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Optimization of Weather Model

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***Abstract*—**Weather Research and Forecasting (WRF) is a primitive application of High Performance Computing (HPC). Research on WRF being able to utilize the computation efficacy. Today's HPC has so much research going on. There are various parallel Programming Technologies used to achieve the speedup.The Stencil Computation is used by WRF model for regional grid computation and it's a difficult to compute because it depends on their entire neighbor's. In this paper propped method to achieve the stencil Computation for parallel approach like open MP then apply Vectorization flags O3 and then last Vectorization. Analysis of all the results to how its speedup and achieved Optimized code for Stencil Computation.

Keywords*—Stencil Computation, Vectorization, Open MP, WRF.*

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I. INTRODUCTION

Numerical weather prediction models, uses systems of differential equations based on the laws of physics, fluid motion, and chemistry to describe the atmosphere and ocean. The mathematical models based on the same basic principles are used to predict weather based on current weather conditions.

The Weather Research and Forecasting (WRF) model is a next generation mesoscale numerical weather prediction system design for both atmospheric research and operational forecasting needs. The model serves a wide range of metrological applications across scales from tens of meters to thousands of kilometres. The effort to develop WRF began in the latter part of the 1990's and was a collaborative partnership amongst various government as well as private communities. .To provides timely and accurate weather forecasts, the simulation of model need huge computing power. To make a simulation more feasible the use of High Performance Computing (HPC) is essential. HPC is the use of supercomputers and complex algorithms to do parallel computing i.e. to divide large problems into smaller ones, distribute them among computers so as to solve them simultaneously.

WRF, being the compute intensive and data intensive application, has been successfully optimized on a wide variety of HPC clusters over the years. High performance computing are the fastest and most powerful computers available, and at present the term refers to machines with hundreds of thousands of processors. They are the superstars of the high–performance class of computers. Personal computers (PCs) small enough in size and cost to be used by an individual, yet powerful enough for advanced scientific and engineering applications, can also be high–performance computers. The HPC have huge amount of storage capacity and computation compare to personal computer is huge. HPC introduce parallel programming concept the vectorization, thread level and like other parallel programming to get speedup. C-DAC has the series of HPC cluster which is PARAM YUVA-II. It is the more than 33,000 cores and achieves 529.74 TF peak performances.

WRF is a state-of-the-art atmospheric modelling system that is applicable for both meteorological research and numerical weather prediction. It offers a host of options for atmospheric physical processes and can run on a variety of computing platforms. WRF is suitable for a broad range of applications across scales ranging from tens of meters to the global, including the following:

- Metrological investigations
- Real time NWP
- Idealized atmospheric simulations
- Data assimilation studies and development
- Coupling with other earth system models
- Modelling and model use instruction and training

The paper is organized as Section II describes Stencil computation and hoe it related this weather model. Section III describes the proposed System for weather model. Section IV describes Experimental results which have taken during research. Section V section is conclusion.

II. STUDY OF STENCIL COMPUTATION

This section shows Stencil Computation. The below figure shows, how it's computation in Weather model and the computation of region take place for forecasting.

Stencil computation is taken important role in weather model for grid structure. All the region of the map is divided in the grid then for the unknown values of the particular region the stencil computation is used. Here one picture which is taken from the WRF official site www.**wrf**-model.org where the grid structure is explains.

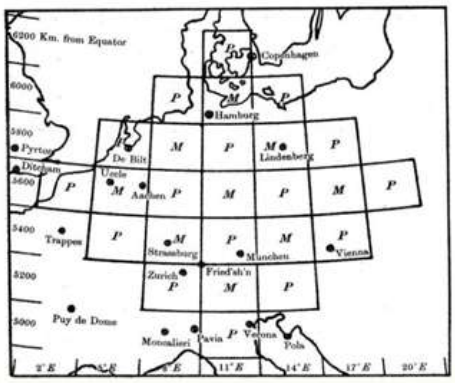

Figure 1: Region wise Grid

A. *Stencil Computation*

Detecting and measuring similarities in large medical image archives may be a necessary task for diagnostic radiology

III. PROPOSED SYSTEM

Optimization of any model can be carried out in two ways: Software Optimization and Hardware Optimization. Hardware capabilities that speeds up performance mainly includes easy memory access, usage of caching, multicore processing, SIMD register files. Where, in case of software various techniques of code optimization can be utilized.

The TLP (Thread Level Parallelism) is the process of splitting a program into independent parts and having these parts run side by side as threads. This can be having separate independent programs running together or having separate activities inside the same parallel program. There are two basic methodologies to Thread Level Parallelism, fine-grained multithreading and course-grained multithreading. Multithreading tries to eliminate the time lost during the stalls present in process which contain only one thread by sharing the functional units between multiple threads. This process provides each thread with its own copy of the Program Counter (PC), register files, etc. The only thing that is not duplicated is the memory space since it already supports multiple processes. While there is additional overhead due to alternating threads, multithreading improves the throughput of computers that are running multiple programs and the execution time of multi-threaded programs is decreased.

The SIMD (Single Instruction Multiple Data) is a one type of parallel computing architecture that is classified by Flynn's taxonomy. A single computer performs the same action simultaneously on two or more pieces of data.

In Computer science the process of converting an algorithm from a scalar implementation, which does an operation one pair of operands at a time, to a vector process where a single instruction can refer to a vector (series of adjacent values) is called Vectorization. It is the process ofrewriting a loop so that instead of processing a single element of an array N times, it processes (say) 4 elements of the array simultaneously N/4 times.

In the proposed project work, following techniques will be utilized for the optimization of computationally intense modules of WRF model:

1. TLP (Thread Level parallelization)
2. SIMD (Single Instruction Multiple Data)
3. Vectorization

The performance analysis of modules as standalone code, will be carried out on C DAC's Param Xeon E5 processor with Xeon Phi Coprocessor.

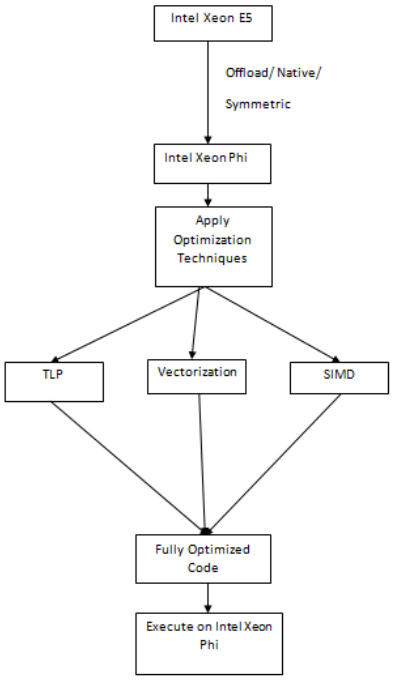

Figure 2: Proposed System

IV. EXPERIMENTAL WORK

We implement the serial code of Stencil Computation on 4 cores Linux system and after that we execute the parallel code on Xeon processor.

A. *Computing System for Execution*

Figure 3: PARAM cluster Access

Here Eight Processor and each processor have four core so total 32 core we have to parallel the code and after apply the parallel execution there is 16 hardware thread so it give optimizes result compare to single dual core processor.

B. *Execution of Serial Stencil Computation*

Stencil computation has the data dependency to their four neighbor's so it gives not give the expected results.

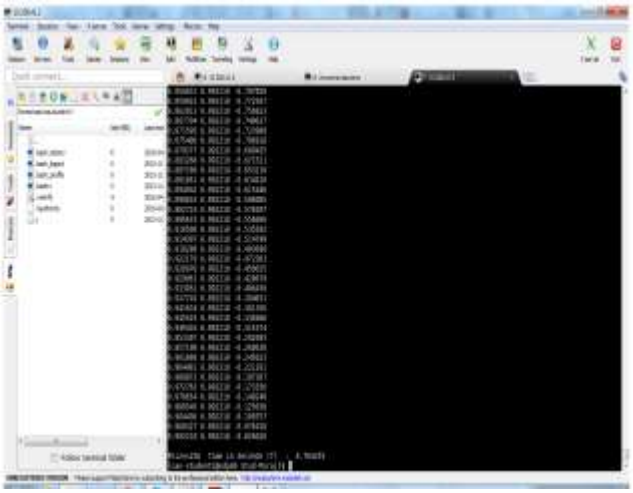

Figure 4: Output of sequential Stencil computation of grid size 256

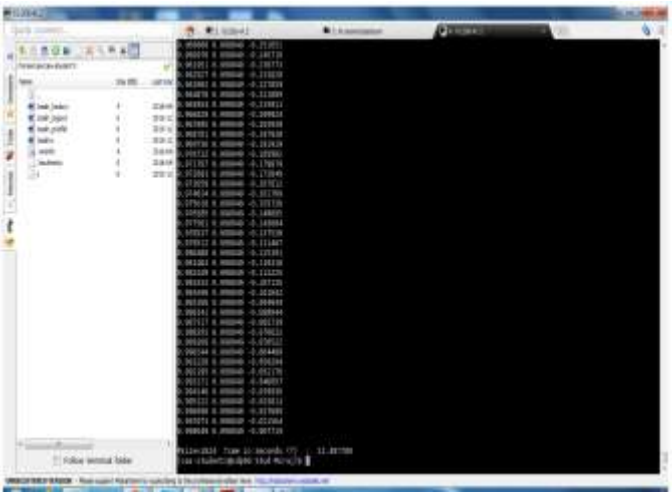

Figure 5: Output of sequential Stencil computation of grid size 1024

As shown in the figure 4 and 5 the execution time taken by the sequential code is 0.764255 and 12.487780 respectively. This two different grid size shows how the execution time varying because in the weather model there is huge amount of grid size so this can also be applied for huge size of data. The three values in the output figures show the values of neighbor's values.

The next chapter will show the parallel programming code execution time. The parallel model there is several methods is used like TLP, Vectorization, and Openmp etc.

C. Execution of Parallel Stencil Computation

Here the various techniques to optimize the Stencil Computation. Following is the different phase to improve the parallel code.

1. Openmp code for Stencil computation.
2. Apply the Optimization Flags
3. Apply Vectorization.

Here only main motive to optimize the stencil computation code which should be useful to CES group for Weather prediction.

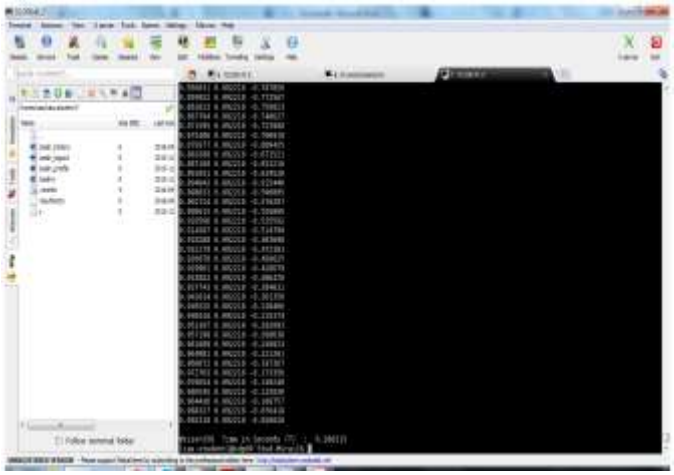

Figure 6: Output of Parallel Stencil computation of grid size 256

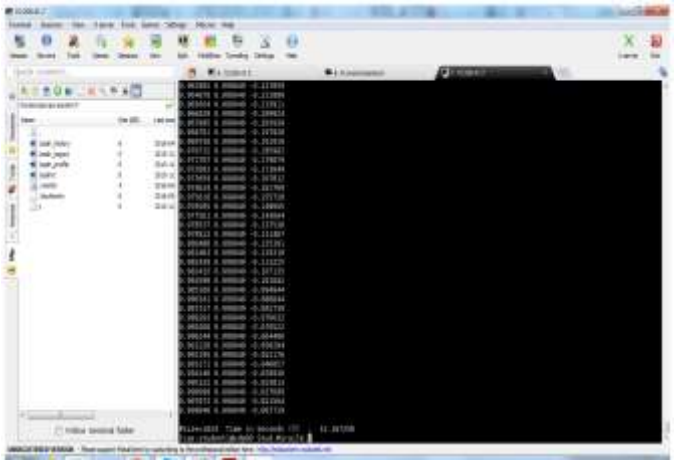

Figure 7: Output of Parallel Stencil computation of grid size 1024

	Grid Size **256**	Grid size **1024**
Sequential Execution time	0.764255	12.487788
After OpenMP + O3 Flag	0.206215	12.167250
After Vectorization	0.104521	11.525635

Here following is the table which shows how's the execution time is speedup after apply the parallel techniques.

V. CONCLUSION

Though High Performance System allows an application to reduce the execution time it can be further optimized by optimizing an application. For this various optimization techniques are available. In this literature Survey we studied various optimization techniques which can be implemented on Weather Research Forecasting (WRF) model to give better performance. Some of the techniques studied.

we implement the Optimized code for Stencil Computation using the parallel programming techniques like Open MP and after that we apply the Vectorization flags which is complier level optimization flags and it provided by GNU. But there is

one major problem with optimization model that the data dependency. All the stencil point is dependent on their neighbor's. It's difficult to achieve the optimized result compare to Sequential.

REFERENCES

[1] Bogdan Rosa, MiłoszCiżnicki, Krzysztof A. Rojek, Damian K. Wójcik, Piotr K. Smolarkiewicz, and Roman Wyrzykowski; "Porting Multiscale Fluid Model EULAG to Modern Heterogeneous Architectures"; International Journal of Applied Physics and Mathematics, Vol.4, No .3,May 2014

[2] SrikanthYalavarthi, Aksharakaginalkar; "An Early Experience of Regional Ocean Modelling on Intel Many Integrated Core Architecture"; IEEE, 21 International Conference on High performance computing, 2014

[3] Jack Deslippe, Brain Austin, Chris Daley, Woo-Sun Yang I; "Lesson Learned from Optimizing Science Kernels for Intel‟s „"Knight Corner" Architecture"; IEEE, Computing in Science & Engineering, 2015

[4] SreeramPotluri, AkshayVenkatesh, DevendarBureddy, Krishna kandalla, DhabaleswarK. Panda; "Efficient Intra-node Communication on Intel-MIC Cluster"; IEEE, ACMInternational Symposium on Cluster, 2013

[5] Eduardo R. Rodrigues, Jairo Panetta, Celso L. Mendes; "Optimizing an MPI Weather Forecasting Model Via Processor Virtualization"; IEEE, International Conference on High Performance Computing, 2010

[6] Don Morton, OraleeNudson, Don Bahls, Greg Newby; "The Weather Research and Forecasting (WRF) Model as a Tool for Evaluating HPCMC Assets and Capabilities in Grand Scale Numerical Weather Prediction"; IEEE, High Performance Computing Modernization Program User Group Conference, 2010

WEB LINK

1. http://wrf-model.org/index.php
2. http://www.intel.in/content/dam/www/public/us/en/documents/datasheets/xeon-phi-coprocessor-datasheet.pdf
3. http://www .top500.org
4. https://software.intel.com/sites/default/Beginning%20Intel%20Xeon%20Phi.pdf
5. http://cdac.in/index.aspx?id=ces