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Hybrid Algorithmical Approach for VLSI Physical Design – Floorplanning

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Abstract —**The traditional floor planning is that usually handles only block packing to minimize silicon area, So modern floor planning could be formulated as a fixed-outline floor planning. It uses some algorithms such as B-TREE representation, simulated annealing and adaptive fast simulated annealing. Comparing above three algorithms the better efficient solution came from adaptive fast simulated annealing, it leads to faster and more stable convergence to the desired floorplan solutions. But the results are not an optimal solution. To get an optimal solution it is necessary to choose effective algorithm. Combining global and local search is a strategy used by many hybrid optimization approaches. Memetic Algorithm (MA) is an evolutionary algorithm that includes one or more local search phases within its evolutionary cycle. MA applies some sort of local search to improve the fitness of individuals in the population. The algorithm combines a hierarchical design technique, Genetic algorithms, constructive techniques and advanced local search to solve VLSI floor planning problem. MA quickly produces optimal or nearly optimal solutions for all the popular benchmark problems.**

Index Terms —**Floorplan Problem, Memetic algorithm, Genetic Algorithm, Delay, Cut size.**

I. INTRODUCTION

Floorplanning is a critical step, as it sets up the ground work for a good layout. However, it is computationally quite hard. Very often the task of floor planning is done by a design engineer rather than a CAD tool. The process of determining block shapes and positions with area minimization objective and aspect ratio requirement is referred to as Floorplanning. A common strategy for blocks floorplanning is to determine in the first phase and then the relative location of the blocks to each other based on connection-cost criteria. In the second step, block sizing is performed with the goal of minimizing the overall chip area and the location of each block is finalized [2]. Simulated annealing (SA) has been considered a good tool for complex nonlinear optimization problems. The technique has been widely applied to a variety of problems.

However, a major disadvantage of the technique is extremely slow and hence not suitable for complex optimization problems such as scheduling. There are many attempts to develop parallel versions of the algorithm. As an optimization technique, Genetic Algorithm examines simultaneously and manipulate a set of possible solutions. The power of GA's comes from the fact that the technique is robust, and can deal successfully with a wide range of problem areas, including those which are difficult for other methods to solve.

Genetic Algorithms are not well suited for fine-tuning structures which are close to optimal solutions. Incorporation of local improvement operators into the recombination step of a Genetic Algorithm is essential if a competitive Genetic Algorithm is desired. MAs are evolutionary algorithms (EAs) that apply a separate local search process to refine individuals (i.e) improve their fitness by hillclimbing. Under different contexts and situations, MAs are also known as hybrid EAs, genetic local searchers. Combining global and local search is a strategy used by many successful global optimization approaches, and MAs have been recognized as a powerful algorithmic paradigm for evolutionary computing. In particular, the relative advantage of MAs over EAs are quite consistent on complex search spaces.

II. PROBLEM FORMULATION

Generally the floorplanning problems are such as size, chip area, total wire length, delay of critical path, routability, noise, heat dissipation. The modern floorplanning typically needs to pack blocks within a fixed die (outline) and additionally consider the packing with block positions as well as the interconnect constraints. The modern floorplanning problem is categories as Fixed-Outline floorplanning.

A module B is a rectangle of height h_B, width w_B, and area A_B. A super-module consists of several modules, also called a sub-floorplan. A floorplan for n modules consists of an enveloping rectangle R subdivided by horizontal lines and vertical lines into n non-overlapping rectangles such that each rectangle must be large enough to accommodate the module assigned to it. In the given problem, we are given a set of hard modules and an outline-constraints are provided.

The modules in the given Fixed-Outline (denoted as FO) have freedom to move while the modules outside the FO are infeasible in the final floorplan.A feasible packing is a packing in the first quadrant such that all the modules inside FO are not duplicate and overlapping. The objective is to construct a feasible floorplan R such that the total area of the floorplan R is minimized and simultaneously satisfies the fixed-outline constraint

III. MEMETIC ALGORITHM

Memetic Algorithms (MAs) are a class of stochastic global search heuristics in which EA-based approaches are combined with problem-specific solvers. The later might be implemented as local search heuristics techniques, approximation algorithms or, sometimes, even (partial) exact methods. The hybridization is meant to either accelerate the discovery of good solutions, for which evolution alone would take too long to discover, or to reach solutions that would otherwise be unreachable by evolution or a local method alone. As the large majority of MAs use heuristic local searches rather than, e.g., approximation or exact methods, in what follows we will focus only on the local search adding for the Evolutionary Algorithm (EA). It is assumed that the evolutionary search provides for a wide exploration of the search space while the local search can somehow zoom-in on the basis of attraction of promising solutions [6]. A quick glance at the algorithm allows identifying the basic structure of an EA for which hot-spots, i.e. the places where hybridization could take place, it has to be identified and marked with red circles [6]. Each of these hot-spots provides opportunity for hybridization. For example, the initial population could be seeded with solutions arising from sophisticated problem specific heuristics, the crossover (mutation) operator could be enhanced with domain specific and representation specific constraints as to provide better search ability to the EA. Moreover, local search could be applied to any or all of the intermediate sets of solutions (e.g. the offspring set). However, the most popular form of hybridization is to apply one or more phases of local search, based on some probability parameter, to individual members of the population in each generation.

MEMETIC ALGORITHM

1. Encode Solution Space
2. (a) set pop size, max gen, gen=0;
   (b) set cross rate, mutate rate;
3. Initialize Population.
4. While(Gen < Gensize)
   Apply Generic GA
   Apply Local Search to Population EndWhile
   /* end of a run */
5.. Apply Final Local Search to Best Chromosome

A. Genetic floorplan algorithm

The overall procedure of GFA [5] is described in the pseudocode given below..At the beginning, a set of Polish Expressions (PEs), denoted as P, is randomly generated to compose a population. The fitness of each sub-floorplan or floorplan, P, is calculated by eq .1

$$\textbf{Fitness (p)} = \frac{A(R) - \sum_{B_i \in R} A(B_i)}{A(R)} \qquad (1)$$

GENETIC ALGORITHM

1. Encode Solution Space
2. (a) set pop size, max gen, gen=0;
   (b) set cross rate, mutate rate;
3. Initialize Population.
4. **While** max gen ,gen
   Evaluate Fitness
   For (i=1 to pop size)
   Select (mate1,mate2)
   if (rnd(0.1) < cross rate)
   child = Crossover(mate1,mate2);
   if (rnd(0.1) < mutate rate)
   child = Mutation(); Repair
   child if necessary
   End For
   Add offsprings to New Generation.
   gen = gen + 1
   End While
   Return best chromosomes.

where Block Area is the area of each module and Floorplan Area is the area of the floorplan, consisted of modules. The fitness calculates the proportion of the dead area of a floorplan, i.e., the more the fitness closes to zero. The threshold value T_s, is initially set closes to zero, which is used to identify the quality of sub-floorplans .

B. Crossover_FO

The process of the crossover operation to solve the constraint of Fixed-Outline is explained. The input is a pair of floorplan P_1 and P_2.The output is a floorplan that inherits good sub-floorplans from P and P and satisfies the fixed-outline constraint. Assume the number of gs of P_1 is larger than or equal to the number of gs of P_2.There are four steps in this operation [6].

C. Mutation

There are three possible operations for mutation. These operations are randomly selected to perform mutation in order to escape the space of local optimal search [5].

D. Local search

Simulated annealing (SA) [11] is widely used for floorplanning. It is an optimization scheme with non-zero probability for accepting inferior (uphill) solutions. The probability depends on the difference of the solution quality and the temperature. The probability is typically defined by min {1,exp-ΔC/T},where ΔC is the difference of the cost of the neighboring state and that of the current state ,and T Is the current temperature. In the classical annealing schedule, the temperature is reduced by a fixed ratio for each iteration of annealing.

IV. EXPERIMENTAL RESULT

To test the effectiveness of proposd Fixed-outline floorplanning algorithm, set the maximum percentages of dead space to 15% and10%.The expected aspect ratios R * of the floorplans are chosen from the range with interval 0.5. Experiments were performed on a 1.6-GHz Intel Pentium4 PC using the GSRC benchmark circuit n100.The results were averaged for 50 runs for each aspect ratio. We compared with FASA based on the same platform. We have tested MA with polish expression floorplan representations, polish Table I lists the average success rates for FASA and the MA. Proposed method obtained 100% success rates of fitting into the given fixed outlines for all runs with dead space Γ =15% and Γ =10%.Incontrast, the success rates when Γ =10% for MA, FASA were 30.3%, 65.5%, and 99.4% respectively. The dramatic differences reveal the effectiveness of our approach. Also, this proposed method required the least running time on average.

TABLE I
COMPARISON OF WIRELENGTH UNDER FIXED-OUTLINE CONSTRAINT FOR n100, n200, & n300 WITH ASPECT RATIO R =1, 2, 3, 4

Circuit	Aspect Ratio R*	Fast-SA		ours	
		Wire (mm)	**Time (sec)**	**Wire (mm)**	Time (sec)
n100	**1**	**33.56**	**30**	**32.06**	**26**
	2	35.44	30	34.39	24
	3	35.48	30	34.23	27
	4	36.89	29	32.74	27
n200	1	63.55	175	58.33	150
	2	62.76	173	59.84	156
	3	63.70	180	61.55	156
	4	66.31	176	63.72	171
n300	1	76.05	399	71.00	363
	2	77.60	386	74.22	358
	3	81.67	391	79.56	371
	4	88.58	382	82.18	370
Comparison		1.06	1.11	1.00	1.0

V. CONCLUSION

The proposed algorithms for modern Floorplanning problems with Fixed-outline is based on the new Memetic algorithm. Experimental results have shown that MA leads to faster and stable convergence to desired Floorplan solutions. For fixed-outline floorplanning, the new cost function considering the aspect-ratio penalty drives MA more efficiently to find floorplans inside the given chip outline. The experimental results on the fixed-outline floorplanning have shown the efficiency and effectiveness of this floorplanning algorithms; for those applications, this results out-performs the related recent works by large margins. Research along this direction is on going.

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