Towards a Self-Configurable Weather Research and Forecasting System

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ABSTRACT

Current weather forecast and visualization systems lack the scalability to support numerous customized requests for weather research and forecasting, especially at the time of natural disasters such as a hurricane landfall. Most of these systems provide somewhat generic forecasts for different types of users including meteorologists, business owners and emergency management officials. Such forecast while may be relevant to some specific group of users; to others it may not provide any useful information apart from the prediction of impending weather hazards. In other words, one size does not fit all. Weather data and its visualization indicating inclement weather conditions such as snow or ice storm, tornadoes and hurricanes need to be customized for the different type of users using such systems; thus, assisting them in ensuring effective preparatory and meticulous recovery plans. In this paper, we propose a self-configurable, user specific on-demand weather research and forecasting system that utilizes Grid computing to facilitate scalable weather forecast data analysis and prediction.

1. INTRODUCTION

Weather Forecast paradigm has utilized distributed computing resources specifically clusters to analyze weather related data and predict weather forecasts for regions across the globe. Over the period of time, numerous weather forecast systems have been designed and developed to assist the meteorologists in weather prediction and to facilitate the preparation and recovery planning for emergency management officials and the general public. Such forecast systems aim in addressing the needs of only a specific group of users.

One such system, RAMS [1] was utilized in the 1996 Atlanta, USA Summer Olympics for weather forecasts. RAMS was a cluster based meteorological system assisting the meteorologists to better predict the weather forecast across the city of Atlanta. Deep Thunder [2] also utilizes a cluster to provide businesses with customized weather predictions for six major metropolitan areas across the USA. We note that the size and granularity of the data sets used for the above examples can be easily found in typical clusters available today to medium size organizations. However, on-demand inclement weather forecasts involve numerous user requests for customized and simultaneous weather model runs that can not be satisfied by any one cluster available today.

On the other hand, other systems such as Weather.com [3] and AccuWeather.com [4] only support the meteorologists in analyzing and predicting customized weather forecasts for a city or metropolitan area rather than providing general users with the ability to manipulate and interactively identify possible threats associated with impending weather hazards.

The lack of on demand user specific experience rendered by the aforementioned systems stresses upon the need for a user specific on-demand weather research forecast portal that not only can assist the meteorologists in configuring weather forecast model runs but also allows for business owners and emergency management officials to identify their assets. Geographical Information System (GIS) domains encompassing the user specified assets for such model configurations can then be identified and run in a resource efficient manner across a scalable Grid computing environment.

2. OVERVIEW OF OUR APPROACH

We present a Web-based, self-configurable, on-demand weather research forecast portal that utilizes the Weather Research Forecast (WRF) model [5] for configuring and scheduling on-demand, asset specific weather forecast runs for domains encompassing these assets and generates weather visualizations relevant to its audience. Currently, we focus on the inclement weather conditions specifically hurricanes by utilizing ensembles for better and effective storm track and intensity predictions. The portal allows for an interactive, easily accessible Web-based interface that allows user specific WRF model configurations and runs for the domains or assets defined by the meteorologists, business owners and emergency management officials.

On-demand, transparent and resource efficient ensemble based hurricane forecast model runs and visualizations require that the portal be self configurable. Our Grid based WRF Portal is self configurable in the sense that it allows for meteorologists to identify GIS domains for which the WRF ensemble parameters are configured and perturbed for more accurate hurricane forecasts. Moreover, it allows the emergency management officials and business owners to identify their assets across these GIS domains. The portal then utilizes these domain and asset definitions to dynamically configure, schedule and run user specific WRF ensemble runs across a Grid environment. The portal employs our meta-schedular [6] for efficiently scheduling these WRF ensemble runs across the Grid architecture.

978-0-7695-3175-5 2008

DOI 10.1109/ICAC.2008.17

Figure 1 shows the basic architecture for our On Demand Grid enabled WRF Portal.

Self-configuration requires the definition of certain policies governing the behavior of the portal and its underlying Grid based architecture. Our portal aims at assisting meteorologists for model configuration and result analysis or research; and business owners/emergency management officials for asset specific hurricane forecasts, visualizations and weather forecast dissemination along with preparation and recovery plans. Hence, we devised a self configuration policy for dynamic configuration of WRF ensemble runs across the Grid architecture via the Portal. An example of such policy is illustrated in Figure 2.

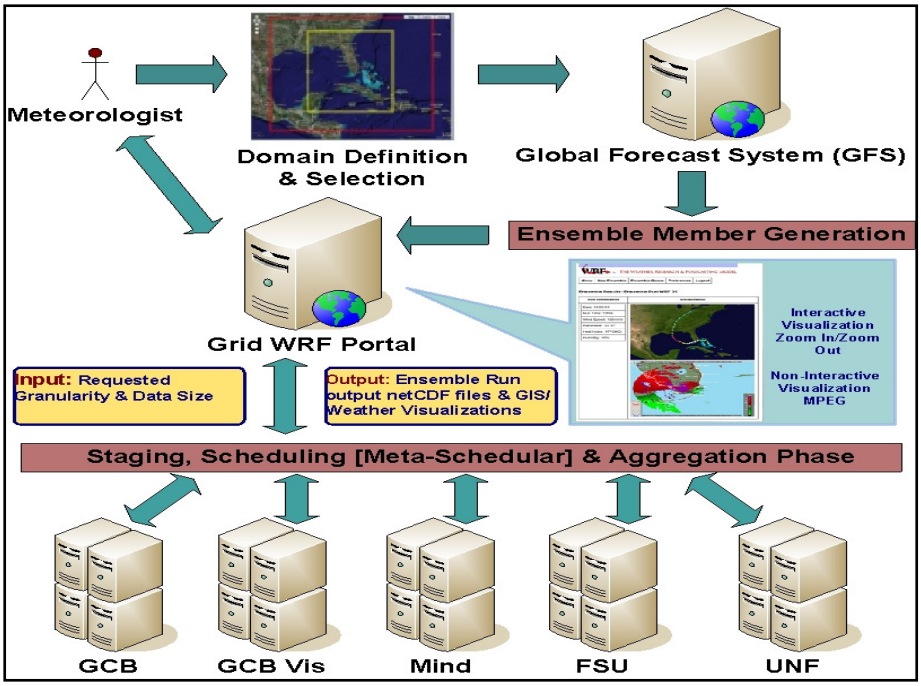

Figure 1. Portal Architecture

1. Identify priority of pending user requests and their resource requirements;
2. Determine current available resources;
3. **IF** resource requirements of pending requests exceeds the currently available resources
   THEN
   3.1 Identify priorities of scheduled and executing requests;
   3.2 **IF** priority of a pending request higher than scheduled requests
   THEN
   3.2.1 Schedule the pending request ahead of pre-scheduled requests;
   ELSE
   3.2.2 **IF** priority of pending requests higher than executing requests
   THEN
   3.2.2.1 Identify one or more requests consuming resources equal to the needs of a pending user request;
   3.2.2.2 Save current state of identified request/s under execution;
   3.2.2.3 Execute the new request;
   3.2.2.4 Upon Completion, recall state of pre-empted request/s and continue execution;
   END IF
   END IF
   ELSE
   3.3 Schedule the requests according to their priorities and execute upon availability of resources;
   END IF

Figure 2. Proposed Self-Configuration Policy

We have utilized Yahoo UI to provide a highly interactive, Web 2.0 compliant user interface; Google Maps for generating the underlying map projection; and VisAD [7] for WRF model output file read capability while Java Server Pages and PostGreSQL is used for Server side data processing and storage.

3. CURRENT STATUS AND FUTURE WORK

Our current framework utilizes Hurricane Floyd data with three-level nested domains (15 km, 5 km and 1km grid-point resolution) as a test bed for our on- demand Grid based WRF portal. We plan to extend our efforts and incorporate real time atmospheric conditions for real time ensemble generation, scheduling and forecasts for hurricane data.

Acknowledgment: This work was supported in part by IBM and the National Science Foundation (grants OISE-0730065, OCI-0636031, REU-0552555, and HRD-0317692).

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