JEMS-FDTD and Its Applications in Electromagnetic Scattering and Coupling by Large Complex Object

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***Abstract*— A massively parallel electromagnetic field simulation software named JEMS-FDTD (J Electromagnetic Solver-Finite Difference Time Domain) is presented. JEMS-FDTD uses FDTD-related methods to solve the Maxwell equations in time domain. JEMS-FDTD has the capability of solving electric-large problems of thousands wavelengths with hundreds of billions mesh cells, which makes it a suitable tool to simulate electromagnetic scattering and coupling by large complex objects. In this paper, the characteristics of JEMS-FDTD is discussed. As a numerical example, the computation and analyzing of electromagnetic wave scattered and coupled by a building is presented.**

Keywords-computational electromagnetics; FDTD; parallel computation; coupling, scattering

I. INTRODUCTION

The FDTD method [1], which is a simple and direct way to solve the Maxwell equations and easy to implement, has been widely employed to solve various electromagnetic problems for decades. However, FDTD always requires a finer mesh compared to other numerical methods such as MoM, thus limits its application. Recently, as the development of parallel computation technique, FDTD solving electric-large problems becomes possible [2].

II. A BRIEF TO JEMS-FDTD

Despite of the simplicity of parallel FDTD in principle, a high efficiency parallel FDTD program is always difficult to develop because of the complexity and flexibility of parallel computation technique, especially when thousands of processors and hundreds of teraflops of computation performance are involved.

We have been developing a massively parallel electromagnetic field simulation program named JEMS-FDTD since 2008 [3]. JEMS-FDTD is a universal massively parallel electromagnetic field simulation program, which is capable of simulating transient high frequency electromagnetic problems, such as transmitting, propagation, scattering and coupling. JEMS-FDTD adopts FDTD-related methods, including conventional FDTD method, AMR-FDTD. JEMS-FDTD is designed and structured oriented to using thousands of processors with multi-core on HPCs (High Performance Computers), with MPI (Message Passing Interface) and OPENMP (Open Multi-Processing) hybrid-parallel techniques.

Usually, there are two key issues that may constrain the massively parallel computation performance, the load balance and system RAM (Random Access Memory) latency. JEMS-FDTD adopts a four-level hierarchical data structure strategy to deal with these problems. The efficiency test performed on TIANHE-1A super computer shows a high parallel efficiency of >80% of 30000-task parallel computation case (parallel efficiency E is defined by $E = T_s/(T_n\ n)$, where T_s and T_n is the computation time on one processor and n processors respectively. In our test, we considered the efficiency of 600-task parallel computation case is 100%).

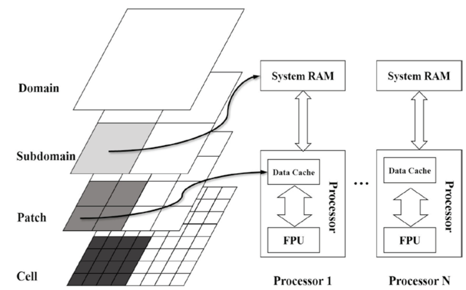

Figure 1. Hierarchical data structure strategy of JEMS-FDTD

III. NUMERICAL EXAMPLES

In this example, the scattering and coupling by a real building is simulated. The dimension of the building is 15m × 7.5m × 13.27m. The electric properties of materials are obtained by field test. The incident wave is set to a wideband pulse from 1 to 3 GHz. A fine mesh of 12.5 billion cells is generated to describe this model. The computation takes approximate 30 hours on 5760 Intel Xeon X5670 2.93GHz processors. The computation result shows good agreement with experiment test.

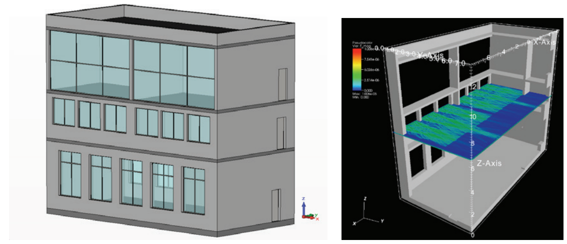

Figure 2. Building model and Electric field distribution on horizontal slice

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