Grid Calculations in the Field of High-Energy Physics

Oleksandr Dyomin, Sergey Barannik
Laboratory for Information Systems
Institute for Scintillation Materials NAS of Ukraine
Kharkiv, Ukraine;
Department of Nuclear and Medical Physics
V. N. Karazin Kharkiv National University
Kharkiv, Ukraine
e-mail: oleksandr.dyomin@gmail.com

Anton Alkin
Bogolyubov Institute for Theoretical Physics NAS of Ukraine
Kyiv, Ukraine

Abstract—**This article is devoted to distributed calculations of experimental data of high energy physics experiments. A role of Grid infrastructure and virtual organizations is considered. GEANT4 as a distributed package for HEP experiment modeling is inspected. A pilot training course on the use of Grid technologies for computing physical tasks was created in the framework of virtual organization HEP.**

Index Terms—**Grid; HEP; virtual organization; cluster; distributed computing.**

More recently, complex computer calculations were the prerogative of theoretical physics. Now any modern experiment is inconceivable without the use of large computing powers. The most striking example of modernity is the CERN collaboration [1,2] and its experiments in the Field of High-Energy Physics (HEP). Before the creation of a Large Hadron Collider (LHC) at CERN every HEP experiment used a supercomputer for processing a large experimental data [3,4]. When designing the LHC, a dilemma arose — to continue this classic way, or to use distributed computing. When choosing between a large supercomputer and a set of computational clusters, the model of distributed computations won. This happened because the involvement of new members of the collaboration made it possible to use their resources and integrate them into common computing pools.

The user access control and resource provisioning policy allowed maintaining the necessary level of security and access to experimental data within a virtual organization. In the distributed model, it was much better to modernize the computing capacities. Stopping even a large number of clusters did not lead to a halt in the calculations as a whole. This allowed us to quickly and efficiently update both hardware and software.

To provide interaction between clusters, specialized middleware was developed. Its main task was the standardization of the Grid Cluster service application protocols for calculations and data transfer both within the cluster and external data exchange.

An important task was the safety during the calculations and data transfer. This was ensured by the introduction of secure communication protocols in which each server and user (or dedicated service) had their own secure certificate. These certificates are issued and confirmed by the national certification authority. In the Grid network, all interactions are performed over a secure protocol and additionally allows you to identify the initiator of the actions. Accounting services can keep records of used hours and other resources.

To obtain a personal certificate, the user must contact the national certification authority (CA), or his nearest Registration Authority. Site administrators have the ability to independently obtain new ones and renew valid certificates for their servers and services.

Grid calculations are performed within the framework of virtual organizations (VO). A member of a virtual organization can be either an individual user or an institution. Registration of VO users takes place on the voms-servers of the national Grid of infrastructure, or international projects. All the features of the work of VO are determined by its constituent documents. In high-energy physics, a large number of international VOs operate. The most famous of them are CMS, ALICE, ATLAS, BELLE etc. Institutes of the National Academy of Sciences of Ukraine also take part in the work of some VOs. For example ISMA is a member of VO ALICE [5]. The virtual organization HEP is registered in the Ukrainian National Grid Infrastructure (UNMI). The priority activities of VO "HEP" are the implementation of research and scientific and technical projects of individual VO participants. Implementation of joint national and international scientific projects on high-energy physics by the participants of the VO. Creation, constant support and updating of the software environment for performing research on high-energy physics using Grid computing. Providing methodical and technical assistance to HEP members. In addition to computftional tasks, this VO sets itself educational tasks, i.e. familiarizing young scientists and students of physical specialties with the use of Grid technologies.

Working in VO can greatly simplify the execution of calculations for users. On clusters that support the Virtual Organization, the same type of midlewawe & software is installed. You can see structure of software of experiment ALICE (and appropriate virtual organization) on figure 1. Cluster administrators synchronize the intermediate and

accounting software within the VO framework. This avoids errors in the compilation of tasks and the execution of calculations on different clusters.

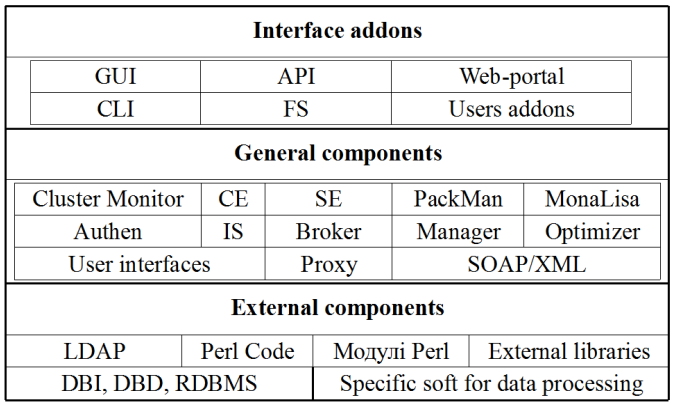

Figure 1. Software structure of virtual organization ALICE

Support for VO on a large number of clusters makes it possible to flexibly use resources for calculations and simplifies the access of users to computing resources. The use of Grid services enables users to run tasks for calculations on clusters that are supported by virtual organizations.

Clusters usually use a significant amount of software. This imposes certain features that need to be considered for efficient computing and the use of computer resources. For this purpose, specialized scripts for running programs are created and different queues on the cluster are organized according to the class of tasks. For each queue, a limited processor time is determined for making calculations, resources by memory and the number of processors are also allocated.

Usually members of virtual organizations of physical experiments are not programmers, but physicists. Accordingly, it is somewhat difficult for them to formulate the problem in terms of low-level programming languages. To overcome this complexity, application packages such as Root and GEANT are created. It allow users to concentrate on the physical basics of the task, rather than programming. The most popular package for modeling the passage of radiation through a substance (in particular detection of radiation) is the GEANT (GEometry ANd Tracking)] package [6].

Versions of GEANT 1,2,3 were written in Fortran. At one time this language was very common among physicists. The new version of GEANT 4 is written in CERN on the object-oriented language C ++. The first releases were presented in 1998 and have been continuously improved ever since. As stated on the official website of the project "application areas include high energy physics and nuclear reactions research, medicine, particle accelerators and space physical research."

The base environment for running GEANT4 is ScientificLinux, but there are compatible releases for both Windows and other Linux versions. This makes it possible to create and debug a program on your personal computer and then transfer it for settlement to the Grid under your certificate for long calculations or calculations that require significant resources.

When creating a program on GEANT, users operate with concepts such as the shape and location of detectors, tracks of particles passing through it. In the same way, you can specify collimators, structural elements and the location of any other elements that absorb or scatter radiation. By modeling using the Montecarlo method, the scattering cross sections, the detection probabilities, the efficiency of a particular detector. This allows you to concentrate on physical laws and engineering solutions and not be distracted by programming features.

On the basis of ISMA, in cooperation with the Kharkov National University named after Karazin, a pilot training course on the use of Grid technologies for computing physical tasks on a cluster was created. The course will be taught to students of the Department of Experimental Nucleus Physics of the Faculty of Physics and Technology. Within the framework of the course, students will receive Grid certificates, become members of VO HEP and will perform laboratory work on VO computing clusters.

The practical use by students of GEANT4 and other application packages is very important. This will enable them to quickly and efficiently join the scientific teams in the field of HEP.

The popularization of Grid technologies and the training of various categories of Grid users allows the use of new methods of computing and data processing in various fields of science, medicine and education.

ACKNOWLEDGMENT

This work is partially funded by the Targeted integrated scientific research program of the National Academy of Science of Ukraine "Grid infrastructure and Grid technologies for scientific and applied-science applications"–

REFERENCES

[1] CERN — the European Organization for Nuclear Research; [Електронний ресурс] http://public.web.cern.ch/public/

[2] The Large Hadron Collider at CERN; [Електронний ресурс] http://lhc.web.cern.ch/lhc/; http://public.web.cern.ch/public/en/LHC/LHC-en.html

[3] A. J. BevanB. GolobTh. Mannel al al. “The Physics of the B Factories ,” The European Physical Journal C, November 2014, 74:3026

[4] M.Harrison, T.Ludlam, S.Ozaki “RHIC project overview,” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 499, Issues 2–3, 1 March 2003, Pages 235-244

[5] S. Barannik, O. Dyomin, O. Sobolev “The Organization on the Calculating Cluster of the ISMA a Grid Distribution Calculations for International Experiment ALICE (LHC, CERN)” IXth International Scientific and Practical Conference "Electronics and Information Technologies"(ELIT-2018), Lviv, Ukraine.

[6] Allison, J., Amako, K., Apostolakis, J. et al. "GEANT4 developments and applications," IEEE Transactions on Nuclear Science., vol. 53 (2006), issue 1, pp. 270-278