Performance Evaluation of WAVEWATCH III on a KMA Cray-X1E Supercomputer

Sangwook Park*

Marine Meteorology Laboratory
Meteorological Research Institute / Korea Meteorological Administration (KMA)
460-18 Shindaebang-dong, Dongjak-gu, Seoul, 156-720 Republic of Korea
E-mail: swpark@kma.go.kr - Web page: http://www.kma.go.kr

Woo-Sun Yang

Cray Korea Inc.
381 Mannyeon-dong, Seo-gu, Daejeon, 302-150 Republic of Korea
E-mail: wyang@cray.com - Web page: http://www.cray.com

Key Words: Wind Wave Model, WAVEWATCH III, MPI

ABSTRACT

The demand for accurate modelling of atmospheric and oceanic process has steadily grown. The ocean wind wave modelling is a way of expression that momentum transfers in the interface of ocean and atmosphere. With the definition of energy balance equation and contribution from the observational experiment of JONSWAP[1], the 3rd generation wave model WAM[2] becomes available in early 1990's. The denotation of wave generation comes from how the nonlinear interaction of each spectral component is handled. The exact computation of nonlinear interaction comprises of a six-fold Boltzmann integral[3]. Due to its huge computational requirements the exact solution of this integral is not feasible in operational wave prediction models. Therefore various approximate methods have been developed, and the Discrete Interaction Approximation (DIA) is the best known[4]. Still this calculation demands the most computational time of practical wave prediction models. Even with the success of DIA, it has been generally recognized that the accuracy of DIA has some deficiencies. The two branches of conquering this problem have been emerged among researchers: one is simplification or speeding up the exact interaction and another is improving DIA.

Until the advent of so called the 4th generation wave model which circumvents previously mentioned problem, the 3rd generation wave model such as WAM, WAVEWATCH III[5], and SWAN[6] is adopted as an operational wave prediction model in most of institute. The Korea Meteorological Administration (KMA) have employed WAM model for its global and regional wave prediction system since 1999. This model had run on NEC SX5 supercomputer until 2005. The platform uses 16 parallel vector processors in one node and each processor has 8 Giga flops in peak performance. The compiler automatically optimizes the multi-tasking jobs. Under the very high vector ratio (97%) of the WAM cycle 4 code, the calculation speed was within allowable limit in operational point of view. Although the WAM code has pioneering role in ocean wind wave modelling communities, this has some limitation in resolving new research results in theoretic and computational circles since its birth in early 1990's. There have been found some limits in propagation scheme and source term integrations, and the code architecture suited for vector computers inhibits expansion to parallel structured machines. Under these circumstances, the US organization NOAA/NCEP developed the WAVEWATCH III, which embodies flexible options to choose various schemes and Message Passing Interface (MPI) for

utilization of the model code in parallel architecture platforms. Although this model is developed under sole constitution in the beginning, it is opened to public and becomes a community model now. The latest version v2.22 is organized in modules written in Fortran 90, all common blocks have been removed, and all relevant arrays have been made allocatable.

As a 2nd period supercomputer at KMA, the NEC SX5 is replaced by the Cray X1E in 2005. The Cray X1E is a Parallel Vector Processor (PVP) machine with 256 node modules in three cabinets. Each module uses common memory of 16 Gigabytes unified memory access with four Multi-Streaming Processors (MSP). Each MSP is composed of four scalar/vector processors with 18 Giga flops peak performance. This machine ranked 16th among supercomputer top500 list for November 2005 with 14.5 Teraflops theoretical peak performance. Under this renewal process of power computing packs, it becomes feasible to explore higher resolution in spectral component and spatial grids of operational wind wave model. This paper investigates the performance of the WAVEWATCH III under the future operational model design. Also the parallel architecture of new supercomputer provides a good testing bed for examining parallel run time efficiency of the WAVEWATCH III code. Although this code is highly portable regardless of platform, a proper code modification was required. Those modifications will be mentioned. The parallel performance is also assessed under configuration of new operational wind wave prediction system. The timing test runs is done from single to maximum number of processors. The scalability of MPI application is examined. The model displays much of the expected timing behaviour.

REFERENCES

[1] K. Hasselmann, T.P. Barnett, E. Bouws, H. Carlson, D.E. Cartwrite, K. Enke, J.A. Ewing, H. Gienapp, D.E. Hasselmann, P. Kruseman, A. Meerburg, P. Muller, D.J. Olbers, K. Richter, W. Sell, H. Walden, (1973). "Measurements of wind-wave growth and swell decay during the Joint North Sea Wave Project (JONSWAP)", *Dtsch. Hydrogr. Z. Suppl.* A(8), Vol. **12**, 95pp.

[2] WAMDI Group, (1988). "The WAM model – a third generation ocean wave prediction model", *J. Phys. Oceanogr.* Vol. **18**, pp. 1775-1810.

[3] K. Herterich, K. Hasselmann, (1980). "A similarity relation for the nonlinear energy transfer in a finite-depth gravity wave spectrum", *J. Fluid Mech.*, Vol. **97**, pp. 215-224.

[4] K. Hasselmann, (1962). "On the non-linear transfer in gravity wave spectrum, Part 1. General theory", *J. Fluid Mech.*, Vol. **12**, pp. 481-500.

[5] H.L. Tolman, B. Barasubramaniyan, L.D. Burroughs, D.V. Chalikov, Y.Y. Chao, H.S. Chen, V.M. Gerald, (2002). "Development and implementation of wind generated ocean surface wave models at NCEP", *Wea. Forecasting*, Vol. **17**, pp. 311-333.

[6] N. Booij, R.C. Ris, L.H. Holthuijsen, (1999). "A third-generation wave model for coastal regions, Part 1, Model description and validation", *J. Geoph. Research*, Vol. **104**, C4, pp. 7649-7666.