Efficient FM Algorithm for VLSI Circuit Partitioning

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***Abstract*-In FM algorithm initial partitioning matrix of the given circuit is assigned randomly, as a result for larger circuit having hundred or more nodes will take long time to arrive at the final partition if the initial partitioning matrix is close to the final partitioning then the computation time (iteration) required is small . Here we have proposed novel approach to arrive at initial partitioning by using spectral factorization method the results was verified using several circuits.**

Keyword- FM algorithm, nodes, spectral factorization method, partitioning

I. INTRODUCTION

Circuit partitioning serves as one of the most vital part of designing a VLSI circuit. For more than three to four decade, partitioning of circuits has been an interest for many around the globe. After the design is synthesized, the synthesized netlist must undergo a sequence of step before the design can reach the foundry. Circuit partitioning is one of those steps which is involved to partition or separate the whole netlist into some groups of blocks commonly denoted as logical blocks. The circuit partitioning is actually done in order to optimize the circuit by means of separating the circuit into a group of logical block to make the circuit to work efficiently. Although partitioning helps in optimization of circuits, the size of the circuit decides the complexity involved in the task. As the size of the circuit increase the complexity associated in partitioning the circuit into different logical blocks will also increase.

To partition the circuit effectively, there were different partitioning algorithms that were used in the past decades. These partitioning algorithm were used to partition the circuit on some constraints, they are

1) Reduction of interconnections between partitions.
2) Reduction of delay due to partitions.
3) Reduction in total number of terminals(less than the predetermined maximum value).
4) Maintenance of area of the partition within specified bounds.
5) Maintenance of number of partition within specified bounds.

Different partitioning algorithm may work with different partitioning protocols to partition the circuit. But they all work to achieve the same goals to optimize the circuit. FM algorithm is one of the efficient partitioning technique in which size of each partition is different for different logical block. However, to reduce the complexity involved in partitioning the circuit, each circuit must be modeled as a graph with its nodes representing some logical block and vertices representing the interconnections between those logical blocks. Although there are tools which exist to partition the circuit, the partitioning of circuit in terms of graphs were always viewed as a simpler way to do the partition.

To partition the graph in an effective manner, a clustering concept called spectral factorization were used with FM algorithm. Spectral factorization is a concept for which nodes of a graph is clustered in terms of some criterion associated with the graph. This paper gives a novel approach of partitioning irregular graphs by spectral factorization method using FM algorithm.

II. FM ALGORITHM

FM algorithm **i**s the heuristic proposed by Fiduccia and Mattheyses for circuit partitioning. It is nothing but the modification of Kernighan-Lin(KL) group migration method for circuit partitioning. The original KL heuristic is an iterative procedure of improvement for which the current partition is improved by swapping a pair of nodes repeatedly. Each node in a pair are taken from two different subset belonging to the current partition. The best pair is swapped by searching the space of O(n2) items and performing the search O(n) times. As per the modification suggested by Fiduccia and Mattheyses , only one node must be moved at a time. The moves are made a consecutive manner in the opposite direction. A sorted list of interior nodes is maintained by the algorithm for moving to the other sub circuit, after which the updates are made for each move.

III. GRAPH PARTITIONING

Consider a graph G = (V,E) which is undirected with set of vertex V and edge E, together with a positive edge cost function c:E→[0,∞) [4]. A K-partition of V is a group or collection $P = \{V_1, V_2, \dots, V_k\}$of K disjoint subsets of V, whose union equals V. the cost associated with P is defined by

$$C(P) := \sum_{i \neq j} \sum_{\substack{(v,v') \in E \\ v \in V_i, v \in V_j}} c'(v, v').$$

The *l-bounded graph partitioning* (*l*-GP)[5], problem consist of finding a k-partition *P* that minimizes C(*P)*, with no element in partition having more than *l* vertices .

The smallest value of l for which this problem is solvable is l = [n/k], where n denotes the number of vertices in V . When l takes this value we say that the partition is perfectly balanced . For l = [(1+∈)n/k] we say that the partition has an ∈ percentage of imbalance.

Without considerable generality loss, it has been assumed that the graph is fully connected and set C (v, *v')* = 0 for every edge which is not present in original graph. In this case we simply write

$$C(P) := \sum_{i \neq j} \sum_{v \in V_i, v \in V_j} c(v, v').$$

Note that since the graph is undirected, $c(v, v') = c(v', v), \forall v, v' \epsilon\, V$.

This dilemma is related to the MAX k-CUT problems , which consist of finding a partition for V that maximizes the reward

$$R(P) := \sum_{i \neq j} \sum_{v \in V_i, v \in V_j} r(v, v').$$

For a given edge –reward r : V ×V →[0,∞) with the property that $r(v, v') = r(v', v), \forall v, v' \epsilon\, V$.

Consider a variation of the MAX k-CUT problem[1],[2] ,called the hyper graph MAX k-CUT problem with size of parts (HMkC),which adds the constraint that $|V|_i = s_i$, $\forall_i$for a given set of k integers $\{S_1, S_2, \dots, S_k\}$. We are pursuing spectral techinique to solve this problem i.e., techinique based on eigenvector /eigenvalue decomposition.

IV. K-MEANS CLUSTERING

K-means is considered as one of the simplest learning algorithms. It is an unsupervised algorithm which can be used to solve clustering problem. There are some simple steps involved in this procedure to categorize a given set of data's into one or more clusters (assume k clusters) fixed a priori (8). The idea is to define k centroids, one for each cluster. The algorithm follows a sequence of steps:

1. The objects to be clustered are placed with K points in the space. Each points represent centroids initial group.
2. Each object to the group is assigned such that the group has the closest centroid.
3. The positions of the K centroids are recalculated as soon as all objects have been assigned,
4. Steps 2 and 3 are repeated until the centroids stop moving. The objects are grouped by a separation from which the metric to be lowered can be calculated.

V.PROPOSED DESIGN

The circuit is represented as graph, this graph is then partitioned since a graph is used it's suffers from *I*-GP problem which can be avoided by using spectral factorization methods. Here k means clustering is used to provide initial partitioning for the Fm algorithm which helps in achieving better results. For a graph which has say five nodes and which are placed equidistant from each other the partitioning will result in same result as in the case of the regular fm algorithm consider the (Fig: 1) which shows the graph having such constraint, partitioning such a graph will result in partition A and partition B as which is the same as in the case of a regular FM algorithm.

For a graph with 7 node, whose vertex or nodes which are not regularly spaced ,partitioning the graph in a such a way that all the nodes whose nets are long gets grouped into one sub-graph and whose nodes are short gets grouped into another set as shown in (Fig: 2)

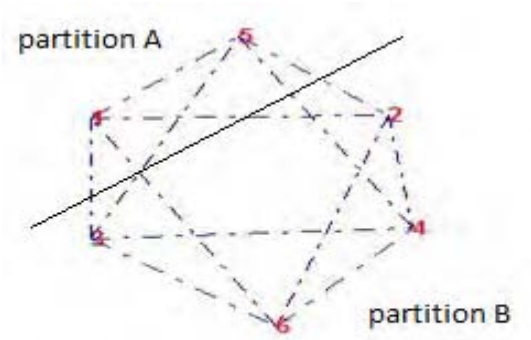


Fig:1

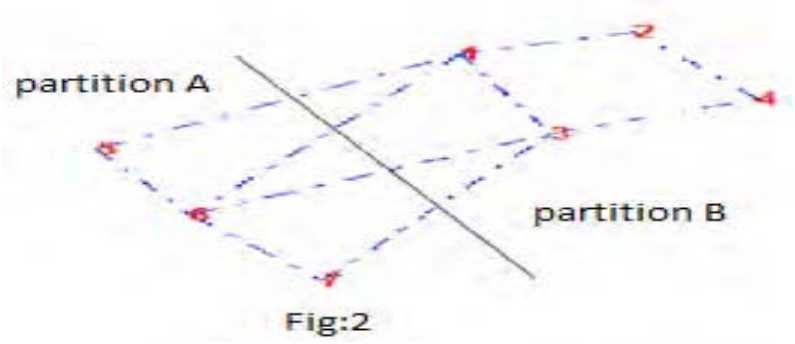
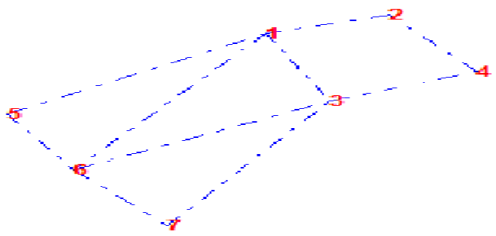
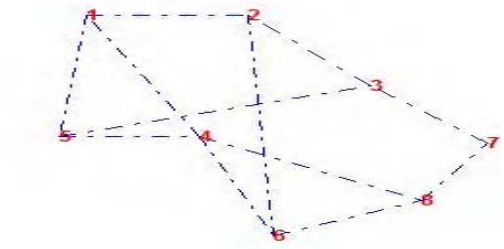


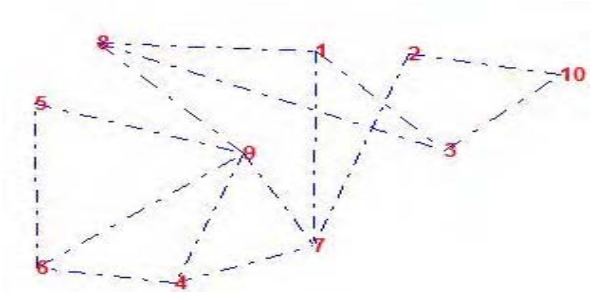
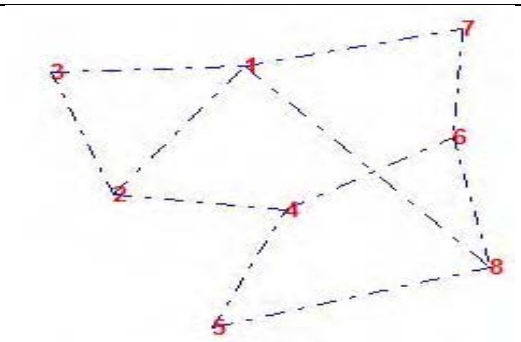
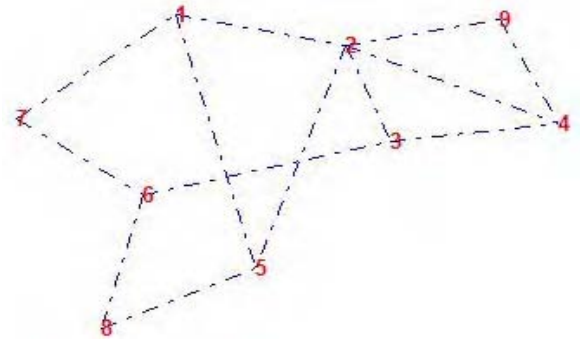
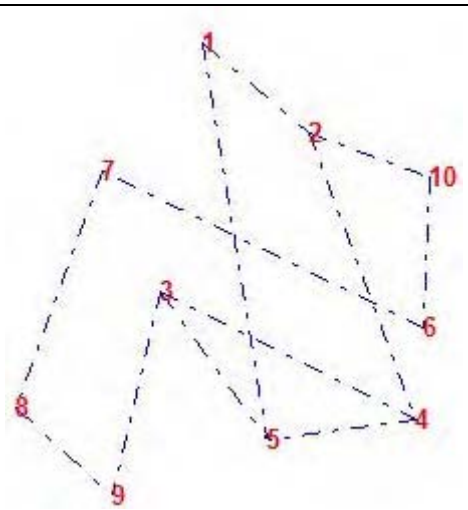
Fig:2

VI.ANALYSIS AND RESULTS

The proposed work was implemented using matlab 7.11.0 (R2010b) along with @graph class which facilitates in providing graphs as inputs and results can be viewed in graph format. The work was tested for different circuits which are represented as graphs and the resulting partitioning are tabulated as follows

TABLE I
REPRESENTATION OF PARTITION RESULTS OF DIFFERENT GRAPHS

Graph	Partition A	Partition B
	partition A: 5 6 7	partition B: 1 2 3 4
	partition A: 3 7 8	partition B: 1 2 4 5 6

	partition A: 4 5 6 9	partition B: 1 2 3 7 8 10
	partition A: 1 2 3	partition B: 4 5 6 7 8
	partition A: 2 3 4 9	partition B: 1 5 6 7 8
	partition A: 1 2 4 6	partition B: 3 5 7 8 9 10

VII. CONCLUSION

For obtaining an effective partition of a particular system, the partitioning algorithm used to partition the circuit must produce good results. In this work,we have implemented the initial partitioning matrix for standard FM algorithm with the help of spectral factorization using MATLAB R2010b.From the simulation results, It has been proved that by using spectral factorization concept, we have managed to achive better results for irregular graphs. Future work include partitioning of such irregular graphs using other efficient algorithms which are less sensitive to factors like size and complexity of the graphsto produce even better results.

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