CHAPTER 7

CONCLUSION AND FUTURE PERSPECTIVE

CHAPTER OUTLINE

In extension to comparisons presented in chapter-6, now we present conclusions based on the algorithms presented in chapters 2-5. To achieve desired objectives SAA, PMSAA, HNN and CNN based algorithms alongside GA were first implemented, tested and compared for SCP problem. Subsequently, two local search approaches including TS and TA were implemented and tested. These methods were further compared to other methods and in the same case gave reasonable results too. The Memetic Algorithm presented in the work is observed as the best overall technique for Standard Cell Placement problem. Moreover, it being new, there is reasonable scope of development on the Memetic Algorithm frame work leading to future possibilities of research in the area of standard cell placement which may encompass clock skew minimization, avoidance of cross talk, even power distribution and many more.
CHAPTER-7: Conclusion and Future Perspective

7.1 CONCLUSIONS

In the work presented here, several new methods for single and multi-objective standard cell placement optimization were implemented and investigated. A large number of test runs were conducted to study the performance of the methods with regards to the standard cell placement problem. To achieve desired objectives SAA, PMSAA, HNN and CNN based algorithms alongside GA were first implemented, tested and compared for SCP problem.

Classically, a graphical comparison of wire length and CPU times in case of SAA with different parameter settings depicted an improvement of 8 to 10% of wire length at a heavy cost of CPU time. Also, PMSAA provided a significant reduction of 2 to 3 times in execution time to that of SAA.

Further, in HNN, it is important to find an appropriate problem representation and then to formulate the constraints and the objective function need to be a ‘Lyapunov’ to satisfy the stability condition. It was observed that the network with given parameter values always converge to a valid solution with good quality of placement and smaller wire-length. With decreasing gain, the placements were better but converging time increased considerably.

Binary HNNA generally gave good results and converged fast. Result evolution validated that for complex net-lists with large number of cells caused the resulting wire length to become nearer to SAA. Additionally, CNN (using cascaded HNN) gave the wire-lengths less than that obtained by GA but was slower as compared to GA.

Comparison of GA and HNNA showed that if the wire-length be computed according to the bounding rectangle criterion, the results of GA were better over HNNA. On the other hand, if the basis is pair-wise wire-lengths, HNNA excelled. For HNNA the computing time increased exponentially as the problem size increased. Large computation time of HNN was also due to simulation of its ‘parallel’ configuration as a serial (sequence) on computer. Note that the computational per cycle becomes square times the number of neurons in the network.

Two local search approaches including TS and TA were implemented and tested. These methods were further compared to other methods and in the same case gave reasonable results too. In case of TSA we tried the same algorithm for maximum lengths of tabu list (tabu_max) varying from 5 to 100 along with various combinations of number of neighbours (inner_loop_iter) in the range 10 to 100 in different combinations with number of iterations (wait for change) in the range of 1000 to 100000. The results were surprisingly poor for some combinations of these parameters. For instance, with high value of tabu_max in combination with very small value of inner_loop_iter, we got very poor results of wire lengths. Similarly, having very large value of ‘wait for change’ made the algorithm very sluggish. In short, parameter sets presented here for TSA (TS-I to TS-VI) were the best combinations that gave suitable results to facilitate reasonable comparison within and with other techniques.
TAA was marginally faster over the TSA but results were seen poor. Both the algorithms had reasonable performance but on comparison, they did not prove better than SAA. But, in the course of investigating these algorithms, it was observed that a LSA approach if used in combination with some inherently parallel evolutionary algorithms including GA may prove to be better. It was attempted in chapter 4 wherein a hybrid of GA and dynamic hill climbing based LSA was explored.

A hybrid of GA and HNN was implemented and tested subsequently. The hybrid method ran the HNN algorithm first to solve a part of the problem and GA for the rest. It was to save considerable computational time over the original HNN. Still the computing time for large problem was exorbitant and hence bigger problem sizes could not be tested.

Another hybrid method investigated had been the hybridization of GA with SA in SAGAP algorithm. One advantage of this method was its global convergence property inherited from SA approach. Both sequential and parallel SAGAP were implemented and examined in this work. A grid based topology of parallel processors was chosen for communication. Various parameters were set in the parallel SAGAP. Parameter settings were examined with regard to their effect on the performance. In some cases, SAGAP performed better than SA and GA with marginal improvement in wire lengths, but then the run time also increased significantly.

The last hybrid method employed GA and LSA using simple dynamic hill climbing approach for the local search at two stages. GA was used to choose initial population and subsequently LSA for faster convergence of objective function and improved wire lengths. This algorithm was tested for large set of parameters. The performance of MA surprisingly varied with different combinations of the values of mutation and cross-over rates, sometimes giving very poor results and at other occasions giving results far better than any previously established technique. The results with right parameter sets of this algorithm proved to be the best as compared to any stand alone or hybrid technique. MA presented 12-15% improved results in terms of reduced wire length and 20-30% faster execution of the algorithm compared to GA.

Subsequently, motivated by the encouraging results of memetic algorithm for wire length optimization, firstly, multi-objective memetic algorithm MA-I (MOGALS) was implemented and tested wherein we used the algorithm of MOGAF as the basic and introduced the procedure of local search based SDHC as discussed in chapter 4 and applied to each offspring using the same scalar fitness function in the selection of their parents. Secondly, we implemented MA-II: MOGALSP (Multi-Objective GA based Local Search with Probability) wherein we introduced a probability of local search $p_L$ with an intention to reduce the computation time. The local search was applied only to selected solutions $N_L$ with probability $p_L$. MA presents results better than the other hybrid techniques of SAGAP and hybrid of HNN & GA in specific, and moreover proves to be even better than any of the iterative, local search or coupled network approach in general. The detailed comparison of the algorithms is presented in chapter 6 of this thesis.
The results of MOGAF showed marginal improvement in the values of wire-length, delay and power as compared to that of Algorithm-I. However, a significant improvement in these values was observed in case of MOGALS. This includes 10% improvement in wire-length, 7.5% lesser delays and power consumption reduction by nearly 6%. This was at the cost of increased computational time. The computational time was significantly reduced in the case of MOGALSP with restrictive application of LS. MOGALSP always gave marginal improvement in values of wire-length, delay and power.

The detailed comparison of the results of SCP algorithms for SOSCP and MOSCP established MA as the best approach for standard cell placement. Also, the results remain unaffected even when the algorithms were re-run under time constraints, to give a fair chance to all.

From the above discussions we conclude that:

1. Stochastic effect of running the methods do not compensate for the difference in solution quality.
2. A slow but good method, which runs only a few times, outperforms fast but bad method.

Thus we see that in this work MA proved to be the best method for standard cell placement. It was better than the other existing and newer methods under study. Because of its simplicity, it was easy to understand and implement. Also, since the memetic framework is still developing, it is expected to lead to newer and faster optimization algorithms to be investigated in future.

7.2 FUTURE PERSPECTIVE

SOSCP algorithms presented in this thesis intended to optimize wire length with low CPU time. These algorithms may be extended towards optimization of other parameters including power and delay with minor modification in the objective function. Also the hybrid algorithms may be used for the same. Apart from wire length, power and delay optimization, the work can be further extended towards optimization of placement algorithms for:

1. Minimization of clock skew
2. Avoidance of cross talk
3. Even power distribution
4. Reduced routing congestion
5. Uniform thermal distribution may be a focus area for further research to ensure:
   a. Minimum temperature gradient and
   b. Avoidance of hot spots across the chip area

as it may be a major contributor towards improved MTBF of an integrated circuit.