Software System for Hydro-Meteorological Disaster Modelling and Simulation Study in HPC Platform

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Abstract: In this paper an attempt is made to know about the Hydro-meteorological Disaster and different types of Hydro-meteorological disaster and their causes and effects and also a study on Numerical Weather Prediction tools like Weather Research and Forecast(WRF) Model which is fully Functioning System that is used for atmospheric research and in weather prediction communities. With Properties such as Portability, Efficiency, Maintainability, Scalability and productivity. Over the Years WRF model has been deployed successfully on a wide range of variety of High Performance Computing (HPC) Clustered compute nodes which is connected to high speed interconnects.

INTRODUCTION

Climate is a Statistics of weather, for over 30-year interval. It is measured by patterns assessing variations in temperature, humidity, atmospheric pressure etc. Based on weather conditions climate differs from region to region. The climate of a particular region is generated by the climate system.

A sudden calamitous event bringing destruction and devastation n of life and property, causing great damage and loss to lives and livelihood. Disaster can also be defined as a very serious disruption for the functioning of the society; it leads to heavy human and environmental losses which becomes difficult for the society to cope up with that losses using its own resources.

Disasters are mainly classified into two types: Natural Disaster and Human Induced Disaster. Natural Disaster are difficult and is impossible to prevent whereas the cost and damage induced by natural disasters especially water-related disaster exceeds more than any other type of natural disaster.

Water related disaster can be of several types like land and mud slides, floods, tsunami, tidal waves, storm surges, avalanches, drought cyclones and debris flow. With these geophysical disasters there are some water-related biological disasters. Human induced natural disasters mainly include different types of pollution, accidents, and wildfires caused among others. In the present modern world the major environmental disaster in many regions is the pollution of the water environment.

The Natural Disaster Mainly Include 3 types, Geological, Hydro-meteorological,

Biological, of these three types Hydro-meteorological disaster account for almost over 75% of causes disruption to normal life. Hydro-meteorological disaster mainly includes Floods which is usually termed as the overflow of water that is common in places where it rains and merges the land that is usually dry. Drought which means the deficiency of rain or water for over a long period. Cyclones of all types, landslides that is a movement of rock down the slope. Avalanches which is the huge mass of snow, ice and even rocks falling rapidly down towards the mountainside. Heat Waves that is a prolonged extreme hot weather period. This mainly accomplished with high humidity, mainly in the regions such as oceanic climate countries. Cold Waves which is usually caused when the cold air masses over a large areas are brought together. And Regionally Asia suffers the most with these type of disasters compared to other continents. According to the survey of recent years, flood disasters are resulting more due to extreme rainfall that have been on increase in many regions of world.

This Hydro-meteorological Disaster are predicted nowadays using some tools among which Numerical weather Prediction (NWP)is one of the main tool that now forecasters use to predict the weather.

DISASTER CAUSES AND EFFECTS.

As there occurs different types of natural disasters the causes is also varies from one type to another. For example, the cause of Tsunami is not same as that of the forest fire. These disasters are naturally caused due to various reasons such as air pressure, soil erosion, ocean currents etc. These disasters are not new as they have been occurred from the earth begun and they cause serious damage and loss of life all over globe for many years.

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These are caused due to the imbalance caused in environment. This imbalance is due to various forms of pollution like air, water, noise, and soil pollution and also the result of all together.

The main reasons for this disaster are the activities that are naturally taking place on earth's crust and surface. The root cause of volcanoes in the seismic activity which is caused by earth quakes.it is known that the continents sit on huge plates and these plates shift occasionally which will cause an increase in pressure under the earth surface which also leads to the cause of natural disaster, this leads to a cause to natural disaster. The movement on earth's crust such as tectonic movement is also responsible for earth quakes. Volcanoes that are formed by solidified magma, and from pressures from magma and also gasses will explode and sends tons together of ash to atmosphere.

Based on the activity of the moon we can determine the oceanic waves that can get really high during full moon and can be really dangerous. For example the tsunami that occurred in December 2004 was also on full moon day itself which was a deadly and lead to a heavy loss of life and livelihood

WEATHER RESEARCH AND FORECASTING (WRF)

A Numerical Weather Prediction (NWP)system that is used to serve both atmospheric research and operational forecasting needs is called as Weather Research and Forecasting model. It is a non-hydrostatic Mesoscale model that is fully compressible with a hydrostatic option. This model is designed to be efficiently massively parallel programming and computing code to make use the advantage of the well advanced high Performance computing. This code can be used for both Research and operations and provides many numerous physical options. WRF is supported and maintained as community model that facilitate wide use, and it can be used in a broad spectrum of applications that ranges from meters to kilometers, which include research and operation, data parameterized-physics and assimilation.

Figure 1:WRF System Components

The Figure 1 shows the software framework of WRF that provides an infrastructure for an efficient use of array of HPC systems, and the architecture will continue to evolve as it moves further into Petascale computing and beyond. This Architecture accommodates with multiple physics packages, dynamics solvers ,which will plug into the solvers throung an standard interface of physics,it also consists of several programs for initialization,and also the system called WRF variational data assimilation system that is abrivated as WRF-Var.This WRF sopfware framework consists of two dynamics solvers ,The advanced Research WRF (ARW) solver and the Nonhydrostatic Mesoscale Model(NMM)Solver.

HPC CLUSTERS MULTI-CORE ARCHITECTURE FOR WRF

The simulations of WRF require an effective compute resource that requires that is capable of handling complex and parallel simulations and hence these WRF simulations are carried out in these High-Performance Computing (HPC) clusters. HPC Clusters are more scalable performance compute solutions based on the industry standard hardware connected by a private system high speed network. These HPC clusters are more benefits because these clusters high performance, scalability,flexibility,affordability,availab-ility. This cluster uses the aggregated power of compute server nodes to form a high performance solution for parallel applications such as the WRF model. When some simulation needs more compute power, it can be simply achieved by adding more server nodes to the cluster.

The way HPC clusters is architected (i.e. multi-core, multi-processor based HPC servers with high speed interconnects) has impacted a great influence on the overall application performance and also on productivity. In the way to meet the demand of more powerful HPC servers, more execution cores (e.g. dual, quad-core) are being integrated into each of the processor and more processors are being tightly connected (e.g. 2,4,8 processors have been connected through the Hyper Transport technology, which is a packet-based, high-bandwidth, scalable, low latency point-to-point technology that links processors to each other, processors to coprocessors and processors to I/O and peripheral controllers). There are important challenges in this strategy (e.g. larger scale integration, reduction of voltages and core frequencies) in order to keep the power consumption low while increasing the computational capabilities of the HPC servers.

The cluster interconnect is very difficult to deliver efficiency and scalability for the applications as it needs to handle the networking requirements of each CPU core without imposing the additional networking overhead. In a multi-core multi-socket HPC server based cluster, the driving factors of performance and scalability for WRF have shifted from the frequency and cache size per core to the memory and interconnect throughput per core. The memory bottleneck can be solved by using interconnects that support Direct Memory Access (DMA), Remote DMA and zero-copy transactions.
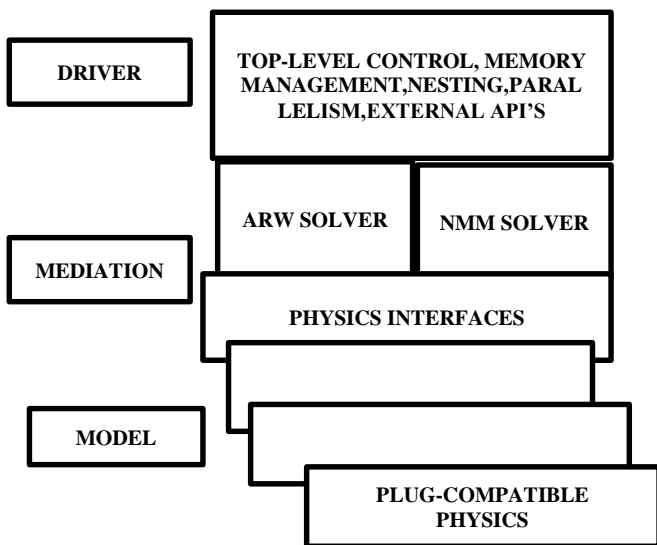
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CONCLUSION

Numerical weather prediction models have been aroused as a critical tools for forecasters. WRF is designed to provide real-time, extremely accurate and sophisticated weather analysis. For efficient analysis, WRF requires high-performance computing systems. Commodity clusters have become very important for high performance computing due to the price for performance, flexibility and scalability they can deliver. Because high performance computing systems offer a

complex array of hardware and software intended to improve performance, which is elected to limit the investigation to the maximum performance that can be achieved on commodity clusters comprised of open source software and standards based hardware.

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