A GLOBAL CRITICAL PATH AWARE PLACEMENT TECHNIQUE

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ABSTRACT

This paper will present a novel technique to improve the placement critical wirelength. The technique is called Critical Star. The technique changes the placement graph that connects the cells. The Critical Star connects all the cells of a critical path for a set of paths. With this connection we reduce the path delay of this set. It improves the average critical wirelength of a set of critical paths. The improvement in CAPO is 29.16% with penalty average total wirelength 0.65% and in FastPlace3 is 27.01% to increase in average total wirelength of 0.98%.

1. INTRODUCTION

With the device scaling is necessary to meet the needs of high performance VLSI systems and the interconnect delay dominates the total delay. Thus decreasing the wire delay is essential to improve the quality of solutions. Placement is an important step, whose affect interconnection, solution area, routability, performance and others.

The usual timing-driven placement schemes have been classified as net-based and path-based. The net-based algorithms assign delay budget on each net and seek to control the delay on the net. The path-based algorithms are usually fast and exact, but they fail in controlling numerous paths. Our technique is critical-path aware. We have an approach very similar to path-based timing-driven technique reducing the distance of cells in critical paths.

In this paper we will present a technique to reduce a set of critical-paths. The technique is called Critical Star. Then we reduce the critical-path penalizing total wirelength. Other very interesting works at the same subject are [6, 7, 8, 9 and 10].

The remainder of the paper is organized as follows: in the second part, it describes the fundamental theories of CAPO and FastPlace placers. In the third part, it presents the Critical Star technique. In the fourth we show our experimental results and fifth we conclude and present the future works.

2. MIN-CUT AND QUADRATIC PLACEMENT

The placement algorithms can be classified in three big categories, as follows: Simulated Annealing, algorithms based on recursive partitioning and force directed methods. A very important subset of the force directed methods are the analytical methods, such as the quadratic placement technique.

The simulated annealing methods [14, 15] have disappeared in academic research because of there is not scalability for large circuits, and then we choose two placers of the others category to apply our technique: based on recursive partitioning (CAPO Placer) and a Quadratic Placement based, i. e. a force direct placer (FastPlace). Analytic and heuristic partitioning algorithms have a lower time complexity compared to simulate annealing based methods. If simulate annealing improves the scalability we could obtain excellent results in future.

2.1. Min-Cut Algorithm

If we divide the CAPO placer in two parts, we can explain that global placement is performed with recursive bisection using a leading-edge multi-level partitioner. The detailed placement is performed with optimal branch-and-bound partitioner and placer.

The CAPO placer has excellent trade-off between wirelength and runtime. When we partition a placement problem, we improve the scalability and the runtime, but at the same time we lost some global problem information. And the Critical Star method increase the global information about the critical path, and this is very useful to improve the placement quality, considering the critical wirelength.

2.2. Quadratic Placement

The FastPlace [3 and 4] start applying a hybrid net modeling and weighting the connections. Nets of size 2 or 3 are modeled as a complete graph, while every net larger than three pins is translated into a star. After transforming the netlist, FastPlace apply the quadratic wirelength function $\phi(x,y)$ as described by equation (1). It can be observed that the three coordinates x, y can be optimized independently with $\phi(x) + \phi(y)$. Applying the derivative on each of the optimization equation, the optimal solution can be found at the minimum point (derivative equals to 0). After some algebraic transformations, each coordinate is solved by the system of equations $Q \times x = dx$, where Q is the part of connectivity matrix related to the movable cells, x is the vector of unknowns which represents the position of movable cells and dx is the right-hand-side vector. The details of how these matrices can be obtained are found in the review provided in [1].

$$\frac{1}{2}\sum_{i,j=}^{n}\left[\sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}\right]^2$$