© 2022 IJRTI | Volume 7, Issue 6 | ISSN: 2456-3315

Restrictive Channel Routing Using Genetic Algorithm

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Abstract: This paper explores the comparative Study of classical Heuristic Left Edge Algorithm and newly proposed Left Edge Algorithm of Channel Routing to find the best possible near optimal Solution. The main aim of this project is to reduce the number of tracks and to minimize the channel Height of the assigned net list. As the algorithm is Heuristic, we will apply the classical Genetic Algorithm where the three steps Selection Crossover and Mutation will be followed based on a particular Fitness function. This algorithm will use and implement the Horizontal Constraint Graph (HCG) and Vertical Constraint Graph (VCG) and Testing Table; Testing Graph will also be implemented for acting as a input to the fitness function.

Index Terms- **Left Edge Algorithm, Horizontal Constraint Graph, Vertical Constraint Graph, Testing Graph, Fitness Function**

I. INTRODUCTION

A. Channel Routing

Routing Problem is a VLSI design problem that involves completing the required interconnections between different modules. Several routing strategies exist for achieving efficient interconnection between different Modules. Channel Routing is one of the most important routing techniques. The Channel Routing Problem (CRP) is the problem of interconnecting all of the nets in a channel with the least amount of routing space possible. Since a channel's number of terminals is set, the channel's area is reduced by reducing the number of tracks used to accommodate all of the nets' horizontal wire segments.

We look at the Reserved Manhattan Routing (RMR) model, in which a specific form of interconnect segment is assigned to a specific set of Layers. The horizontal and vertical wire segments are positioned in two separate layers in the two layer RMR model when routing a path. Similarly, when routing a channel in a three layer RMR model, a collection of layers is set aside for horizontal wire segments and the remaining layers are set aside for vertical wire segments before designing algorithms to ensure that the routing solutions computed are suitable and fabricated.

We presume grid-based routing models in which wire segments from two separate nets cannot overlap on two adjacent layers of interconnect. Via through holes, wire connections between orthogonal wire segments of the same net on adjacent

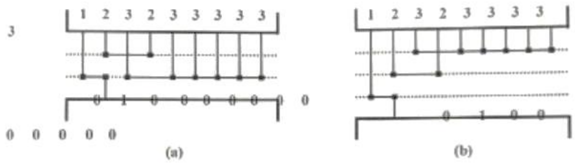

Fig. 1. Routing Solutions

layers are made. The alternating reserved multi-layer Manhattan routing(ARMMR) model, which is a generalization of the RMR Model, is a naturally developed Multi-Layer Routing model. The Manhattan routing Model is advantageous because it is one of the most realistic routing models from a variety of technology-supported design aspects, and it is commonly used in industries due to its flexibility, modularity, and acceptability. In our Routing Model, we alternately use the reserved layers, reducing the unwanted electrical hazards caused by wire segments from two separate nets overlapping on adjacent layers, and eliminating the need for stacked through holes connecting wire segments allocated to nonadjacent layers.
The two-layer CRP for area minimization is known to be NP-Complete [12], while the two-layer CRP for wire length minimization is known to be NP-Hard [19]. As a result, it's impossible that a polynomial-time algorithm exists that computes a routing solution with the smallest number of tracks and/or total wire length. As a result, several two-layer heuristic algorithms are employed in the computation of the minimum field. We may mistakenly believe that a minimum area routing solution also produces a minimum wire length routing solution and vice versa, allowing us to create heuristics for either. It's almost as if developing heuristics for computing minimum area and minimum wire length routing solutions separately isn't necessary. However, we've noticed that minimum area routing solutions don't always mean minimum wire length routing solutions, and vice versa. Figure 1 depicts an example of this.

Since the routing solution in Fig. 1(a) uses the shortest total wire length (despite requiring more channel area), the routing solution in Fig. 1(b) uses the shortest total wire length (despite requiring more channel area), which is less than the wire length used in routing the channel in Fig. 1(a).

We use a graph theoretic system called Track Assignment Heuristics (TAH) in this paper to compute a minimum-area routing solution. In channel routing with area minimization is a classic problem that has been regarded as the most critical cost efficiency criterion since the CRP's inception. The CRP is often characterized in terms of the feasibility of a routing solution that uses the smallest possible channel field. Minimization of area is also critical from the standpoint of removing impurities in wafer fabrication. As the die size shrinks (due to advances in packaging technology) and the area needed to route a channel shrinks (due to the development of novel algorithms), yield rises.

Another important cost efficiency criterion that we consider in this paper is the total wire length needed to route a channel. The length of the wire needed to route a critical net point of view is also part of the wire length minimization issue. In high-performance routing, the routing solution's performance is just as critical as its feasibility. Crosstalk delay, power consumption, hot spot formation, frequency distribution, power density distribution over a chip, and other factors all affect the performance of a routing solution. Unwanted Crosstalk is an electrical hazard that has developed as a result of a chip's functionalities. Devices and interconnecting wires were put closer together as fabrication technology advanced, allowing circuits to work at higher frequencies. Crosstalk between wire segments occurs as a result of this. Delay is a factor that causes a device to fail to propagate signals to specified destinations in a timely manner. In both of these situations, the total wire length must be kept to a minimum. Rather, the increased wire length used to route a channel increases power consumption. As a result, we consider the total wire length minimization problem as one of the most significant high performance criterion in this paper, and create an algorithm for optimizing it within the TAH framework.

B. Preliminaries

The horizontal wire segment (i.e. the Spans) of the nets must be distributed among a minimum number of tracks in order to compute a feasible routing solution of minimum area, which is guided by two important constraints, namely the horizontal constraint and the vertical constraint. Two graphs can be used to describe these constraints: the Horizontal Constraint Graph and the Vertical Constraint Graph. The maximum number of nets passing through a column in a channel is called its local Density. The channel density is the sum of the local densities in all of the channel's columns. Let's call the maximum channel density dmax.

Consider the channel instance depicted in the diagram below. The number of nets passing through column 1 is one, column 2 is three, column 3 is five, and so on for this channel. So column 1 has a local density of one, column 2 has a local density of three, and column 3 has a local density of five. The channel density is five, by the way.

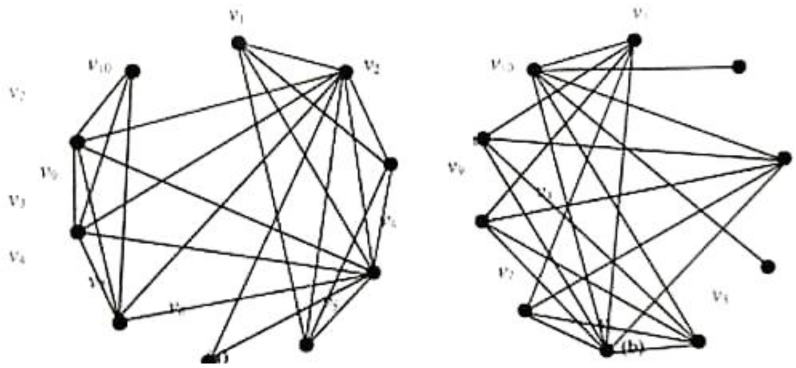

Fig. 2. Net with Required Interconnection

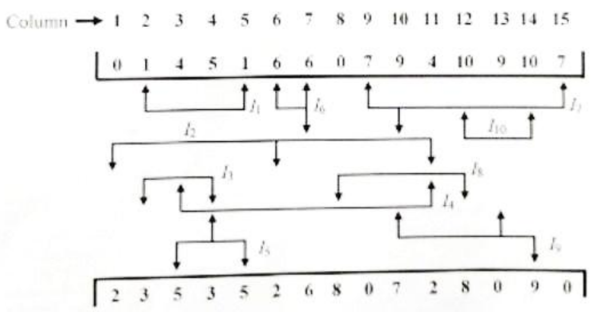

Fig. 3. HCG and HNCG

The complement of the HCG is used to describe horizontal constraints in this paper. The horizontal non constraint graph (HNCG) is the complement of the HCG, HC=(V,E), and is denoted by HNC =(V,E), where V is the set of vertices corresponding to the nets in a channel, and E= Vi,Vj— Vi,Vj does not belong to E. Horizontal Constraints are defined bythe HNCG, which was first proposed in [18]. In a routing solution, a clique, or maximal complete subgraph of the HNGC, corresponds to a set of non-overlapping intervals that can be safely allocated to the same route. The HCG and HNCGof the channel instance of Figure 2 are shown in the following diagram:

The HCG is a perfect graph since it is an interval graph.The induced sub graph HNCs=(S,Es/) of the HNCG, i.e. the

HNCG,HNC =(V,E/), is also a comparability graph. It's worthnoting that the size of the clique in HCG is the same asthe maximum independent set generated by the vertex setV1,V2,V3,V4,V5. As a result, the channel density (Dmax)in figure 2 is Five, since the nets n1 through n5 overlap at column 3 (or column 4) of the channel.

The vertical constraints of a channel are represented by the VCG,VC = (V,A) formula. Let us denote the length of the longest path in the VCGbe Vmax for an acyclic VCG. Inother words, Vmax is equal to the number of vertices in the VCG's longest direction. An acyclic VCG is a VCG that offersa sequence of ordering of the nets in a channel along the channel's height. Figure 4 shows the VCG for the channel instance in figure 2. In Figure 4, the value of the Vmax of the VCG is clearly three.

The lower bound on the number of tracks needed in computing a two layer VH routing solution in the RMR model is the limit of dmax and Vmax. A trivial lower bound on the number of tracks is what this is called.

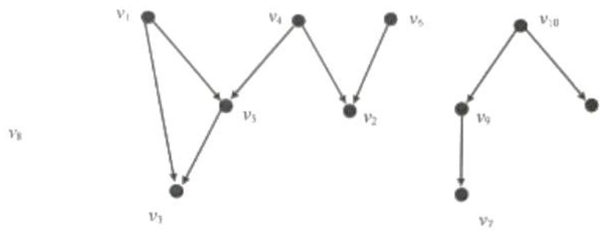

Fig. 4. VCG

The shape of a net's route in a channel is critical when computing a routing solution in a given routing model. Dog- legging occurs when a net's horizontal range is divided into two or more sub segments for the purpose of assigning them toseparate tracks in a routing solution. Otherwise, we call it no- dogleg routing when a net's horizontal width is assigned to a single track of a (horizontal) layer of interconnect. Frequently, doglegging aids in the computation of a feasible routing solution (which may not be possible in non-dogleg routing)or a routing solution with a smaller channel field (Wherenodogleg routing solution may require more area or morenumber of tracks). In any case, the dogleg-routing model is easier to implement and needs less through holes whenswitching conducting layers.

In this paper, we use the framework Track AssignmentHeuristic (TAH), which was built to compute minimum area routing solutions, to create a purely graph theoretic frameworkfor computing minimum wire length routing solutions for two and three layer channels. For most of the well-known benchmark channels, the method is used to compute routing solutions using an optimal or near-optimal number of tracks and/or reduced total wire lengths. The structure introduced in this paper is unique in that it defines suitable sets of eights ina logical order of priority for computing the above-mentioned routing solutions. Backtracking is not included in any of the framework's algorithms. The performance of the algorithms inthis paper is very promising. Almost all routing solutions are computed to minimize total wire length, despite the fact that this algorithm does not take up much space in doing so.

II. OVERALL DESIGN OF THE PROPOSED SYSTEM

Let us now move on to the formal formulation of the problem. A channel is represented by two sequences, Topand Bottom, in which the channel's top and bottom rows are respectively located. Both sequences are C in length (number of columns in the channel). Net = N1, N2, N3,..., Nn, wheren is the number of nets, is the set of nets. For example, Top = 1,0,3,1,4,2,3,2 Buttom = 6,4,6,6,3,0,5,5 where C = 8 and n=6 NET=1,2,3,4,5,6 The channel's configuration with linked netsis depicted in the diagram below.

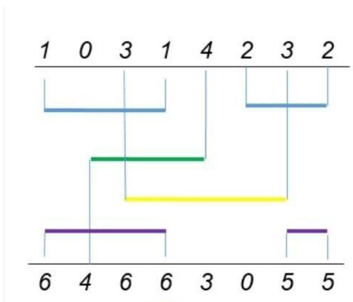

Fig. 5. Net Assignment on Tracks

Vertical and horizontal section overlaps can be avoidedusing graphs of vertical and horizontal constraints. The directed Constrainted Graph (GV)= (ENet,EV) describes verticalconstraints, where ENet is the set of vertices that corresponds to the set of nets and EV is the set of connections. Edge(n,m) in E occurs only if and only if net n is placed abovenet m to prevent crossings of the vertical segments of nets.For example, in GV in Fig. 2, there is a path from node 1to node 6, indicating that net 1 must be positioned above net6 to prevent vertical segment crossing. GV should be acyclic for contacts 1 and 4 (Fig. 1).

To solve the problem using the RCRP system. Doglegs, which are not allowed in the RCRP, can be used to fix the problem if nothing else is done. We will use an Extended Vertical Constraints Graph GEV=(ENet,EEV) in this article, where ENET denotes the set of nets and EEV denotes the set of ties. If and only if there is a path from vertex n to vertexm in GV, edge (n,m) in EEV exists.

In Figure 2, there is a path from node 4 to node 5 thatpasses through node 3. As a result, In GEV, there is an edge (4,5).

Horizontal constraints are presented by the Horizontal Constraints, which are undirected. Enet is the set of nets,and EH is the set of edges in the graph GH = (ENet,EH). Edge(n,m) occurs in EH if and only if n and m must be routed on n separate tracks to prevent horizontal segments n and m colliding. There is an edge (1,4), for example, indicating that net 1 cannot be put on the same track as net 4.

III. GENETIC ALGORITHM FOR RESTRICTIVE CHANNEL ROUTING

The Genetic Algorithm (GA) is an iterative method for processing a population of individuals (Solutions). Each person has a chromosome that encodes a potential solution. GA, like any other search method, necessitates some kind of criteriafor evaluating the results. This criterion, known as the fitness function, estimates an individual's efficiency. Various genetic operators, such as crossover and mutation, are then applied

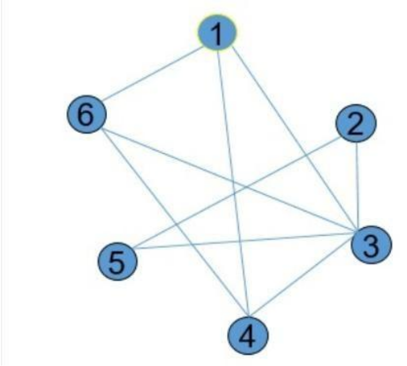

Fig. 6. HCG

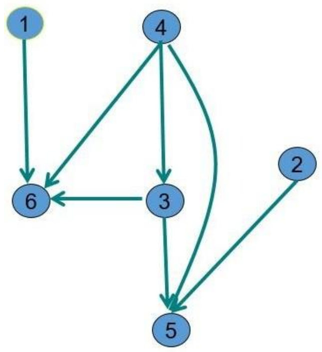

Fig. 7. VCG

to solutions selected from the population using the selection operator, with certain probabilities PC and PM, respectively. In subsequent iterations of the algorithm, known as Generations, the population is made up of the best parents and offspring. This project employs a novel topological channel description. The relative locations of the nets are thus defined by a chromosome. Each pair of nets (n,m) corresponds to a gene, which can have three different values:

• - relative location is irrelevant to the relative positions of the other nets

0 – net m should be placed above net n1 – net m should be placed below net n

In this case, the chromosome length is n-1 L I i=0, which is very long. The analysis of GEV and GH whichresult in a shorter duration. Since the relative positions of certain pairs in nets are already set in GEV, the decrease is possible. Constraint breaches occur when these positions are

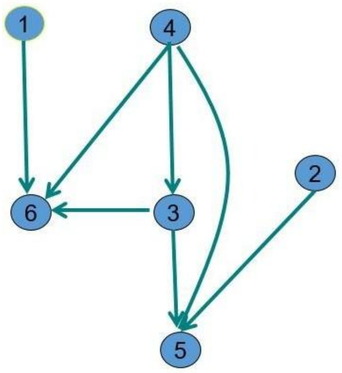

Fig. 8. Extended VCG

changed. The following is the second observation that allows for chromosome length reduction: If there are no horizontal constraints on nets, their relative locations are irrelevant orcan be deduced from their interactions with other nets. In the illustration above, a '*' sign denotes this fact. As a result, a chromosome's length is: NGC – NEVC = L The number of horizontal constraints imposed by GH is NGC,and the number of vertical constraints imposed by GEV is NEVC. GEV determines the relative positions of pairs of nets (1,6),(2,5),(3,4),(3,5),(3,6),(4,6) in our example. Since thenets in these pairs do not have horizontal constraints, therelative locations of the nets (1,2),(1,5),(2,6),(4,5),(5,6) areinsignificant. As a result, the chromosome will have a length of 3 and will appear as shown below.

We use guided TopologyGraph GT = (ENet,ET) to get an instance of a channel from a chromosome, where ENet is the set of nets and ET is the set of links describing the relative locations of the nets in the channel. Edge(m,n) occurs in ETif and only if net mis is located above net n in the pipe. The topological graph will look like this if the Gene was 0 1 0.

We'll use the LEA to route the channel after we've generated the topological graph, and the routing diagram willlook like this: Figure 3A The following is a list of simple fitness exercises that can be used to solve this problem: TotalWireCost+th = c1*(t+1)+c2*(TotalTrack–t +1)/Net F(A)
= TotalWireCost+th 2) There is a track number assigned toit. 3) c1 denotes the number of upper terminals in a given network.

4) c2 denotes the number of lower terminals in a given net. 5) Th is a net’s complete horizontal segment.

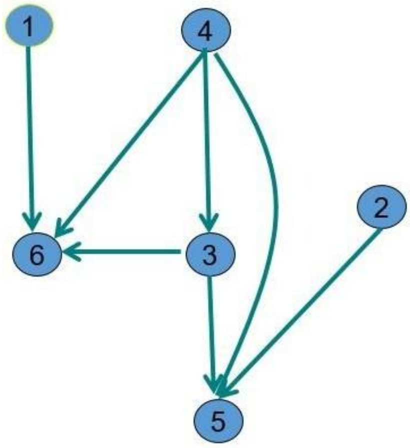

Fig. 9. Topological Graph

The following algorithm min pseudocode is used to extract GTfrom the chromosome: Step 1: Make a copy of GEV and pasteit into GT. i=1 is the second phase. Step 3: Add Edge (mi,ni) toGT if it isn’t already there. Step 4: Search for the existence of a path from node mi to node k for all nodes k (k=1,...,N) such that k= mi and k=ni and edges (mi,k) not found in GT. Add edge (mi,k) to GT if such a route exists. Step 5:If i=L, increaseI and return to Step 3. Step 6: The GT has been created. The channel from the chromosome is restored using the following algorithm: Step 1: Take GT out of the chromosome. i=0 isthe second phase. Step 3: Locate nodes with only outgoing links and position them on track I, then remove them fromthe graph GT. Step 4: Increase the value of i. Phase 5: Return to step 3 if GT is not empty. Step 6: Arrange the nets on the tracks in such a way that the vertical segments of the nets are the shortest possible. Return to step 7 I got a draught of the placement and a width channel.

The fitness value for Fig. 3 is Net 1: 2*(2+1) + 0 = 6. 2
* (1+1)+0 =4 Net 2 2 *(3+1) *(3+1) *(3+1) *(3+1) *(3+110 = +1*(4-3+1) 1*(1+1) = 1*(1+1) = 1*(1+1) = 1*(1 2*(4-4+1)*(4-4+1)*(4-4+1)*(4-4+1)*(0+2*(4-4+1) = 214 in net 5.
Total wire cost = 6+4+10+6+2+3 = 31. Net 6: 0+3*(4-4+1) =
3. F(A) = 31+22=53 since the total Horizontal Segment = 22.Genetic Operations in Practice: 1) Selection Process: Now, by randomly modifying the genetic code for a period of time,we can produce an initial population from which we canchoose the best two solutions for the crossover operation toachieve the best result. 2) Crossover Operation: After collection , all chromosomes are grouped into pairs, and each pair

Fig. 10. Solutions

is then subjected to the crossover operation with probability PC. Offspring are subjected to mutation with probability PM after recombination. The classic one and two point crossover for our chromosome encoding. The recombination process is demonstrated in the following example.
Parent 1: 0 1 0 fitness =53; Parent 2: 0 1 0 fitness =53;
Parent 3: 0 1 1 0 1 health =58 Parent 2: Fitness = 51
For offspring 1: 0 0 0 fitness for offspring 2: 0 0 0 fitness for
offspring 3: 0 1 1 1 health = 51 Offspring 2 In this case,the offspring, Offspring 1, has a higher fitness level than the parents. Parent 1 is depicted in Figure 3, Parent 2 is depictedin Figure 4, Offspring 1 is depicted in Figure 1, and Offspring 2 after chromosome decoding appears in Figure 2.

Before Mutation: 0 (1) 0 fitness = 72, after Mutation: 0
(1) 0 fitness = 72, after Mutation: 0 (1) 0 fitness = 72, after Mutation: 0 0 (0) 0 health = 70 after mutation Where (x) denotes the point of mutation. Figure 3 depicts the Channel prior to the implementation of the mutation process. Figure7 shows the Channel after the mutation operation has been applied.

A. Experimental Result

Consider the following net list for net length 12, where the upper boundary is 0 1 4 5 1 6 7 0 4 9 10 10 and the lower boundary is 2 3 5 3 5 2 6 8 9 8 9 8 7 9. If we use the left edge algorithm, the above net list would need 6 tracks, but if we usethe genetic algorithm, we can reduce the number of tracks to just 5. To predict the outcome of Restrictive Channel Routing,we used the Left Edge Algorithm and the C C++ language. While it is an effective tool, it does have some drawbacks.

IV. CONCLUSION

Application of the Genetic Algorithm to restrictive channel routing is investigated in this paper. The experiment's findings revealed that the proposed algorithm generated near- optimal solutions in a short amount of time. The proposed chromosome encoding, which is derived from a mathematical analysis of the problem, is credited with these advantages. Asa consequence, by removing solutions that cannot be accepted in advance due to constraint violations, the search space is significantly reduced. This is the key benefit of the presented algorithm, which explains why it performs better. The results of this research show that using domain-specific information in genetic operators and encoding schemes will help high- complexity genetic algorithms perform better.

Though the current findings are promising, using Gene sorting and personalized genetic operators, as well as other problem-specific details, further improvements are possible.

REFERENCES

1. G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of
2. Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955.
3. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol.2. Oxford: Clarendon, 1892,
4. pp.68–73.
5. I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III,
6. G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
7. K. Elissa, "Title of paper if known," unpublished.
8. R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.
9. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and
10. plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th
11. Annual Conf. Magnetics Japan, p. 301, 1982].
12. M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.