WP3: High-Performance Framework for Advanced Grid Applications

1. Major Activities and Results

Task 3.1: Development, deployment and testing of high-performance environment for the innovative Grid applications.

In the second phase of the project we have worked actively to expand the environment towards the integration of resources in Cloud, and towards distributed processing of large volumes of data. On the high performance cluster in IICT -BAS a pilot installation of Computing Cloud components was undertaken. New resources for data storage and computing using graphics cards, which raised the overall performance of the cluster to over 9 teraflops double precision, were introduced into operation.

A system for distributed query processing was developed, which provides a single entry point and can use the grid or cloud resources for the computations and is particularly suitable for processing datasets .

Analysis of the Sobol sensitivity coefficients for modeling of atmospheric pollution using U.S. EPA methodology on the territory of Bulgaria with step 3 km was performed. In this context, a graphic interface was developed.

Modules for access the gLite Grid services using web services over a secure connection were developed.

The performance of the regional Grid infrastructure when executing resource- intensive simulations using the U.S. EPA system software components for modeling the transport of pollutants in the atmosphere was investigated. The parameters that determine the overall performance were identified and the problems and bottlenecks of the regional grid cluster resources were identified as well.

Involved in this task: E. Atanassov, T. Gurov, A. Karaivanova, S. Ivanovska, M. Durchova, R. Hristova.

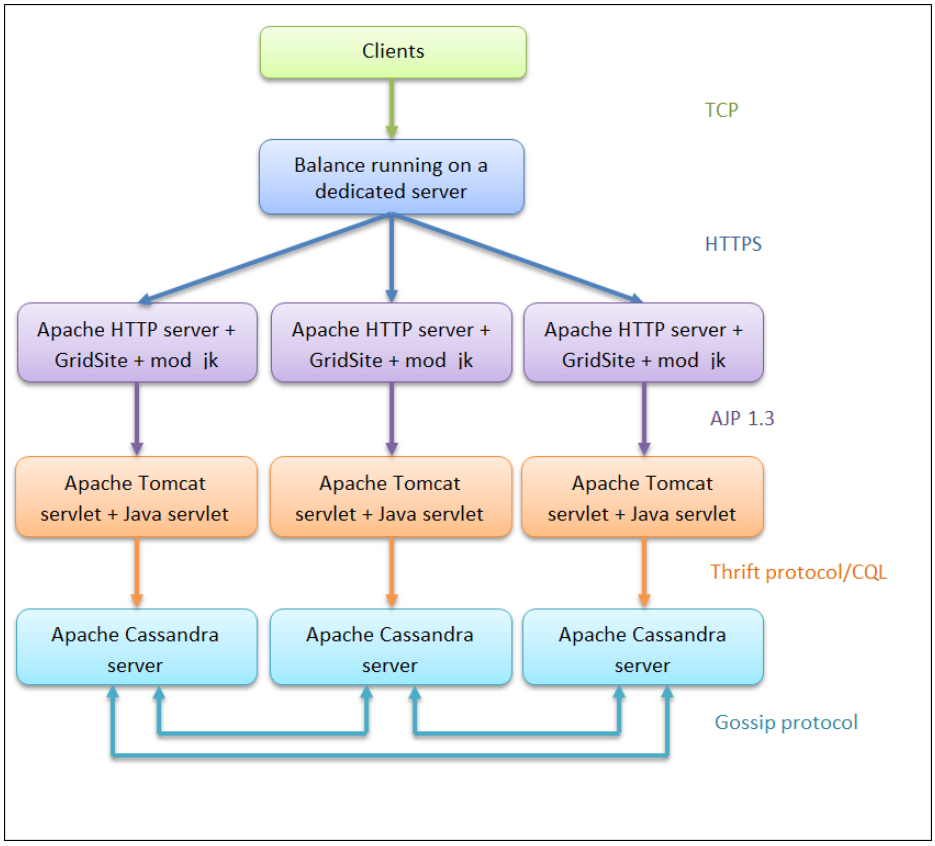

Fig. 1: Schema of the distributed system for query processing.

<u>Task 3.2</u>: Developing applications in the field of financial mathematics and solving transportation problems using the developed tools and services.

The areas of financial mathematics and modeling of electron transport were identified as the main areas of application of the developed schemes and services.

The scalability and performance of the developed Monte Carlo methods for solving multidimensional integrals and integral equations used in the simulation of electron transport were sudied. The comparisons were made for versions developed for Blue Gene / P, cluster with Infiniband connection and cluster with graphics cards NVIDIA M2090, in terms of their parallel efficiency and overall productivity. Access to other high-performance clusters in the region of SEE was obtained allowing to perform and scale simulations.

In the field of financial mathematics we have worked on different models to simulate the movement of financial assets and modeling the price of options and other derivative instruments . During the last period the methodology for estimating the coefficients of the Heston model was refined using the potential of GPGPU resources available to us. We have obtained more precise

estimates, the computations were performed in real time, and the sensitivity of the model in relation to the input data was also estimated.

Involved in this task: N. Manev, A. Karaivanova, T. Gurov, S. Ivanovska, E. Atanassov, M. Durchova, D. Georgiev.

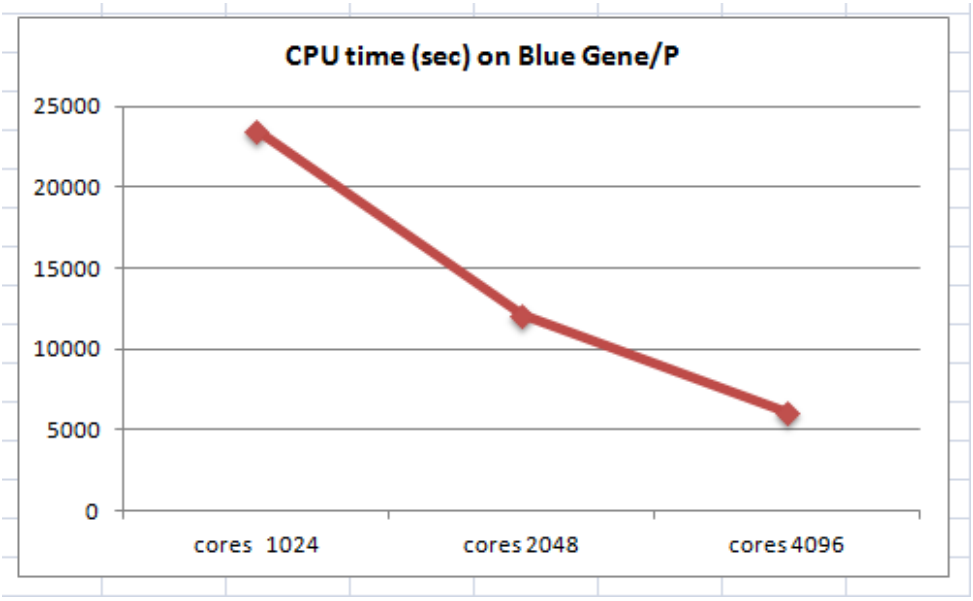

Fig. 2. Scalability on BlueGene/P when estimate Wigner function at $t = 180$ fs presented in the plane $z \times kz$. The electric field is $15 kV/cm$ and the number of Markov chains per pointsolution is 1 billion.

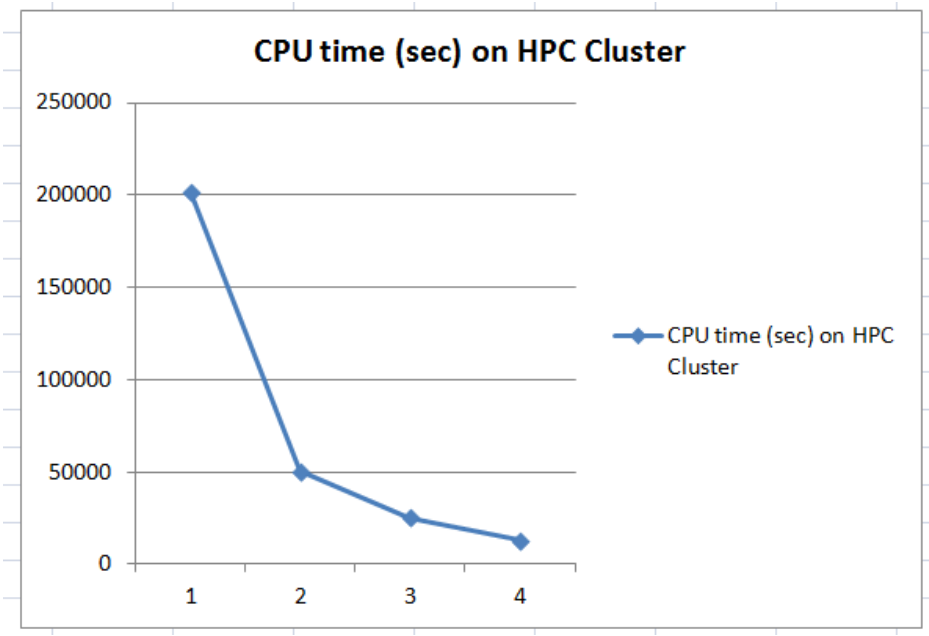

Fig. 3. Scalability on high-performance cluster.

***Task 3.3**: Increase the reliability, fault tolerance and security environment.*

Bulgarian high performance resources - the supercomputer Blue Gene / P and high performance cluster in IICT -BAS – are monitored through regional monitoring system based on nagios, as well as European monitoring systems. The emergence of problems identified by users and their solution can be traced by the use of regional helpdesk. There is secure access for the members of the project to both the Bulgarian resources and the resources available through the European and regional networks of high performance resources using Grid certificates issued by IICT - BAS.

A method was developed and a software implementation of a system for the Grid services was prepared using language Erlang. The language Erlang is a functional programming language , which is primarily oriented towards the development of distributed services with an extremely high level of reliability. The technical difficulties in using Erlang for grid services arise from the fact that the implementation of SSL and HTTPS in the most used OTP distribution of Erlang, does not support proxy certificates and allows to directly add the option for identification VOMS type, which is used within the European Grid initiative . Modification of OTP distribution was developed which adds the necessary information so as to be able to use such certificates. As a result, it becomes possible to use widely used services that are written in Erlang, or regulatory schemes (frameworks), to add options for authentication and authorization in Grid proxy certificates. Program implementations of such services were developed , which are mainly used for various popular modules written in Erlang. The results confirmed the feasibility of building a secure and resistant to collapse distributed Grid services by using this programming language.
We continue our research on security issues for the coordinated use of Grid and Cloud resources.

Novel parallel algorithms for the decomposition of large integer factorization based on elliptic curves using GPGPU resources were developed. These algorithms were tested on various resources and showed excellent performance on cards that have high performance only in single precision.

2. Publications with acknowledgements to the project ДЦВП02/1

a) published:

[A_13] E.Atanassov, Development of Grid Services using Erlang, CSIT2013 Conference, Yerevan, Armenia, September 23-27, pp. 286-289. ISBN: 978-5-8080-0797-0.

[AD_13] E. Atanassov, M. Durchova, Generation of the Scrambled Halton Sequence Using Accelerators, MIPRO 2013, Proceedings of the 36th International Convention, IEEE, pp. 197-201, ISSN: 1847-3946.

[AD_12] E. Atanassov, D. Dimitrov, Pricing Financial Derivatives on GPU, BGSIAM'11 Proceedings, 2012, 15-20, ISSN: 1313-3357

[ADI_12] E. Atanassov, D. Dimitrov and S. Ivanovska, Efficient Implementation of the Heston Model Using GPGPU, Monte Carlo Methods and Applications, De Gruyter, 2012, 21-28, ISBN: 978-3-11-029358-6, ISSN: 0929-9629 .

[ADPKGD_12] E. Atanassov, M. Dechev, G. T. Petrov, A. Karaivanova, T. Gurov, M. Durchova, HPC Cluster with GPGPU Capabilities. Performance and Features Evaluation, Proceedings of the VIII Serbian-Bulgarian Astronomical Conference, No 11, 2012, 147-152, ISBN 978-86-80019-55-0.

[AGKa_13] E. Atanassov, T. Gurov, A. Karaivanova, Message Oriented Framework with Low Overhead for Efficient High-Performance Monte Carlo Simulations, MIPRO 2013, Proceedings of the 36th International Convention, IEEE, pp. 189-191, ISSN: 1847-3946.

[AGKb_13] E. Atanassov, T. Gurov, A. Karaivanova, Simulation of Electron Transport Using HPC Infrastructure in South-Eastern Europe, High-Performance Computing Infrastructure for South East Europe's Research Communities, Modeling and Optimization in Science and Technologies, Volume 2, pp. 1-13, ISSN 2196-7326, DOI 10.1007/978-3-319-01520-0_1.

[AGKa_12] E. Atanassov, T. Gurov, A. Karaivanova, Cloud and Grid Computing: Security Aspects, BGSIAM'11 Proceedings, 2012, 21-25, ISSN: 1313-3357.

[AGKb_12] E. Atanassov, T. Gurov, A. Karaivanova, Security issues of the combined usage of Grid and Cloud resources, MIPRO 2012/DC-VIS, 417-420, ISBN: 978-953-233-069-4.

[AGM_13] E. Atanassov, D. Georgiev, N. Manev, Number Theory Algorithms on GPU Clusters, High-Performance Computing Infrastructure for South East Europe's Research Communities, Modeling and Optimization in Science and Technologies, Volume 2, pp. 131-138, ISSN 2196-7326, DOI 10.1007/978-3-319-01520.

[AGM_12] E. Atanassov, D. Georgiev, N. L. Manev, ECM Integer factorization on GPU Cluster, MIPRO 2012/DC-VIS, 343-346, ISBN: 978-953-233-069-4.

[AI_13] E. Atanassov, S. Ivanovska, Computation and Analysis of Sobol Coefficients for Air Pollution Concentrations over the Territory of Bulgaria, MIPRO 2013, Proceedings of the 36th International Convention, IEEE, pp. 254-257, ISSN: 1847-3946.

[AI_12] E. I. Atanassov and S. Ivanovska, Sensitivity Study of Heston Stochastic Volatility Model Using GPGPU, LSSC 2011, LNCS, Springer, 2012, Volume 7116/2012, 439-446, DOI: 10.1007/978-3-642-29843-1_49, ISSN: 0302-9743.

[AID_12] E. Atanassov, S. Ivanovska and D. Dimitrov, Parallel Implementation of Option Pricing Methods on Multiple GPUs, MIPRO 2012/DC-VIS, 383-388, ISBN: 978-953-233-069-4.

[GI_12] R. Georgieva and S. Ivanovska, Visualization Tool of Sensitivity Studies Results, BGSIAM'11 Proceedings, 2012, 50-55, ISSN: 1313-3357.

[GG_12] R. Goranova, G. Goranov, Web Service Module for Access to g-Lite, AIP Conf. Proc. 1487, 2012, 63-70, doi: http://dx.doi.org/10.1063/1.4758942, ISSN: 978-0-7354-1099-2.

[GAK_12] T. Gurov, E. Atanassov and A. Karaivanova, Monte Carlo Methods for Electron Transport: Scalability Study, Proceedings of ISPDC 2012, IEEE CPS, p.188-194, DOI Bookmark: http://doi.ieeecomputersociety.org/10.1109/ISPDC.2012.33, ISBN: 978-1-4673-2599-8.

[GIKM_12] T. Gurov, S. Ivanovska, A. Karaivanova, and N. Manev, Monte Carlo Methods Using a New Class of Congruential Generators, L. Kocarev (Ed.), ICT Innovations 2011, AISC, Springer, 2012, Volume 150/2012, 257-267, DOI: 10.1007/978-3-642-28664-3_24, ISSN: 1867-5662.

[IKM_12] S. Ivanovska, A. Karivanova, and N. Manev, Numerical Integration Using Sequences Generating Permutations, LSSC 2011, LNCS, Springer, 2012, Volume 7116/2012, 455-463, DOI: 10.1007/978-3-642-29843-1_51, ISSN: 0302-9743.

[KG_12] A. Karaivanova, T. Gurov, Quasi-Monte Carlo Approach for Solving BVPs, BGSIAM'11 Proceedings, 2012, 62-67, ISSN:1313-3357.

[SI_12] K. S. Shterev and S. Ivanovska, Comparison of some approximation schemes for convective terms for solving gas flow past a square in a microchannel, AIP Conf. Proc. 1487, 2012, 79-87, doi: http://dx.doi.org/10.1063/1.4758944, ISSN: 978-0-7354-1099-2.

[SSA_12] K. Shterev, S. Stefanov, and E. Atanassov, A Parallel Algorithm with Improved Performance of Finite Volume Method (SIMPLE- TS), LSSC 2011, LNCS, Springer, 2012, Volume 7116/2012, 351-358, DOI: 10.1007/978-3-642-29843-1_40, ISSN: 0302-9743.

d) in preparation:

[AGGKN_13a] E. Atanassov, D. Georgiev, T. Gurov, A. Karaivanova, Y. Nikolova, Distributed System for Query Processing with Grid Authentication, LSSC 2013, LNCS, Springer, (accepted for publication)

[HID_13a] R. Hristova, S. Ivanovska, M. Durchova, Performance Analysis of the Regional Grid Resources for an Environmental Modeling Application, LSSC 2013, LNCS, Springer, (accepted for publication)

[HG_13a] R. Hristova, G. Goranov, User-level Framework for Performance Monitoring of HPC Applications, AMITANS2013, AIP Conference Proceedings, (accepted for publication)

[SAS_13a] K. Shterev, E. Atanassov, and St. Stefanov, GPU calculations of unsteady viscous compressible and heat conductive gas flow at supersonic speed, LSSC 2013, LNCS, Springer, (accepted for publication)

3. Presentations, talks and posters

D. Georgiev, E. Atanassov, T. Gurov, A. Karaivanova (poster), Lightweight Distributed System with Grid Authentication, EGI Technical Forum 2013, Madrid, Spain, September 16-20, 2013.
Е. Атанасов, Високопроизводителен клъстер в ИИКТ-БАН и HP-SEE инфраструктура, еднодневен курс „Въведение в паралелно програмиране с MPI и CUDA", ИИКТ-БАН, София, 25 февруари 2013.
Е. Атанасов, Грид приложения върху високопроизводителни изчислителни системи: постижения и нови перспективи, Суперкомпютърни приложения, Трявна, 31 март – 2 април 2013.

E. Atanassov, High-Performance Framework for Advanced Grid Applications, Supercomputing Applications, Bansko, April 22-24, 2012.

E. Atanassov, D. Georgiev, N. Manev, Parallel implementation of ECM Integer factorization on GPU Cluster, Supercomputing Applications, Bansko, April 22-24, 2012.