Proceedings of ISAP2007, Niigata, Japan

Solving Large-Scale Antenna Problems on World's Fastest Supercomputer─The IBM BlueGene

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Recent years have witnessed a phenomenal growth in our ability to numerically model, simulate the performance, and design complex electromagnetic systems. Nonetheless, as designers, we continue to be challenged by the need to solve even larger and more complex problems than we have been able to handle in the past. e.g., antennas mounted on satellites, aircrafts or ships as well as communication antennas used in various applications. There are many competing CEM approaches at our disposal, for instance, the Fast Multipole Method (FMM) for Method of Moments (MoM) problems; hybrid techniques that combine the asymptotic methods with the MoM; and, Finite Element and Finite Difference Time Domain (FDTD) methods. We present in this paper a few representative examples of Large-Scale Electromagnetic problems, all of which belong to the category of real-world problems of practical interest. A common feature, shared by the problems belonging to this group, is that they are characterized by a very large number of DOFs (degrees of freedom), 109 or even higher, and are typically beyond the range of many, if not most available CEM solvers. Additionally, they are sufficiently complex and inhomogeneous in nature, often because they contain metamaterials and articulated RAMs that render them unsuitable for analysis via the asymptotic techniques such as the ray methods, and they are only amenable to attack via numerically rigorous techniques.

Some examples of such complex problems include large phased arrays, with or without FSS radomes; conformal-antennas mounted on large curved surfaces; large antennas operating in a complex environment; electromagnetic compatibility and interference problems involving curved multilayered dichroic surfaces used in dual-frequency antenna systems; to name just a few.

One of the fastest computers that offer up to 65,000+ processors is the IBM BlueGene (BG). IBM has tested a number of codes on this platform and has found that not all codes scale equally well on this computers, i.e., the parallelization efficiency depends upon the algorithm. Fortunately, the torus architecture of the IBM BlueGene provides an excellent match for implementing the FDTD algorithm and, hence, the FDTD scales very well on the BG.

The presentation will include a number of example, will discuss the numerical simulation of some representative large problems mentioned above, and show results that could not have been simulated on conventional platforms using most of the existing CEM codes. Some information on the BlueGene is presented in Figure.1, and its parameters are shown in Table.1.

ISBN: 978-4-88552-223-9 C3055©IEICE

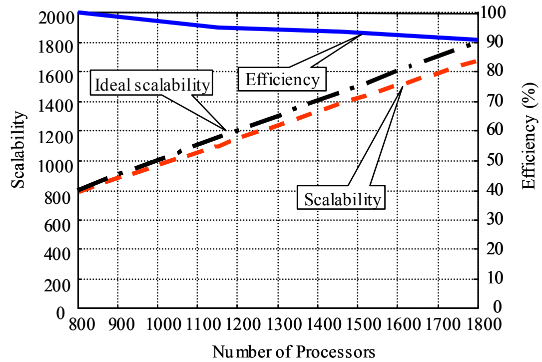

Figure.1. Scaling of FDTD on BlueGene

Table.1. Basic BlueGene/L parameters

Platform Characteristics	512-node prototype	64 rack BlueGene/L
Machine Peak Performance	1.0 / 2.0 TFlops/s	180 / 360 TFlops/s
Total Memory Size	128 GByte	16 / 32 Tbyte
Foot Print	9 sq feet	2500 sq feet
Total Power	9 KW	1.5 MW
Compute Nodes	512 dual proc	65,536 dual proc
Clock Frequency	500 MHz	700 MHz
Networks	Torus, Tree, Barrier	Torus, Tree, Barrier
Torus Bandwidth	3 B/cycle	3 B/cycle