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Performance and Scalability Analysis of WRF on Multicore High Performance Computing Systems

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Numerical Weather Prediction (NWP) model is an important tool for both research and operational forecast of meteorology, which can be used for various other purposes such as weather aviation, agriculture, air pollution modeling, etc… It faces the fundamental challenge of understanding how increasingly available computational power can improve the accuracy of modeling climate processes, and in addition also the reliability of the NWP output itself.

The Weather Research and Forecast model (WRF) is one of the most commonly used NWP system specifically designed to run on a large variety of platforms, either serially or in parallel. WRF model is widely adopted for the assessment of weather prediction and atmospheric science, at least for two main reasons: 1) its superior computational scalability and efficiency, and 2) because belongs to the latest generation of NWP equipped with current developments in physics, numerical models and data assimilation.

Performance benchmarking and analysis of WRF model has been done under different environments to demonstrate the scalability of the code and the possibility to use it for higher productivity forecasting. In this work, we conducted WRF performance analysis and scalability focusing on recent multicore High Performance Computing (HPC) systems, using our own benchmarking configuration. In particular, we used WRF for testing its application for a tropical region domain in Southeast Asia (SEA), mainly dominated by convective meteorology conditions.
First, we tested performance and scalability using a WRF single domain configuration for different grid sizes (experiment E1), and then followed by two-way nesting configuration (experiment E2). In this study we have run the code enabling both Message Passing Interface (MPI) to exploit parallelism among different node-processors, and Open-MPI to exploit parallelism within each node-processor, under different set-up of nodes, MPI tasks and threads.

E1 results showed that the simulation speed decreased when the number of grids in the domain increased, as expected. The increase in number of nodes used in the simulation would increase the simulation speed. In E1, using the total of 64 numbers of cores gave the better performance, with the highest speed in domain 80x80 and 128x128. E2 results also showed the optimum performance using 4 nodes, 8 MPI-per-Node and 2 Threads-per-MPI which was slightly better than using only 2 nodes. Overall, times required for computation contributed the most (89-99%) for both experiments as compared to input processing and output writing. Simulation speed of nesting domain configuration experiment (E2) was 100 times slower than the one-way nesting simulation for single domain (E1) when 2-way nesting applied for simultaneous simulation on 3 domains. This shows that WRF model domain configuration (one way or 2-way nesting) was an important factor for simulation speed,in addition to the computing core configuration. In the future we plan to extend this work in several directions making extensive performance analysis and scalability for ideal cases of WRF simulation such as hurricane/typhoon and meteorology forecasting, and run run on different computing configuration, using also GP-GPUs able to boost significantly the execution time of most computing intensive kernel routines.

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