

Title	繰り返し分割再配置に基づく 2 次元配置最適化
Author(s)	金子, 哲
Citation	
Issue Date	2002-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/1522
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Description	Supervisor:金子 峰雄, 情報科学研究科, 修士

2-Dimensional Placement Method Based on Divide-and-Replacement

Akira Kaneko (010032)

School of Information Science,
Japan Advanced Institute of Science and Technology

February 15, 2002

Keywords: Simulated Quenching, 2-dimensional placement, iterative optimization, partition, wire length .

VLSI is constituent of various electronic equipments such as computer systems, telecommunication systems and controllers. By the continuing progress of the fabrication technology, the possible on-chip feature size is becoming smaller and the possible chip area is becoming larger, which enable us to integrate huge number of transistors in a chip. On the other hand, the difficulty of VLSI design is also growing due to not only a huge number of design variables but also intricate parasitic effects inherent in deep-submicron VLSIs.

VLSI design process can be classified hierarchically into system design, RTL design, logic design, circuit design and layout design. Layout design is the task to determine the positions of components and to determine the routes of interconnections between components so that the total area and total wire length are minimized, which, however, is known to be NP-hard problem. As an approach to such NP-hard problems, stochastic search method with hill climbing mechanism, such as Simulated Annealing (SA) and Genetic Algorithm (GA) is known to be successful for many practical problems. SA repeats (1) generating an adjacent solution of a current solution, (2) evaluating the cost of the adjacent solution and (3) deciding in stochastic fashion whether replacing current solution with the adjacent solution or not. SA is guaranteed to fall into the global optimum point if the annealing is sufficiently slow. On the other hand, GA repeats generation of a new population of solutions by applying selection, crossover and mutation on solutions in current population. We can find several reports in the application of SA or GA to layout problem, however they have drawback in computation time due to huge number of iterations. Therefore, more efficient algorithm is needed, which can solve a large-scale layout problem in a reasonable computation time.

Simulated Quenching (SQ) is a kind of iteration method for 1-dimensional assignment problem, which can produce comparable solutions to SA and GA within a shorter computation time. Inherent features of the SQ are (i) dividing entire problem into subproblems in stochastic fashion, (ii) modified objective function for subproblem (especially local nets (incident to only components in a subproblem) are neglected), and (iii) simple solution method for subproblem.

SQ has been also extended to 2-dimensional assignment problem. 2-dimensional assignment method based on SQ (2DSQ) is using Step-Cost which is decided by resultant wire length of each net. 2DSQ can derive a solution comparable to that of SA. In subproblem, 2DSQ using the minimum cost perfect matching algorithm for the bipartite graph with weighted edges($O(n^3)$). Because of that algorithm, 2DSQ requires very long runtime.

In this research, several 2-dimensional assignment methods are proposed. Their objectives are to derive a solution comparable to that of SA with shorter runtime. Each of them has cost function based on Force-Value or Step-Cost.

The methods based on Force-Value are FVS(Force Value based replacement by Sorting) and FVCH (Force Value based replacement with Convex Hull). FVS executes sequentially horizontal and vertical sort. FVCH adopts fully two-dimensional re-assignment. FVS runs faster than SA, but the resultant total wire length is longer than SA. The reason would be (1) FVS don't adopt fully two-dimensional re-assignment, and (2) FVS use Force-Value that is indirect objective function for total wire length. On the other hand, FVCH is comparable to FVS for the wire length. Thus, the reason of the longer wire length is the objective function, not the sequentially re-assignment. The methods based on Step-Cost are SCM (Step Cost based replacement by Matching) and SCS (Step Cost based replacement with Slope). SCM uses the sequentially horizontal and vertical re-assignment with the minimum cost perfect matching algorithm. SCS is approximate method that uses the difference of Step-Cost between adjacent two slots. SCM can derive a solution comparable to that of SA, while it needs the longer runtime. It shows that Step-Cost is better than Force-Value. SCS can derive a solution comparable to that of SA with shorter runtime. SCS runs 18 times faster than SCM and 12 times faster than SA.

The complexity of the re-assignment of SCS is smaller than SCM. While, the complexity of the computation of the wire length is still large. Thus, for obtaining the faster method, reducing the computation of the wire length needs.