Globus Toolkit Web Interface – application to seismology

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Abstract. *We present web-based grid application that provides interface to solution of custom geophysical problem in distributed computing system. The problem is determination of seismic anisotropic parameters of Earth crust and upper mantle by SKS phases and converted waves waveforms. Use of web interface allows to hide most technical details of grid and provide user convenient way to control govern parameter, run calculations and receive results. In order to create grid system, we use Globus Toolkit middleware because of presence well documented components, which cover most of typical grid functionality. The application consists of two parts: the web interface and the middleware connector. The web interface allows user to specify computation parameters, estimate computation time, monitor the execution process, graphical representation and analysis of the results. Because the web interface acts as additional layer of security, we can omit middleware authentication services and hide the startup process from user. The middleware connector is a set of programs designed to submit code and data to grid resource allocation manager, places the execution task, arranges the result collection and task execution monitoring. In addition, in order to take into account the compute modules utilization, task scheduler created, because it is not included in Globus Toolkit. Test application was successfully launched on a dedicated grid infrastructure deployed in IPE RAS, VINITI RAS and GC RAS*

Keywords

Grid application, Seismic inversion, Globus toolkit, grid-backed web application

1 Preface

A posterior probability distribution function approach to the solution of inverse problem resembles multi-variable function tabulation [1]. Since the each point of APDF is calculated independently, loosely coupled distributed computing systems increase amount of applications that permits exact solution. Any distributed computing system is based on specific software (middleware). The grid middleware incorporates dedicated high performance machines usually consists of five components: security, task submission tools and/or APIs, task scheduler, data delivery services and asset monitoring subsystem. This components are not necessary mandatory and could vary on functionality and complexity or be replaced by third party software. The choice of middleware software is often governed by problem details, hardware organization, access policy and other context.

Most middleware utilizes X.509 public key infrastructure for user authentication and authorization. In order to access grid user has to acquire a digital certificate from certificate authority, which is used to generate a so-called proxy-certificate. The main idea of this concept is to operate a temporary proxy certificates while holding users identity certificate safe. Each middleware requires specific process to start an application in grid. To set launch parameters, data delivery and other actions in Globus Toolkit, it is imply using Job Description Language, JDL. However, such kind of languages is rarely well documented and tends to change rapidly over versions of middleware. Thus, we cannot call grid easy-to-use system. The user needs to operate very specific software in order to interact with grid. In order to address this issue, grid application toolkits [2] and user-friendly interfaces for grid application can be used. As an example of the latter approach, Quakesim (http://www.quakesim.org), provides access to collection of web-services that allows data acquisition and processing software, visualization and mapping tools. This method naturally does not accept any user modifications; nevertheless, this method is the most convenient way of user-to-grid interaction.

2 The Application

We have built a grid application that hides most technical details of grid and provides user convenient way to control govern parameter, run calculations and receive results. Two parts should be considered: the web interface and the middleware connector. The web interface allows user to specify computation parameters, estimate computation time, monitor the execution process. Significant part of the interface includes tools for graphical representation and analysis of the results. Because the web interface acts as additional layer of security, we can omit middleware authentication services and hide the startup process from user. Besides conveniences, it restricts users from generating and sending codes into the grid. The middleware connector is a set of programs designed to link the application to grid software. The program submits code and data to grid resource allocation manager, places the execution task and arranges the result collection. Additionally the middleware connector allows task execution monitoring.

As a test application we use the geophysical problem: determination of anisotropic seismic parameters of crust and upper mantle by inversion of SKS and P-to-S converted waves waveforms [3]. Our goal is tabulate an objective function that is defined as root mean square deviation of recorded seismograms to the synthetic ones generated for a number of parameters. In computations, we use a layered halfspace model. This approach was already adapted to launch on grid [4]. For test running, we have used one model described in paper [4]. The problem is determination of value of eight "unknown" parameters: S-wave anisotropic coefficient, coefficient η, anisotropy azimuth and layer thickness in two-layer module. Object function calculation was performed on the regular rectangle grid with the following parameters: S-wave anisotropic coefficient between zero and 0.05, step 0.01, parameter η - 1.00-1.05, step 0.01. The layer thickness between 50 and 100 km, step 10 km, anisotropic azimuth between 0 and 175 degrees, step 5 degrees. The overall speedup is about 30 to 50 times, reducing the time elapsed to few hours. A single machine would take a week to process the same task.

The user interaction in implemented web interface could be split into three components: fixing general calculation parameters (number of layers in the model, calculation step etc.), execution monitoring, result visualization. To edit of general calculation parameters we use a dynamic webpage with a number of fields to fill in and control elements to load and save edited parameters as well as estimate execution time and launch the application.

The portage of computation software for grid application is implemented with a toolset of “bag of tasks”-concept. Each task (zipped tarball) consists of executable binary, input data, configuration and management scripts. This task is sent to computation nodes using middleware toolset, GRAM (Grid Resource Allocation Manager - a component of Globus toolkit) in our case.

We use a relational database management system (RDBMS) to store and process the results. Visualization process assumes in particular selection of objective function values along any given direction in parameter space. This means that we have to make such database search to be fast. This feature is supported by MySQL, which we used in our project. It should be mentioned that creation of multiple indices could take a lot of time, a few hours in our case. The database file, containing the results could be downloaded to users computer, however, the interface allows initial preview of the results with set of single- and two-dimensional sections of objective function in absolute minimum point.

Demo launches took place on a dedicated grid infrastructure deployed in Institute of Physics of the Earth of Russian Academy of Sciences (IPE RAS), All-Russian Institute for Scientific and Technical Information of Russian Academy of Sciences (VINITI RAS) and Geophysical Center of Russian Academy of Sciences (GC RAS). The IPE RAS cluster is Intel Modular Server blade system with two E5520 Intel Xeon processors and 12 gigabytes of memory in each blade. The interconnection is Ethernet-based, while the storage is shared. The VINITI cluster is set of standard servers based on Xeon E5430 processors. Storage system is shared with software solution. The GC holds a server for administrative purposes and hosts web interface access endpoint.

The grid is built upon Globus Toolkit middleware. This project requires the following components: certificate authority, identity store, local resource manager and local resource scheduler. The certificate authority is a set of tools that support PKI and enables PKI-based authentication of users. Because we omit user interaction with grid security, the execution is held after a single username specially assigned for this task. To implement this method we have to create and additional software layer that manages proxy-certificates for each launch. Data access is made up using GridFTP, which, as any Globus Toolkit component, utilizes a proxy certificate to operate. Tasks on execution node start and stop by signals from local resource manager. Such software operates locally on a cluster and manages immediate execution of processes. The demo grid utilizes TORQUE resource manager.

All grid services (except for GridFTP), the web interface and middleware connector operate on dedicated virtual host. The hardware virtualization support allows to reduces configuration overhead and minimize the hardware cost. Using virtual private networks, the concept could enable virtual machines to migrate seamlessly without interruption to another cluster.

The project is useful not only by reducing the execution time dramatically but also significantly improves the usability of grid computing power. The presented application is not optimal and could be improved with more efficient solver and more lightweight middleware.

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References

[1] Tarantola A. Inverse problem theory; methods for data fitting and model parameter estimation. Elsevier, 1987, pp. 613
[2] G. Allen, K. Davis, T. Goodale, A. Hutanu, H. Kaiser, T. Kielmann, A. Merzky, R. van Nieuwpoort, A. Reinefeld, F. Schintke, T. Schütt, E. Seidel, B. Ullmer. The Grid Application Toolkit: Towards Generic and Easy Application Programming Interfaces for the Grid. // Proceedings of the IEEE, 93(3), pp 534-550, (2005)
[3] L. P. Vinnik, I. M. Aleshin, S. G. Kiselev, G. L. Kosarev, L. I. Makeyeva. Depth localized azimuthal anisotropy from SKS and P receiver functions: The Tien Shan. // Geophys. J. Int. (2007) 169, 1289–1299 doi: 10.1111/j.1365-246X.2007.03394.x
[4] Алешин И.М., Мишин Д.Ю., Жижин М.Н., Корягин В.Н., Медведев Д.П., Новиков А.М., Перегудов Д.В. Применение распределенных вычислительных систем при определении параметров сейсмической анизотропии коры и верхней мантии // Геофизические исследования. 2009. Т. 10, № 4. С.34–47.