pseudo-Boolean constraints into CNF clauses. The CNF produced by the proposed encoding has small size, and they also characterize the constraints for which one can expect the SAT solvers to perform well on the produced CNF. William N. N. Hung et.al.[4] Presented a novel CAD approach to cell assignment of CMOL. Their method transforms any logically synthesized circuit based on AND/OR/NOT gates to a NOR gate circuit and maps the NOR gates to CMOL. They had investigate various types of static defects for the CMOL architecture and proposed a reconfiguration technique that can deal with those defects. Yuhui Shi et.al.[5] Introduced a parameter, called inertia weight, into the original particle swarm optimizer. There result shows that the PSO with the inertia weight in the range [0.9,1.2] had better performance. Konstantin K. Likharev et.al.[6] Explained the Prospects for the Development of Digital CMOL Circuits. They believed that CMOL technology was the most natural way to extend the Moore's Law beyond the 10-nm. D. Tu et.al.[7] Introduced a three-dimensional (3D) architecture of the CMOL circuit .That structure eliminates the special pin requirement of the original CMOL designs and providing a feasible and efficient solution to build the practical CMOL circuits. Dmitri B. Strukov et.al. [8] Analyzed two options of using hybrid CMOS/nanodevice circuits with area-distributed ("CMOL") interface for the low-level image processing tasks. The first option used a digital, DSP-like circuits based on a reconfigurable CMOL fabric, while the second one was based on mixed-signal CMOL circuits with the analog presentation of input and output data and the binary presentation of the filter function. Shu Li et.al. [9] Proposed an approach to combine resistor with FET to implement the demux, leading to the so-called hybrid resistor/FET-logic demux. Jung Hoon Lee et.al.[10] Described two new methods of"in situ" training of CrossNets, based on either genuinely stochastic or pseudo-stochastic multiplication of analog signals. There result shows CMOL CrossNets with their binary elementary synapses may provide, after the in situ training, classification performance at least on a par with the best results reported for software-based networks. Dmitri B Strukov et.al. [11] Proposed digital logic architecture for 'CMOL' hybrid circuit swhich combine a semiconductor–transistor (CMOS) stack and two levels of parallel nanowires, with molecular-scale nanodevices formed between the nanowires at every crosspoints. In Their approach the functional density was improved. Konstantin K. Likharev et.al.[12] Explained CMOL: Devices, Circuits and Architectures. He gave a brief review of the resent work on various aspects of prospective hybrid semiconductor/ nanowire/ molecular ("CMOL") integrated circuits. Basic idea of such circuits is to combine the advantages of currently dominating CMOS technology with those of molecular devices with nanometer-scale footprint. André DeHon et.al.[13] Explained that available assembly techniques have relatively high defect rates compared to conventional lithographic integrated circuits and can only produce very regular structures. Jung Hoon Lee Xiaolong et.al. [14] Developed a neuromorphic network ("CrossNet") architectures, in which neural cell bodies were implemented in CMOS. They had shown how CrossNets may be trained to perform pattern recovery and classification despite the limitations imposed by the CMOL hardware. There results shows that CMOL cross net were extremely dense and operate approximately a million times faster than biological neural networks, at manageable power consumption.

SECTION-IV

Proposed Work Methodology

Prior methods of CMOL cell assignment can only solve small circuits with long CPU runtime and low area usage.Cell assignment problem is a problem in which Boolean circuits are assigned to the CMOL cell. CMOL cell can only be connected to a limited number of neighbouring CMOL cells. CPU runtime should be reduced so the work can be done to reduce this problem by using some other

method. Particle Swarm Optimization (PSO) method can be used to reduce the CPU runtime.

In Particle Swarm Optimization method the movement of the particles is influenced by two factors using information from iteration-to-iteration as well as particle-to-particle. As a result of iteration-to-iteration information, the particle stores in its memory the best solution visited so far, called pbest, and experiences an attraction towards this solution as it traverses through the solution search space. As a result of the particle-to-particle information, the particle stores in its memory the best solution visited by any particle, and experiences an attraction towards this solution, called gbest, as well. The first and second factors are called cognitive and social components, respectively. After each iteration, the pbest and gbest are updated for each particle if a better or more dominating solution (in terms of fitness) is found. This process continues, iteratively, until either the desired result is converged upon, or it's determined that an acceptable solution cannot be found within computational limits.

In this method a set of inputs are used to get the desired output. A NOR gate circuit is used as a input and a particular cell of CMOL has to be assigned to a particular NOR gate. NOR gate circuit has taken as a graph, the number of NOR gate is considered as nodes and link between two NOR gates is considered as edges. After formulating the circuit as a graph particle swarm optimization is used to assign nodes of a graph to a particular cell. As every optimization problem has certain set of constraints CMOL cell assignment problem also have certain set of constraint. The constraints for these problems are discussed below as:

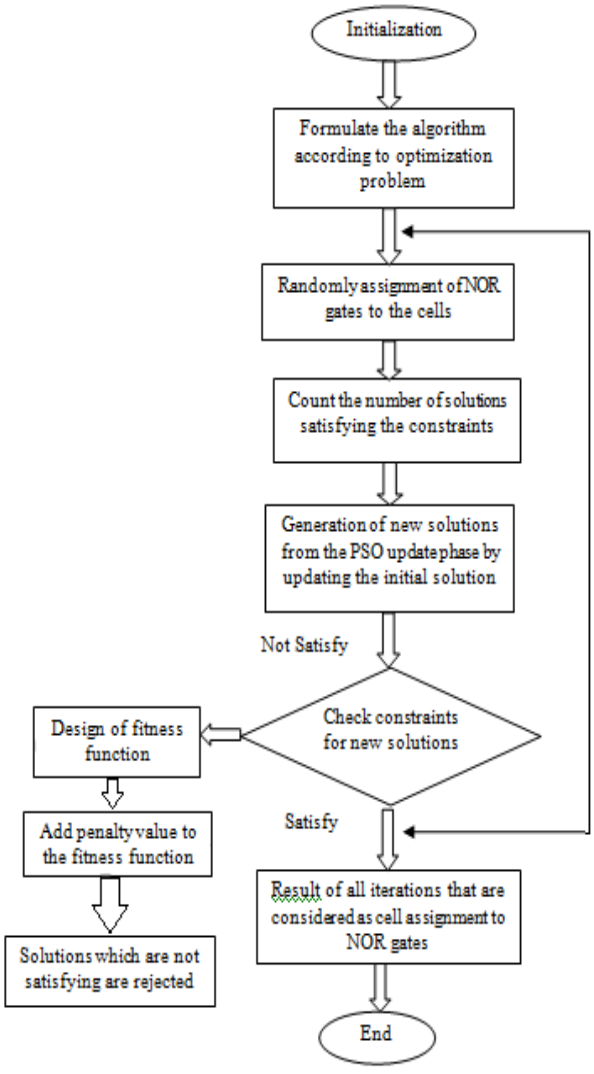
1.Each NOR gate is assigned to a particular cell only.
2. There is a connectivity range for a particular NOR gate under which all the other NOR gate connected to that NOR gate should present. The connectivity range describes the minimum distance between the two connected NOR gate or the nodes edge.

Care must be taken for these constraints while formulating the solution using the PSO. To solve any optimization problem using any optimization algorithm, first formulate the algorithm according to optimization problem.PSO is a population based algorithm and each individual represents the solution and the solution for CMOL assignment problem is a proper schedule that describes which cell of CMOL is assigned to which NOR gate. So each individual of PSO has dimension equal to number of cells in CMOL.

The numbers are assigned to the NOR gates in graph form 1 to total number of NOR gate. Each individual of PSO is formulated and shows the sequence that which cell has NOR gate , and the cell does not assigned any NOR gate remains empty. In the initialization phase of PSO, NOR gate is assigned randomly to the cells so a particular number of solution is selected randomly. After random selection how many solutions satisfy the constraint are checked. After checking the constraint it has the set of feasible solution which satisfies the constraint condition.

After initialization PSO update phase updates the initial solution and generates the new solution. Again the constraint condition applied to the updated solutions or individuals. Fitness function is designed so that the solution which does not satisfy the constraint automatically not taken into consideration. A penalty value is added to the fitness of solution which does not satisfy the constraint condition. After addition of penalty value the individual is automatically not consider for good solution in next phase. All these procedure execute till the maximum number of iteration and at last the best result of all the iterations is obtained and this result is considered as a cell assignment to the NOR gates.

Flow Chart



Applications Of CMOL

1. Nanodevice concept has broad choice of possible materials so it can be used in Nanoelectronics, VLSI, Microelectronics and Embedded systems.
2. CMOL concept is used in Telecommunication which is a demanding area in present days.
3. This concept is used in memory, field programmable gate array (FPGA), and neuromorphic CrossNets .

SECTION-V

Experiment On Full Adder Example Using PSO Method

A simple example on Full Adder Circuit is taken from [4]. Here[4] Full Adder circuit is firstly converted into NOR gate form and then cell assignment is done by using SAT tool. In Particle Swarm Method conversion method for full adder circuit into NOR gate form is same as explained in Satisfiability Method [4] . This can be shown in fig 2 as shown below.

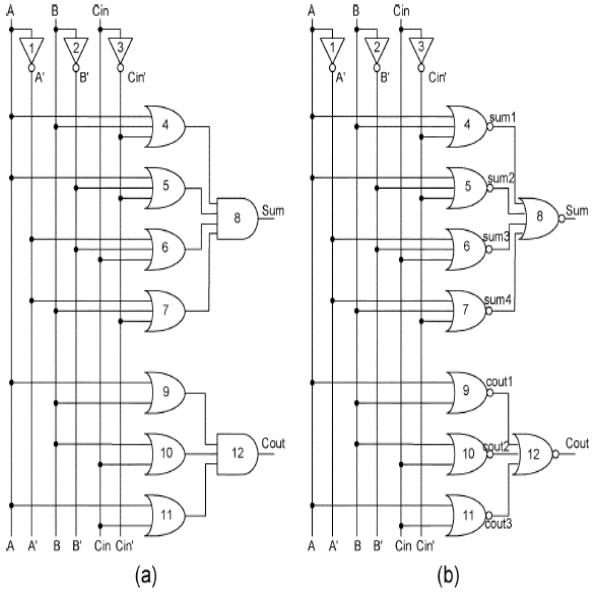


Fig. 2. Example Of Full Adder [4].

For transforming full adder circuit from fig.2(a) into the circuit as shown in fig.2(b) De Morgan's law is used. By using De Morgan's law the AND/OR and NOT gates are converted into NOR gate form. After transforming the circuit into NOR gate form it then given to the CMOL assignment tool with the following constraints:-

1.Each NOR gate is assigned to a particular cell only. 2. There is a connectivity range for a particular NOR gate under which all the other NOR gate connected to that NOR gate should present. The connectivity range describes the minimum distance between the two connected NOR gate or the nodes edge. Then these constraints are given to the PSO tool and by using this PSO tool the CMOL cell assignment is done. Particle Swarm Method is more efficient method then Satisfiebility. This method reduces the time consumption for cell assignment. It also reduces the area utilization. So it can be said that Particle Swarm Optimizer is a challenging tool in CMOL cell assignment Problem.

SECTION-VI

Conclusion

CMOL cell assignment Problem (BP) is a telecommunication problem and this problem is very complex due to its constraint. CMOL cell assignment problem is solved by Genetic Algorithm method. Particle Swarm Optimizer (PSO) algorithm supposed to give better results than Genetic algorithm. Prior methods of CMOL cell assignment can only solve small circuits with long CPU runtime and low area usage. PSO method can reduce the CPU runtime. Particle swarm optimization (PSO) is a population based heuristic search technique, inspired by social behavior of bird flocking or fish schooling. PSO has some properties similar with other evolutionary techniques such as Genetic algorithms (GA), like GA PSO also selects initial population randomly from solution search space. PSO does not use the operators like crossover and mutation like GA. As PSO is inspired from bird flocking it uses velocity equation to update the solutions and fly towards the best solution. Here the runtime analysis of PSO method is performed under same conditions as in Genetic Algorithm method in Visual C++ Environment, It is supposed to give better results so proposed work is in same direction.

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