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SIMRI@Web : An MRI Simulation Web Portal on EGEE Grid Architecture

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In this paper, we present a web protal that enables simulation of MRI images on the grid. Such simulations are done using the SIMRI MRI simulator that is implemented on the grid using MPI. MRI simulations are useful for better understanding the MRI physics, for studying MRI sequences (parameterisation), and validating image processing algorithms. The web portal client/server architecture is mainly based on a java thread that screens a data base of simulation jobs. The thread submits the new jobs to the grid, and updates the status of the running jobs. When a job is terminated, the thread sends the simulated image to the user. Through a client web interface, the user can submit new simulation jobs, get a detailed status of the running jobs, have the history of all the terminated jobs as well as their status and corresponding simulated image.
As MRI simulation is computationally very expensive, grid technologies appear to a real added value for the MRI simulation task. Nevertheless the grid access should be simplified to enable final user running MRI simulations. That is why we develop a tis specific web portal to propose a user friendly interface for MRI simulation on the grid.

Summary

*** Application context ***
The simulation of Magnetic Resonance Imaging (MRI) is an important counterpart to MRI acquisitions [1]. Simulation is naturally suited to acquire theoretical understanding of the complex MR technology. It is used as an educational tool in medical and technical environments. By offering an analysis independent of the multiple parameters involved in the MR technology, MRI simulation permits the investigation of artifact causes and effects. Simulation may also help in the development and optimization of MR sequences. Finally MRI simulator provides an interesting assessment tool of image processing techniques since it generates 3D realistic images from medical virtual objects perfectly known.
The SIMRI simulator is a recent 3D MRI advanced simulator [1] that integrates in a unique simulator most of the simulation features that are offered in different simulators. It takes into account the main static field value and enables realistic simulations of the chemical shift artifact including off-resonance phenomena. It also simulates the artifacts linked to the static field inhomogeneity like those induced by susceptibility variation within an object. It is implemented in the C language and distributed under the CECILL license. The MRI sequence programming is done using high level C functions with a simple programming interface. To manage large simulations, the magnetization kernel is implemented in a parallelized way that enables simulation on PC grid architecture [2].

*** Grid added value ***
Since simulation of the MR physics is computationally very expensive, parallel

implementation is mandatory to achieve performances compatible with the target applications. As an example it takes 12 hours to simulate a 512^2 image on a recent PC. This time has to be multiplied by 16 for a 1024^2 image. In 3D, simulation of a 5123 volume would require 100 years !
Thanks to the linearity property of the main computation task, the simulation job can be distributed easily with almost no communication between nodes during simulation [2]. As a consequence, the computation time is reduced in proportion with the available computation nodes. In this context, by offering a virtually unlimited computing power, grid technologies appear to a real added value for the MRI simulation task. Nevertheless the grid access should be simplified to enable final user running MRI simulations. That is why we develop a specific web portal to propose a user friendly interface for MRI simulation on the grid.

*** Experience, results and perspectives ***
The end user functionalities of the MRI web portal are the following:
- Full access to the MRI simulation parameters.
- Access to MRI simulation on a local cluster as well as on the EGEE grid.
- User authentication.
- Enhanced user job history.
- Enhanced running job status.
- Simulation results sent by mail.

The client interface has been developed in PHP5, HTML. The server side is running on a web server Apache V. 2.0.54. It has been developed using :
- PHP5 including the libraries libssh2.so et mysql.so.
- MySql v.4.
- Java 1.4.2 including the libraries jsch.jar,mysql-connector-java-3.jar.

The web server add each new job submission in a database that contains all the parameters of the jobs, and all the user description. Iteratively, a Java thread screens the job table of the data base. For each new job, the thread submits the job to the required target using LCG2 for EGEE grid or PBS for the local cluster. For all the running jobs, the thread asks the job status and updates the data base. For all the terminated jobs, the thread gets the simulated images from the corresponding platform, saves it in the data base, and sends it by mail to the user.
Each user has access to in personnal account on the web and gets the status of his running jobs as well as the history of all his simulations.
This portal is effective since september 2005. At the moment ,it is opened only to the 6 persons involved in the SIMRI project. After 300 simulations, we observed a job failure rate on the grid of about 20 %.
Our main perspective for this year is to develop a new web portal architecture that would use the web service functionalities of Glite middleware. We target a versatile and open architecture to be able to add easily in the portal new simulation target like the CINES machines and to add other MRI simulation codes like the one linked to susceptibility effect.

*** Key issue of the grid for the application area ***
In the context of this simulation application, the main key issues of the grid are the following:
- Efficient MPI implementation on the grid clusters.
- Improvement of the robustness of the grid to guarantee almost 100% of job success.
- Facilitation of the server certificate usage.
- Enabling in a transparent way job submission to multiple clusters in order to be able to use a large number of nodes for 3D simulation.

*** References ***
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