A Constructive Genetic Algorithm for the Linear Gate Assignment Problem

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Abstract

We present in this paper an application of the *Constructive Genetic Algorithm (CGA)* to the *Linear Gate Assignment Problem (LGAP).* The *LGAP* happen in very large scaling integration (VLSI) design, and can be described as a problem of assigning a set of circuit nodes (gates) in an optimal sequence, such that the layout area is minimized, as a consequence of optimizing the number of tracks necessary to cover the gates interconnection. The *CGA* evolves a dynamic population composed of schemata and structures and uses heuristics in fitness function definitions.

1 CGA APPLICATION TO LGAP

The *Constructive Genetic Algorithm (CGA)* was proposed recently as an alternative to a traditional *GA* approach (Lorena, 2001), particularly, for evaluating schemata directly. The population, initially formed only by schemata, evolves controlled by recombination to a population of well adapted structures (schemata instantiation) and schemata.

Linear gate assignment problems (LGAP) are related to gate matrix layout and programmable logic arrays folding. An example of a gate matrix and the representation used for structures and schemata follows:

1 0 1 1 0 0 1 0 0	1 0 0 0 1 1 0 1 0	1 ? 0 ? ? ? 0 1 ?
0 0 0 1 0 1 0 0 1	0 0 0 1 0 1 1 0 0	0 ? 0 ? ? ? 1 0 ?
1 1 0 0 1 0 0 1 0	0 1 1 0 0 0 0 1 1	0 ? 1 ? ? ? 0 1 ?
1 0 0 1 1 0 1 0 0	1 0 1 0 0 1 0 1 0	1 ? 1 ? ? ? 0 1 ?
0 0 0 1 0 1 0 1 1	0 0 0 1 0 1 1 0 1	0 ? 0 ? ? ? 1 0 ?
0 0 0 0 1 0 1 1 0	1 0 1 0 0 0 0 0 1	1 ? 1 ? ? ? 0 0 ?
0 0 0 0 0 1 0 0 1	0 0 0 1 0 0 1 0 0	0 ? 0 ? ? ? 1 0 ?
1 2 3 4 5 6 7 8 9	s_j= (7 2 5 9 3 4 6 1 8)	s_k=(7 # 5 # # # 6 1 #)
Gate matrix	Permutation (structure)	Permutation (schema)

Two fitness functions are defined on the space of all schemata and structures that can be obtained using this representation. The evolution process considers the two objectives on an adaptive rejection threshold, which gives ranks to individuals and yields a dynamic population. The first function reflects the total cost of a given permutation of gates, and the other drives the evolutionary process to a population trained by a heuristic. The chosen heuristic is the 2-Opt neighborhood.

The initial population is composed exclusively of schemata. Two structures and/or schemata are selected for recombination. The first is called the *base* (s_{base}) and is randomly selected out of the best ranked individuals. The second structure or schema is called the *guide* (s_{guide}) and is randomly selected out of the total population. The current labels in corresponding positions are merged. A new filling operator is proposed to complement a schema, substituting the # labels for gate numbers. A local search mutation is always applied to structures, no matter how they are created (after recombination or after the filling process). The search at 2-Opt neighborhood of the structure was used.

The *CGA* for *LGAP* was run on Intel Pentium II (266Mhz). All best previous results comes of *Microcanonical Optimization* - MCO approach (Linhares,1999). The *CGA* reached all the best results (number of tracks) for instances taken from the literature, but it appears to be more robust than other approaches.

	MCO		**CGA**		
Problem	**Time (s)**	**Tracks**	**Time (s)**	**Generations**	**wire length**
wli	10	**4**	5	5.00	35
wsn	10	**8**	15	7.00	115
v4050	10	**5**	5	5.00	51
v4000	10	**5**	5	5.00	66
v4470	700	**9**	665	33.00	269
v4090	100	**10**	20	13.50	132
x0	700	**11**	755	92.57	343
w1	10	**4**	10	5.00	57
w2	400	**14**	185	19.50	283
w3	3900	**18**	3062	186.00	761
W4	61700	**27**	52246	225.00	1932

References

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