High-Speed Parallel Processing of Electromagnetic Simulations Using Many Core Processors

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Abstract: Large scale and accurate simulations are recent trends in electromagnetic community, since computational complexity becomes huge. In this paper, we investigate the potential of hardware acceleration using Cell Broadband Engine which has high calculation performance with latest parallels.

1. Introduction

Fast and large scale computations are challenging problems in computational electromagnetics. We have studied potential capabilities of software and hardware acceleration for electromagnetic simulations. Cell/B.E. used for the popular video console, SONY PlayStation3, is a promising many core processor. It consists of one power processing element (PPE) and eight synergistic processing elements (SPEs) as shown in Figure 1. In this paper, we investigate the efficiency of parallel processing using Cell/B.E. which has high calculation performance with latest parallels.

2. Efficient Parallel Computation

Cell/B.E. architecture is suitable for wide variety of programming models, however, the optimization of codes is a crucial issue. We introduce the way to optimize programs for efficient parallel computation in terms of the following multithreads, DMA transfers, inline function, unroll loops, and pipelines.

2.1. Multithreads: Ability of an operating system to execute different parts of a program.

We create threads whose number is the same as the CPU cores in order to perform computation using all cores simultaneously. The program should be carefully designed in such a way that all the threads can run at the same time without interfering with each other. Jobs are equally assigned to SPEs for increasing efficiency of parallel computing.

2.2. DMA transfers: Technique for controlling the memory system without using the CPU.

It should be overlapped with computation by double buffering or multibuffering which can hide memory latency.

2.3. Inline function: Entire code of the function inserted by the compiler where the function is called.

The compiler inserts the complete body of the function in every place in the code where the function is used. Inline expansion is performed to eliminate the time overhead when a function is called.

2.4. Unroll loops: Technique for reducing the overhead of loop control and exploiting the large SPU register.

SPEs are in-order processor elements which are needed to keep track of the order of writing in the program. The effect of loop unrolling is more obvious than that for out-of-order processors whose processing order is dynamically replaced.

2.5. Pipelines: Technique for increasing the performance.

The microprocessor begins executing a second instruction before the first instruction has been completed. Therefore computation becomes more high-speed.

Considering the above techniques, we investigate high-speed parallel processing of the method of moments (MoM) for solving electromagnetic simulations. In MoM, unknown current is obtained by solving the linear simultaneous equations.¹²

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The equation solver uses the conjugate gradient method (CG method) which is one of the iteration methods. In general, cores severally access to the main memory so that the memory band width is the bottle neck on many core processors. However, this issue is not crucial for the CG method, since the memory access is little compared with the computational complexity.

3. Computational Results

Figure 2 shows the scattered field of a conducting cylinder for a plane wave incidence. The computational result by MoM using Cell/B.E. is in good agreement with the exact solution.

Figure 3 is a plot of the speed-up rate for varying the number of SPEs. The rate is defined by the ratio of the computational time for PlayStation3 to that for the PC case. Increasing the matrix size \(N\), the speedup rate becomes higher. When the matrix size is \(N = 1920\), the speedup rate for Cell/B.E. with six SPEs using unroll loops is about 3.7 times higher compared with the PC case.

Figure 4 shows the parallel efficiency for varying matrix size \(N\). The efficiency is defined by the ratio of the computational time to the one SPE case. We can confirm that the parallel efficiency is improved for reducing the number of SPEs or increasing the matrix size. When the matrix size is \(N = 1920\), the parallel efficiency is over 97%.

4. Conclusions

We investigate hardware acceleration of the method of moments (MoM) using the Cell Broadband Engine processor. The computational accuracy is in good agreement with the exact solution for the conducting cylinder. The computational time is about 3.7 times faster using PPE and six SPEs and the parallel efficiency is over 97%.

References