International Conference on Hydroinformatics

2014

Hydroinformatics On The Cloud: Data Integration, Modeling And Information Communication For Flood Risk Management

Ibrahim Demir

Scott Small

Radoslaw Goska

Kate Keahey

Patrick Armstrong

See next page for additional authors

Authors
Ibrahim Demir, Scott Small, Radoslaw Goska, Kate Keahey, Patrick Armstrong, Pierre Riteau, Bongchul Seo, and Ricardo Mantilla

HYDROINFORMATICS ON THE CLOUD: DATA INTEGRATION, MODELING AND INFORMATION COMMUNICATION FOR FLOOD RISK MANAGEMENT

DEMIR, IBRAHIM (1), SMALL, SCOTT (1), GOSKA, RADOSLAW (1), KEAHEY, KATE (2), ARMSTRONG, PATRICK (3), RITEAU, PIERRE (3), SEO, BONGCHUL (1), MANTILLA, RICARDO (1), F. KRAJEWSKI, WITOLD (1)
(1): IIHR Hydroscience & Engineering, University of Iowa, Iowa City, IA, US
(2): Mathematics and CS Division, Argonne National Laboratory, Lemont, IL, US
(3): Computation Institute, University of Chicago, Chicago, IL, US

The Iowa Flood Information System (IFIS) is a web-based platform developed by the Iowa Flood Center (IFC) to provide access to flood inundation maps, real-time flood conditions, flood warnings and forecasts, flood-related data, information and interactive visualizations for communities in Iowa. The key elements of the IFIS are: (1) flood inundation maps, (2) autonomous "bridge sensors" that monitor water level in streams and rivers in real time, and (3) real-time flood forecasting models capable of providing flood warning to over 1000 communities in Iowa. The IFIS represents a hybrid of file and compute servers, including a High Performance Computing cluster, codes in different languages, data streams and web services, databases, scripts and visualizations. The IFIS processes raw data (50GB/day) from NEXRAD radars, creates rainfall maps (3GB/day) every 5 minutes, and integrates real-time data from over 600 sensors in Iowa. Even though the IFIS serves over 75,000 users in Iowa using local infrastructure, cloud computing can improve scalability, speed, cost efficiency, accessibility, security, resiliency and uptime. In this collaborative study between the Iowa Flood Center and the Nimbus team at the Argonne National Laboratory, we have analyzed feasibility and price/performance measures of moving the MPI-based computations to the cloud as well as assessment of response times from our interactive web-based system. Moving the system to the cloud, and making it independent and portable, would enable us to share our model easily with the flood research community. This article provides an overview of the tools and interfaces in the IFIS, and transition of the IFIS from a local infrastructure to cloud computing environment.

INTRODUCTION

The Iowa Flood Information System (IFIS) relies on a hybrid of file and compute servers, including a High Performance Computing cluster, codes in different languages, data streams and web services, databases, scripts and visualizations. The IFIS processes raw data (50GB/day) from NEXRAD radars, creates rainfall maps (3GB/day) every 5 minutes, and integrates real-time data from over 600 sensors in Iowa. Even though the IFIS serves over

80,000 users in Iowa using local infrastructure, cloud computing can improve scalability, speed, cost efficiency, accessibility, security, resiliency and uptime. In this collaborative study between the Iowa Flood Center and the Nimbus team at the Argonne National Laboratory, we have analyzed feasibility and price/performance measures of moving the MPI-based computations to the cloud as well as assessment of response times from the interactive web-based system.

The Iowa Flood Information System (IFIS) is a web-based platform developed by the Iowa Flood Center (IFC) to provide access to flood inundation maps, real-time flood conditions, flood warnings and forecasts, flood-related data, information and interactive visualizations for communities in Iowa. The key elements of the IFIS are: (1) flood inundation maps, (2) autonomous "bridge sensors" that monitor water level in streams and rivers in real time, and (3) real-time flood forecasting models [4] capable of providing flood warning to over 1000 communities in Iowa. The Iowa Flood Center operates a real-time flood forecasting system which facilitates two closely related purposes. The first is to provide forecasts which are accessible to the general public through the IFIS. The second is to provide an environment for the testing of experimental hydrological models. Before being made public, new models can be setup in the forecasting system and the results analyzed for accuracy. The general architecture of the IFIS modeling system is given in Figure 1.

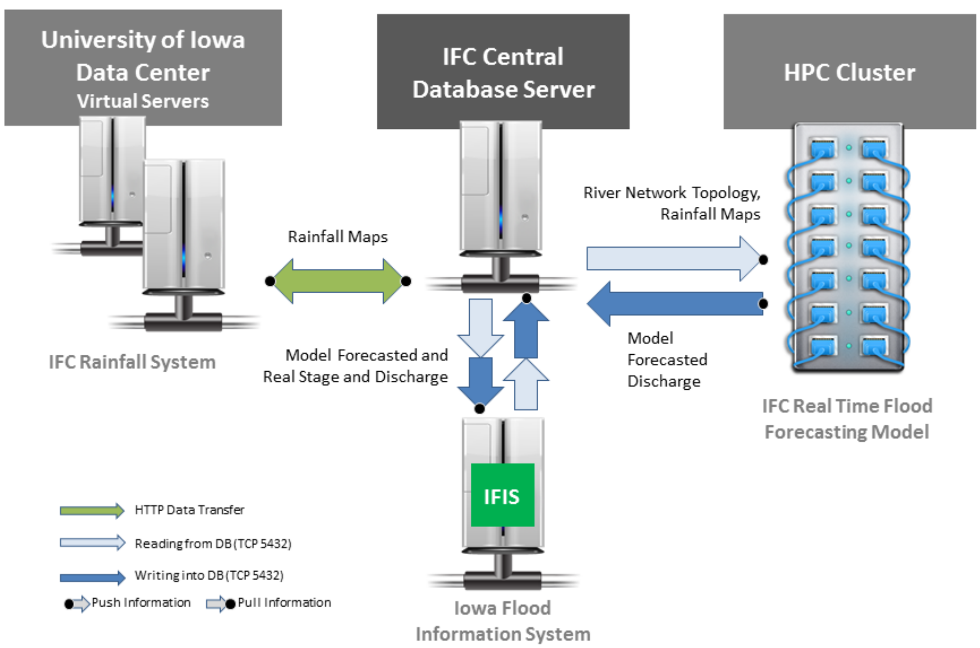

Figure 1. General architecture of the IFIS modeling system

Resiliency in the flood forecasting system is important when considering the needs of the general public. Up to date forecasts must be maintained with no system failures. In response to this, we would like to implement a system which can be migrated to a cloud environment in case of system failure. The three subsystems, IFC Rainfall System, IFC Central Database Server, and IFC Real Time Flood Forecasting Model, should have the ability to migrate when needed. Each of these subsystems is operated from a different physical location, and each can have different periods of down time for different reasons.

Researchers with the Iowa Flood Center use models for both real-time and offline simulations. Real-time flood forecasts for Iowa are available to the general public through the IFIS [2]. Offline simulations are useful tools for researchers to analyze models, study how parameters affect model output, and simulate the effects of variable forcing [1]. Both real-time and offline simulations present an opportunity for a cloud computing environment [3, 5]. A real-time flood forecasting system must have the resilience to withstand hardware failure, as pertinent information regarding flooding conditions will impact the general public. The option to migrate forecasting operations to cloud resources will improve system reliability. For offline simulations, a cloud bursting system allows scalability for times when researchers are demanding more resources than are available locally.

In this collaborative study between the Iowa Flood Center and the Nimbus team at the Argonne National Laboratory, feasibility and price/performance measures of moving the MPI-based computations to the cloud as well as assessment of response times from interactive web-based system have been analyzed. Moving the system to the cloud, and making it independent and portable, would enable us to share IFC model easily with the flood research community. More importantly, it would provide a robust environment resilient to the local effects of flood risk.

REFERENCES

[1] Ayalew TB, Krajewski WF, Mantilla R, Small SJ. Exploring the effects of hillslope-channel link dynamics and excess rainfall properties on the scaling structure of peak-discharge. Advances in Water Resources, 2014. p. 9-20.

[2] Demir, I., Krajewski, W.F., Towards an integrated Flood Information System: Centralized data access, analysis, and visualization, Environmental Modelling & Software, 50, pp. 77–84, 2013

[3] Fox, G., G. von Laszewski, J.G. Diaz, K. Keahey, J. Fortes, R. Figueiredo, S. Smallen, W. Smith, and A. Grimshaw, FutureGrid - a reconfigurable testbed for Cloud, HPC and Grid Computing, in On the Road to Exascale Computing: Contemporary Architectures in High Performance Computing. 2013, Chapman & Hall/CRC Press.

[4] Small SJ, Jay LO, Mantilla R, Curtu R, Cunha LK, Fonley M, Krajewski WF. An asynchronous solver for systems of ODEs linked by a directed tree structure. Advances in Water Resources, 2013. p. 23-32.

[5] von Laszewski, G.; Fox, G. C.; Wang, F.; Younge, A. J.; Kulshrestha, A.; Pike, G. G.; Smith, W.; Vö ckler, J.; Figueiredo, R. J.; Fortes, J.; Keahey, K.; Design of the FutureGrid experiment management framework, Gateway Computing Environments Workshop (GCE), 14-14 Nov. 2010. New Orleans, LA. DOI 10.1109/GCE.2010.567