

3D Finite Difference Method Using Discontinuous Grids (6)----- Parallel computing using PC cluster -----

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<http://www.j-map.bosai.go.jp/j-map/sub3/aoi.htm>

Recently, the hybrid methods are often used for strong-motion prediction. In this method, the statistical Green's function method and deterministic method such as a finite difference method (FDM) are used for generating the shorter and longer period part of ground motions, respectively. By summing them using a matching filter, broadband seismograms are obtained. Shorter period (higher frequency) part of ground motions are strongly affected by minute heterogeneities of source processes and/or underground structures, and this scale of phenomenon is essentially difficult to simulate using deterministic method. The matching frequency of the filter should be determined by the upper limit of the frequency to which deterministic method is applicable, and the proper frequency is thought to be 1 Hz or higher from the result of the recent simulations. However, in some cases, matching frequency is restricted by available computer capability unrelated to a natural phenomenon. Especially, when the object is a subduction earthquake, deterministic calculation is restricted to the frequency much lower than 1Hz, as the target region and the size of the faults tend to be very large.

Use of a computer cluster can be one of the solutions of this difficulty. As a considerably cheap means of large-scale calculation, PC cluster or WS cluster, which is a network of general-purpose personal computers (PC) or workstations (WS), is becoming popular (e.g., Hayashi et al., 2002; Furumura & Koketsu, 2000).

In this research, MPI (Message Passing Interface), which is one of the standards of parallel computing on distributed memory machine, was adopted. Generally speaking, explicit FDM is suitable for parallel computing, because the FD operators are spatially local operators and the total amount of data transfer necessary for each time step can be held down. In this research, parallel computing of the 3-D FDM using the discontinuous grids proposed by Aoi & Fujiwara (1999) was performed. This technique reduces the computation by using the discontinuous grids which consist of, on the one hand, grids with fine spacing near the surface where the wave velocity is low, and, on the other hand, grids whose spacing is three times coarser in the deeper region. Interpolations are needed in order to maintain the continuity of wavefields on the boundary of the regions using the fine and coarse grids. Aoi & Fujiwara adopted the linear interpolations for which only the values of the adjacent grid points are required as in the case of second order accuracy FD operators. Because both the FD operator and the linear interpolations are spatially local operators, the discontinuous grid FDM is expected to be also suitable for parallel computing.

Performance of parallel computing was tested using the model with 36.5×10^6 grid points and 10000-time steps. The calculation time with a PC cluster with 16 PCs and one same PC was 4.3 and 52.8 hours, respectively. Calculation time was shortened to 1/12.3, and this means that the efficiency of the parallelization was 77% of a theoretical (ideal) value, 1/16. This performance is fairly high considering that we used the realistic structure model having finite faults, and a practical method; the discontinuous grid FDM. In a larger-scale model, such as subduction earthquakes, it is thought that parallelization efficiency becomes higher.