# EMC-Driven Placement for MCM*

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**Abstract**

In this paper, we use the hierarchical placement algorithm to implement the EMC-driven MCM placement. To ensure that every maximal connection chip pairs would be placed as close as possible, we provide an clustering development algorithm. A proper model for EMC-driven MCM placement is used in this work. By this model, we use the short wire antenna to simulate the radiation of each chip on the substrate. At present, we have implemented an MCM placement program successfully, and this program can output the layout with the CIF form.

## 1. Introduction

Due to the application of fast device technologies and the increasing complexity of Multi-Chip Modules (MCM) [1], electro-magnetic interference (EMI) may reduce performance, cause logic errors, or even destroy a circuit. In the future, it will be indispensable to already consider phenomena of electro-magnetic compatibility (EMC) during layout synthesis. So far, EMC aspects have been largely neglected during layout synthesis.

MCM is an alternative packaging approach to complement the advances taking place in the IC technology. Without the individual packaging for the chips , the bare chips can be placed much close on the MCM substrate.

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## 2. Survey of Placement Algorithms

Good placement configurations meet performance requirements while providing easy and neat producibility, high reliability, and low-cost [2]. Few methods are available for MCM placement, since most of the placement algorithms are designed for VLSI.

In constructive techniques, the placement configuration is usually determined by positioning unplaced chips onto a substrate containing previously placed chips. In iterative placement methods, chips are selected and exchanged to alternative chip sites based on the new cost which is computed from a cost function In order to control the iterative results without dropping into local optimum, there are four methods to be used, such as simulated annealing, simulated evolution (generic algorithm) [3], force directed, and min-cut placement algorithms

To sum up these placement algorithms[4], we want to develop a fast and good placement algorithm which bases on hierarchical method. The combination of hierarchical method and cluster growth can be viewed as a combined top-down and bottom-up approaches.

## 3. EMC Model

Since the MCM is a high density, high speed and high power dissipation module, the electromagnetic compatibility of the MCM gains more and more importance. With increasing

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integration and operation speed, EM phenomena may increasingly degrade performance, cause logic errors or even destroy a circuit.

To consider the design process as time and cost efficiently as possible, EMC constraints and cost criteria have to be integrated directly into layout synthesis. The approaches for EMC-constrained placement of MCM are very lack now. Figure 1 shows the EMI and parasitic coupling effects on a MCM board.

In this work, we should compute the electric field strength (**E**), the magnetic field strength (**H**), the Poynting vector (ζav), and the radiated power (**P**).

### 3.1 Problem Definition

The point of the emphasis of EMC in this paper is to determine the minimal distance among dice. At this minimal distance, every chip can work at normal function in the electromagnetic environment. So the problem can be defined as follow [5-6] :

Knowing every susceptibility of every chip on the MCM, e.g., noise margin, attenuation of radiated power by others, to find the minimal distances among dice, in such distances and positions, the function of every chip will operate normally.

### 3.2 Electric Dipole Radiation

Figure 2 shows an electric dipole. This model also can be viewed as a short wire antenna [6]. Such antenna can give us to identify some key concepts and the basic entities from which realistic sources and practical antennas can be built up. Now we deduce E, H, the Poynting vector $\zeta_V$ and adiated power P, and the dipole is in free space.

The pattern of electromagnetic fields with wavelength λ around a short wire antenna of length $l \ll \lambda$, carrying an uniform current, is described by function of distance, frequency and angle. The magnetic field of an electric dipole on the MCM surface has only a ϕ component.

Integrating the time-averaged Poynting vector over a sphere of radius r yields the radiated power :

$$P = \frac{2\mu_0\pi}{3c} f^2 I_{rms}^2 l^2 = 8.799 \times 10^{-15} f^2 I_{rms}^2 l^2 \qquad (1)$$

$$= \frac{2 \times 10^{-7} c}{3} (I_{rms} l\beta)^2 = 19.99 (I_{rms} l\beta)^2 \text{ watt} \qquad (2)$$

Based on this analysis, we obtain the radiated power versus distance with different frequency as shown in Figure 3.

## 4. MCM Placement Algorithm

### 4.1 Problem Formulation

The major object is to develop a fast and near optimal MCM placement algorithm including EMC considerations[7].

Let $C_1, C_2, \ldots, C_n$ be the chips to be placed on the MCM substrate. Each $C_i$, has associated with its size($h_i$, $w_i$), frequency $f_i$, and current $I_i$. Let $N = \{N_1, N_2, \ldots, N_m\}$ be the set of nets between different chips.

To find the positions for each of these chips on the module denoted by $P = \{P_1, P_2, \ldots, P_n\}$ such that

1) No two chips overlaps,
2) Placement is routable,
3) All chips satisfy EMC,
4) The total area of module $A$ is minimized, and
5) The total wire-length $L$ is minimized.

### 4.2 Hierarchical MCM Placement Algorithm

A detailed MCM placement algorithm will be introduced in this section. And there is a simple example that shows how the algorithm implements on the MCM placement[8].

#### 4.2.1 System Flowchart

Figure 4 shows the flow chart of the MCM placement system. At first, it is to read the benchmark and build a data structure for this MCM benchmark. The benchmark format is *.yal from **MCNC**. The algorithms are investigated in this work.

#### 4.2.2 An Example of DFS Algorithm

First, we construct a triangular cost matrix to determine which chip will be placed first. The cost is evaluated by

$$Cij = \lambda Wc + \mu We$$

where $\lambda$ and $\mu$ are two control parameters, $W_c$ and $W_e$ are weight of connection and weight of EMC, respectively. We can set the two control parameters as following three case :

1. $\lambda$=1 and $\mu$=0, for only minimizing the total wire length.
2. $\lambda$=0 and $\mu$=1, for only considering the EMC satisfaction.
3. $\lambda$=0.5 and $\mu$=0.5, for considering both the total wire length and the EMC satisfaction.

## 5. Experimental Results

We implemented these algorithms with C language and processed the program on Sun workstation. The output data of our program are a CIF file to display the layout on CADENCE tool. Meanwhile, it supports routing information for routing procedures. The benchmarks of MCM placement are not available yet, and the benchmarks of building block released by MCNC are used instead to test the algorithms.

First, the circuit is looked as one partition and second (test2.yal), the circuit is partitioned to two partitions. There are 49 blocks, 408 nets and 20 I/O counts in BBL4. Tables 1 shows the placement comparison of two different conditions, including our algorithms of cases 1 to 3, the best case and worst case that list on MCNC. Table 2 is the area comparison. Figure 5 shows the comparisons of Table 1. Figure 6 shows the layout result with EMC-consideration.

## 6. Conclusions

In this work, a fast hierarchical MCM placement based on cluster growth algorithm is implemented and the basic EMC analysis of MCM substrate is considered. Using the hierarchical methodology to do MCM placement, the partitioning of circuit should be done at first. By the experimental results, we can find that the processing speed of the two-partition condition is much faster than that of one-partition condition.

We just set three cases of control parameters to make the results of comparison from cases 1 to 3. At present, we have implemented an MCM placement program successfully, and it can output the layout with the CIF format to display the layout at CADENCE tool.

**References:**


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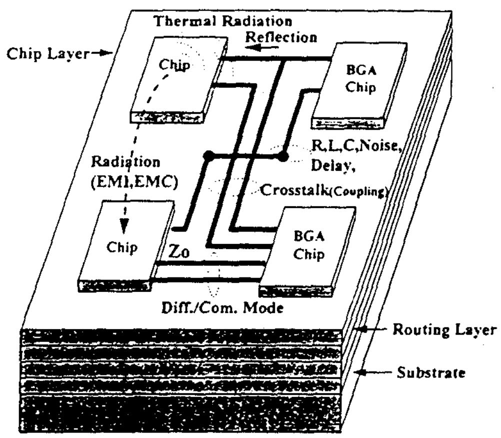



Figure 1 EMI characteristics of MCM board.

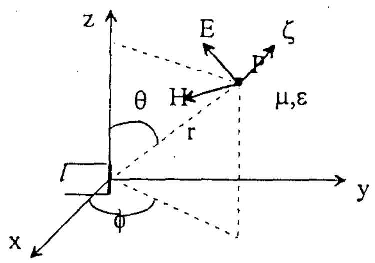



Figure 2 Electric dipole (or short wire antenna).

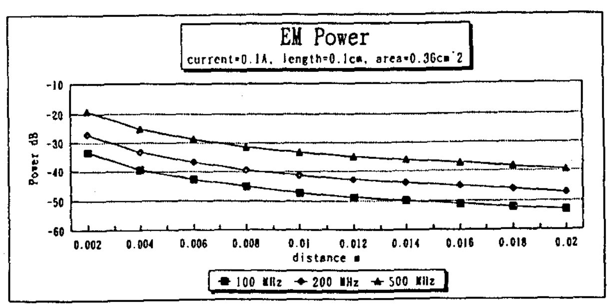



Figure 3 The radiated power as a function of distance and frequency.

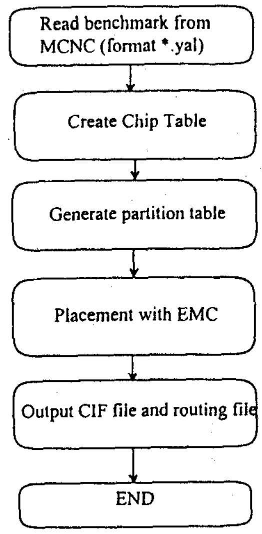



Figure 4 System flowchart of EMC-driven placement

Table 1 The area comparison ($mm^2$).

| | Best case | Worst case | case 1 | case 2 | case 3 |
|---|---|---|---|---|---|
| test1 | 48.61 | 58 | 56.21 | 59.25 | 58.32 |
| test2 | 48.61 | 58 | 48.9 | 52.1 | 50.6 |

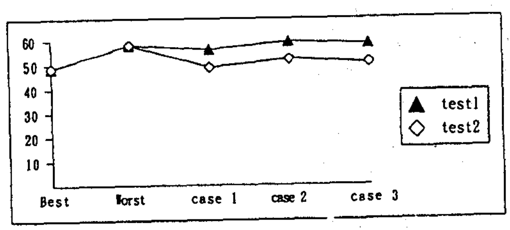
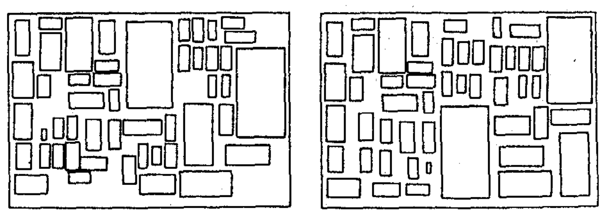



Figure 5 The area comparison.



(a) (b)

Figure 6 Test1 layout, (a) before and (b) after EMC considerations.