A Consideration of Automatic Module Placement for VLSI Layout Design

T.Kutsuwa, M.Nakoshi, K.harashima K.Kobori, K.Oba
Faculty of Engineering,, Osaka Institute of Technology
Ohmiya, Asahi-ku Osaka ,535-8585 Japan
Tel: +81-6-6954-4304, Fax: +81-6-6957-2136
E-mail: kutuwa@elc.oit.ac.jp

Abstract : This paper discusses on application of meta-heuristic algorithms such as the genetic algorithm (GA) and the simulated annealing (SA) to the LSI module placement. We propose useful crossover method for improving of searching capability in genetic algorithm.

By using our proposed crossover method, we have been able to keep good schemata in the chromosome and the variety of the solution. From the experimental results, we have obtained better result than the simulated annealing method by starting from the initial placement of the min-cut method .

1. Introduction

The combinatorial optimal problem of the module placement and the wiring for VLSI layout design is considered to the NP-complete one. Then various heuristic solving algorithms have been applied to this problem. This paper discusses on application of meta-heuristic algorithms such as the genetic algorithm(GA) and the simulated annealing (SA) to the LSI module placement.

2. The problem of LSI module placement

This problem is to minimize the weighted sum of wiring length measures between modules that must be connected in the circuit. The layout example of 2 dimensional network that is consisted of the movable elements (3x3 inner modules) and the fixed elements (12 external modules) is shown in Fig. 1.

3. Application of Genetic Algorithm (GA) to the Placement

GA is shown in Fig. 2 and applied to LSI module placement as follows:

(1) Coding: the number sequence of laid modules in Fig. 3 is treated as chromosome.
(2) Initialization: the individuals consist of many randomly arranged modules are generated, and adopted to initial population.
(3)Calculation of Fitness: fitness value is calculated by a reciprocal of supposed sum of the wiring lengths.

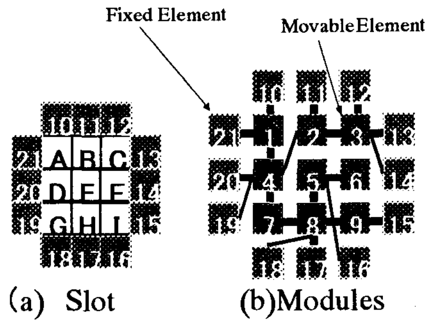

Fig. 1 Layout Example of 2 Dimensional Network

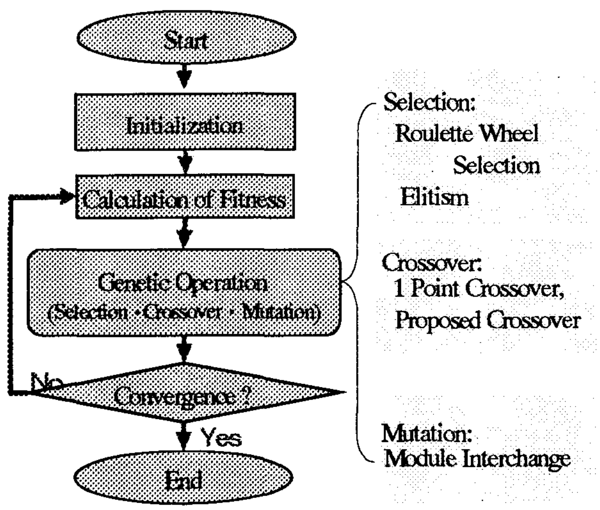

Fig. 2 Application of Genetic Algorithm

(4) Judgment of Convergence: convergence is judged by the number of generations
(5) Selection: the roulette wheel selection is applied.
(6) Crossover: our proposed crossover method is applied and compared with one point simple ordered crossover.
(7) Mutation: 2 modules from one of the population are selected, and interchanged each other by a mutation rate.

4 . Proposed Crossover Method

First of all, 2 parents (individuals) are selected from parent group, and 2 offsprings are generated from selected parents by following steps as shown in Fig.4.

i) One module is selected at random from parent 1.

ii) One module which is connected to the module of i) by the shortest connecting length is chosen.

iii) The choice of ii) is repeated by specified times. If there is no selectable module, those chosen modules are stored, and go to i).

iv)The positioning information of the modules chosen from parent 1 is taken over the offspring 1.

v) For the empty part of offspring 1, modules are copied from parent 2 and offspring 1 is generated.

vi) Offspring 2 is generated similarly by exchanging parents 1,2 and by executing i) ~v).

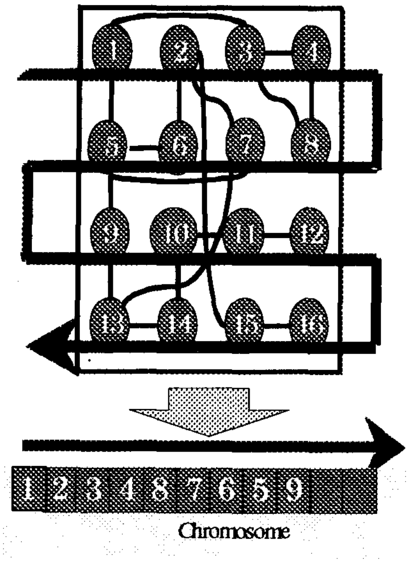

Fig.3 Coding of Module Placement

5. Computer Experiments

5.1 Conditions of Experiments.

The size of placement is 10x10 movable modules. The number of generated placement patterns is 300,000 per one trial. It means that 100 individuals (patterns) are generated in each generation, and 3000 generations are executed in a trial. 100 trials are executed for our experiments.

5.2 Initial Placement Condition

The placement algorithms are classified to (1) constructive initial-placement, (2) iterative placement -improvement and others. (1) is classified furthermore to random-placement , min-cut method and others . (2) is classified to genetic algorithm, simulated annealing method, pair-wise interchange method , and others.

Then in our experiments, by starting from the random-placement or the min-cut placement of (1), our proposed method in GA is compared with the simulated annealing , and the pair-wise interchange method .

5.3 The Conditions for Each Method

In order to compare those methods by almost same conditions, the following conditions are settled. as shown in Table 1.

Genetic algorithm (GA): The number of individuals and the elite retained next generation are 100 and 10, respectively. The maximum number of generations is 3000. The crossover rate is 0.8, and the mutation rate is 0.2, respectively.

Simulated annealing (SA): Initial temperature is 40. The reduction rate of temperature is 0.997. The number of searching times is 3000. The number of the searching for each temperature is 100.

Pair-wise interchange: The maximum number of interchange is 300,000.

5.4 The Results of Experiments

The results of experiments are shown in Fig. 5 . In the results for the random- placement in Fig. 5, Our proposed method is not better than the SA because that the maximum number of generations is not enough to convergent to the optimal result . However, our crossover method is better than the simple one point crossover in GA.

In the case that the min-cut method is used as the initial placement, our method is better than the others.

It is clear from the results of experiments and outline of each simulation in Fig.6 that the convergent speed of our method in GA is not faster than SA, however, the final result of our method is better than SA.

6. Conclusion

By using our proposed crossover method , we have been able to keep good schemata in the chromosome and the variety of the solution. From the experimental results in Fig.5, we have obtained better result than the simulated annealing method by starting from the initial placement of min-cut method .

References

[1]M.Nakoshi, ,K.Watanabe, T.Kutsuwa, K.Kobori, K.Ebata: "Application of parallel genetic algorithm to LSI module placement", Electronic Circuits World Convention Proceedings, Tokyo Japan, PO2-1-1—4, Sept. 1999.

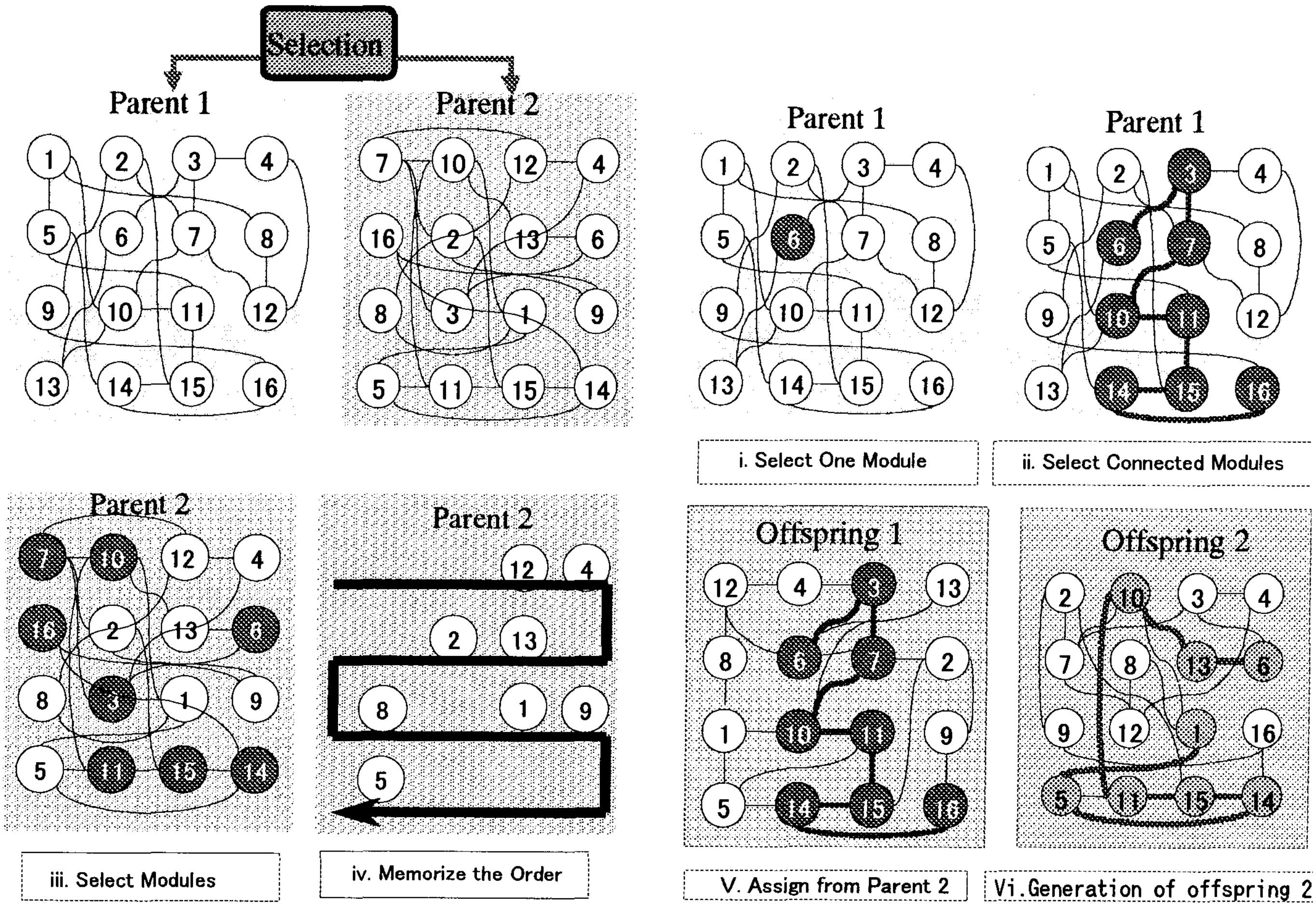

Fig.4 Proposed Crossover Method

Table 1 Conditions for Each Method

- Genetic Algorithm

The number of individuals 100 The number of elites 10
The maximum number of generations 3000
The crossover rate 0.8 The mutation rate 0.2

- Simulated Annealing

Initial temperature 40
The reduction rate of temperature 0.997
The number of searching times 3000
The number of searching for each temperature 100

·Pair-wise interchange

The maximum number of interchange 300,000»

Random Initial Placement Used PC CPU: Pentium Ⅲ 550MHz Memory: 256MB

	Best	Average	Std. Var.	Times(s)	Obtained Best
Initial Value	1430	1556.38	47.61	-	-
Pairwise Interch.	330	460.06	59.44	22	-
SA	220	259.34	27.85	22	22 ◎
GA(1Point Cross)	378	521.82	56.46	20	-
GA(ProposedCross)	352	472.74	58.63	26	-

Initial Placement by Min-cut Method

	Best	Average	Std.Var.	Times(s)	Obtained Best
Initial Value	346	411.30	40.66	-	-
Pairwise Interch.	220	268.06	28.18	21	5
SA	220	257.32	27.43	21	27
GA(1Point Cross)	228	262.40	14.22	19	-
GA(Proposed Cross)	220	224.68	8.92	25	72 ◎

Fig.5 The Results of Experiments

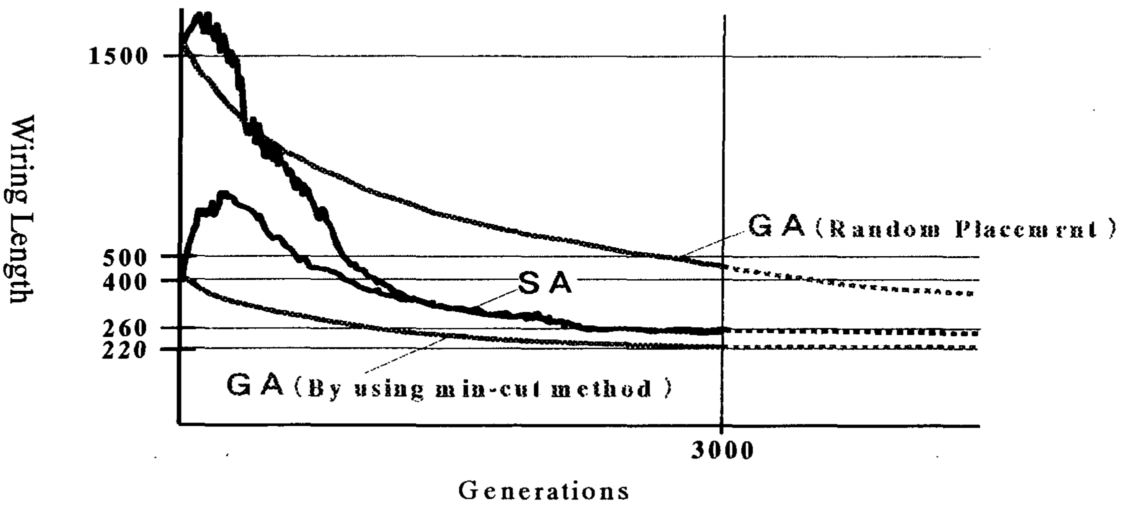

Fig.6 Outline of Each Simulation