IT4Innovations

Centrum excelence

Background information

MINISTRY OF EDUCATION, YOUTH AND SPORTS

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
INVESTMENT IN YOUR FUTURE

2007-13
OP Research and Development for Innovation

What is IT4Innovations?

IT4Innovations is a project focused on the establishment of research capacity required for excellent research in the field of supercomputing and information technologies. In this context, corresponding infrastructure will be acquired in the framework of the project, and created the research environment which will focus on one hand on the development of computing methods as such – with IT as the subject of the research – and on the other hand, in particular, the tools for their effective usage – with IT as a tool of further research or application.

The project consortium is composed of five partners lead by the VŠB – Technical University of Ostrava.

Basic parameters

- **5 partners**: VŠB – Technical University of Ostrava, Brno University of Technology, University of Ostrava, Silesian University in Opava, Institute of Geonics AS CR
- **Supercomputing centre** – constructed in 2 stages
- Project budget: **75 million EUR** (eligible costs)
- **Start of research activities – September 2011**
- Launching of first supercomputer (small cluster – 2012)
- **Supercomputing centre completion - 2014**
- **8 research programmes**

Project funding was approved by the European Commission and Ministry of Education, Youth and Sports in June 2011.

Research programmes

1. IT for Disaster and Traffic Management
2. Numerical Modelling for Engineering
3. Libraries for Parallel Computing
4. Modelling for Nanotechnologies
5. IT for Knowledge Management
6. Soft Computing Methods with Supercomputer Applications
7. Multimedia Information Recognition and Presentation
8. Secure and Safe Architectures, Networks, and Protocols

Research domains

IT4Innovations is a research centre that combines academic research with the research meeting needs of application sphere. The core activity of the centre will be computing within three mutually interlinked key areas of activity:

1. **IT4People (Information Technology for People)** – focusing on improving the quality of life in society through modern information technologies.

2. **SC4Industry (Supercomputing for Industry)** – focusing on supercomputing in solving industry tasks, modelling in the field of natural sciences and nanotechnologies (shape optimization, materials design, biomechanical simulations, etc.)
3. **Theory4IT (Theory for Information Technology)** - focusing on basic research, particularly on the development of new and non-traditional computing methods (knowledge mining, ant colony theory).

IT4People

The basic goal of the project in activities related to the development of the information society (IT4People) is to carry out research and development of IT for the following two key areas, represented by research programmes:

- **IT for Disaster and Traffic Management**
- **Multimedia Information Recognition and Presentation**

The VŠB-Technical University of Ostrava is involved in the long-term development of sophisticated tools based on internet technologies and enabling the modelling, monitoring and management of crisis situations caused by natural disasters. Research projects funded mainly by the Moravian-Silesian Region have resulted in the product FLOREON (FLOods REcognition On the Net), which currently represents a unique system enabling the modelling and prediction of the development of ongoing flood situations and the monitoring of current traffic situations using GSM networks and GPS technologies. Within the **IT for Disaster and Traffic Management** research team, additional modules are being developed to address tasks related to modelling the spread of pollution, fires and the effects of ecological disasters. Internet technologies play a key role in the architecture of such a system from the viewpoint of integrating data sources and making the results available to citizens, crisis teams and integrated rescue services; for this reason, it is essential to have a powerful supercomputer centre making it possible to run a wide range of highly demanding mathematical models. A key requirement is that this capacity should be available in real-time, because all of the above-mentioned crisis situations require response times of minutes, or hours at the very maximum.
In addition to 'classic' numerical algorithms, research and development is also planned in the field of knowledge methods using the principles of case-based reasoning, providing the ability to search databases for records of similar crisis situations and subsequently to generate solutions to newly occurring problems. Logistic issues focus on the research and development of agile logistic conceptions applicable in chaotic market conditions involving the individualization of customer demands, transport and ecological restrictions, and the globalization of business and enterprise. Here too, a key role is played by computational methods based on the principles of expert systems, neuron networks, process simulation and logistic flows. Research will also focus on issues of automatic identification using RFID (radio frequency identification) carried out in real conditions, and its integration with information systems for purposes of company management.

The **Multimedia Information Recognition and Presentation** research team will systematically investigate the processing of multimedia data, particularly the features on the level of signals acquired by means of various sensors. This will enable multimodal information identification and retrieval as well as research in techniques of efficient computing using multimedia data. The emphasis will especially be put on image, video and speech analysis, document and multimedia data information retrieval, imaging, visualization and modelling including human tissue models, accelerated computing using specialized hardware and techniques of semantic web, formal languages and grammars. The program results in the form of new methods, techniques and knowledge related to the above mentioned fields of research will not only be used to improve the parameters of the existing applications but are also expected to facilitate the creation of completely new applications that have so far been impracticable for both technical and economic reasons.

SC4Industry

The basic goals of the project in activities related to supercomputer simulations and the development of algorithms necessary for these simulations (SC4Industry) can be divided into the following areas, solved by the respective research teams:

- **Numerical Modelling for Engineering**
- **Libraries for Parallel Computing**
- **Modelling for Nanotechnologies**

The rapid development of information technologies in the last several years has opened up entirely new opportunities in the computer modelling of complex physical and general natural phenomena. Progress

made in this field has found widespread applications in industry. We are currently witnesses to the penetration of quantitative approaches to problem-solving into everyday practice, replacing traditional processes such as produce-test-adjust or produce-sell-improve, which place considerable demands on time and finances. Computer modelling and simulations increasingly enable production problems to be reduced to equations or other relations in forms suitable for computer-based solutions. However, this process is becoming increasingly difficult, and it is not possible to draw a simple dividing line between basic and applied research – applications frequently throw up new problems whose solution often requires an approach integrating both basic and applied research.
Just such an integrated approach is represented in the research team of **Numerical Modelling for Engineering**, which focuses on the development of effective mathematical methods for solving problems that are currently – due to their extent, non-smoothness or non-linearity – out of the scope of standard methods, and the subsequent incorporation of the new methods into the solution of selected complex scientific and engineering problems. Particular emphasis will be placed on the development of algorithms that are able to use effectively modern supercomputers and that are in a sense optimal or scalable. In these cases the main focus will be on algorithms with asymptotically linear complexity for some classes of relevant problems, in which the computation time decreases proportionally to the number of processors. The research will include the development of effective methods for solving basic direct tasks with special structure, including external problems, which will further be used to solve multiphysics problems, multiscale problems, inverse problems of identification of physical parameters, and optimal design problems. Research activities will include all phases of mathematical modelling, from the selection and correct mathematical formulation of problems to their discretization and the design of effective algorithms, the study of computation complexity, analysis of the reliability of results (a posteriori estimates), to the implementation of the new algorithms. With regard to practical applications, there will also be a focus on areas enabling the integration of existing software products. In the computer implementation of new algorithms, we shall use the fact that many algorithms used for solving entirely different tasks are the same. We plan to achieve the project goals by applying an interdisciplinary approach, integrating research teams in the solution of specific scientific and engineering problems. As part of the research, the current methods will be extended and new approaches will be developed with the aim of achieving demonstrably new results of international significance and practical interest; emphasis will also be placed on finding solutions to selected highly demanding problems across the entire range of issues covered by the research programme.

Many of the results achieved by the above-mentioned research will be applied by the team of **Libraries for Parallel Computing** part of the project. In addition to standard software packages (whether commercial or non-commercial) that will be available at the Supercomputing Centre, it will also be possible to use newly developed software packages produced as an output of research activities in research programme **Numerical Modelling for Engineering**, which will apply the latest findings in the field. The most exciting aspect of this part of the project is the mutual interconnection of the Centre's own self-developed software tools with standard commercial and non-commercial packages. Similar interconnections have already been achieved by the applicant workplace in the past, e.g. when using self-designed parallel solvers for ANSYS, Comsol or PMD finite element systems, or in the AnyBody system solving biomechanical simulations, using the OOSol library developed at the applicant workplace. Thanks to this interconnection, end users of standard software packages will be able to take advantage of state-of-the-art methods in solving their practical problems, without having to learn about supercomputing or the theory behind these methods.

The research team **Modelling for Nanotechnologies** is conceived as a compactly unified whole, consisting of laboratories for basic research of nanotechnologies, an in-house technology base for the preparation of nanostructures, measurement and diagnostic equipment, and an application block. The main element connecting all of these individual activities is the creation of mathematical-physical models both in basic and applied research, plus the application of supercomputing methods for the effective solution of these models.

Theory4IT

The goal of the project in activities related to the development of theory (IT4Theory) is to carry out research focusing on mathematical theories of modern computation methods in the following three key areas:

- **IT for Knowledge Management**
- **Soft Computing Methods with Supercomputer Applications**
- **Secure and Safe Architectures, Networks, and Protocols**

Faced with large quantities of data from various sources, it becomes increasingly necessary to structure and store the data in suitable ways, to carry out effective data searching, and to analyze the data in order to acquire new information and knowledge that would not be accessible without the use of sophisticated methods and algorithms. Topics tackled by the research team of **IT for Knowledge Management** thus include: processing of extensive collections of weakly structured data, knowledge extraction from data, use of dimension reduction methods for high-dimensional data, use of linear algebra methods, neuron networks, statistical methods, and cluster methods for data analysis. Research, development and subsequent application of knowledge supported by the use of software systems require the introduction of a range of specific approaches. Another part of this research team's focus will thus be in the field of formal methods. The fundamental topics of this research will include development of modern methods for the effective creation of software systems aimed both at computer technology and embedded systems, the use of formal methods for the specification of software processes and their effective control, research and development of formal tools for the specification and verification of software products, and knowledge-based approaches to software systems design.

Research activities in the area studied by the **Soft Computing Methods with Supercomputer Applications** research team will be focused mainly on the study of basic mathematical means of creating fuzzy models, including study of the mathematical theory of fuzzy approximation, formal methods for the representation of knowledge burdened with uncertainties, the study of fuzzy models of dynamic and self-organizing systems and systems controlled or influenced by events burdened with uncertainties, the development of special algorithms for fuzzy modelling including the solution of optimization tasks, development and implementation of automatic learning, self-organizing systems, the retrieval of relevant information from data, and the development of special algorithms for the control of mobile robots and their cooperation inspired by the behaviour of living systems. Other part of the project is focused on research of bioinformatics, where there exists great potential for the development of methods and approaches inspired by biological phenomena, such as: biological computation, artificial immune systems, evolution strategies, ant colony theory, pack theory, bacterial foraging, hybrid approaches, etc. However, the development of information science brings with it the need not only to draw inspiration from these biological phenomena, but also adequately to record and evaluate such phenomena. Examples of relevant phenomena and desirable applications include protein analysis, biosignal analysis, brain activity analysis, application of data analysis methods to the collected data, etc.

Main task of the **Secure and Safe Architectures, Networks, and Protocols** research team is systematic development of the concept of security and reliability in the field of information technologies (i.e. development of applications with respect to their security and reliability). Both intentional and accidental abuse of information technologies (IT) represent one of major threats to modern society. In the context of knowledge and IT abuse the demand on the system security becomes as important as its functionality, price or maintainability. Current increase in the complexity of computer systems along with cumulative urgency of tasks they have to cope with requires solving a crucial and highly non-trivial question of how to ensure infallible operation of these systems also in situations in which they are not exposed to potential attacks. Contemporary security and reliability-focused IT research comprises a wide range of issues starting with solving purely mathematical problems (e.g. in the area of cryptographic algorithms or formal verification) up to applied research (e.g. authentication) while making use of the knowledge from a wide range of scientific fields (e.g. biomedicine). Within the research new methods and approaches are developed and investigated concerning the protection of computer systems against attacks, early detection and identification of the attacker, threat elimination, etc. However, these new methods are also intended for reliable computer systems that make a minimum number of mistakes and are capable of self-configuration and self-healing. Apart from software, the research pays special attention to hardware whose security, reliability and resistance to attacks need to be ensured as well. These concerns for example specialized embedded systems and networks providing wireless communication with the surroundings that also need to be secured against both intentional and unintentional abuse.
The entire complex of activities in Theory4IT is conceived both for theoretical and applied research. We consider this to be a key distinction, because the new workplace must retain its innovation potential, i.e. it must function as a source of new ideas which then find practical implementation – and such new ideas

mainly emerge from theory. Innovation potential is further strengthened if there is a synergic interconnection of theories and their applications. The results achieved by the research in the Theory4IT part of the project will be applicable either directly or indirectly, as part of the application-based activities in other parts of the project.

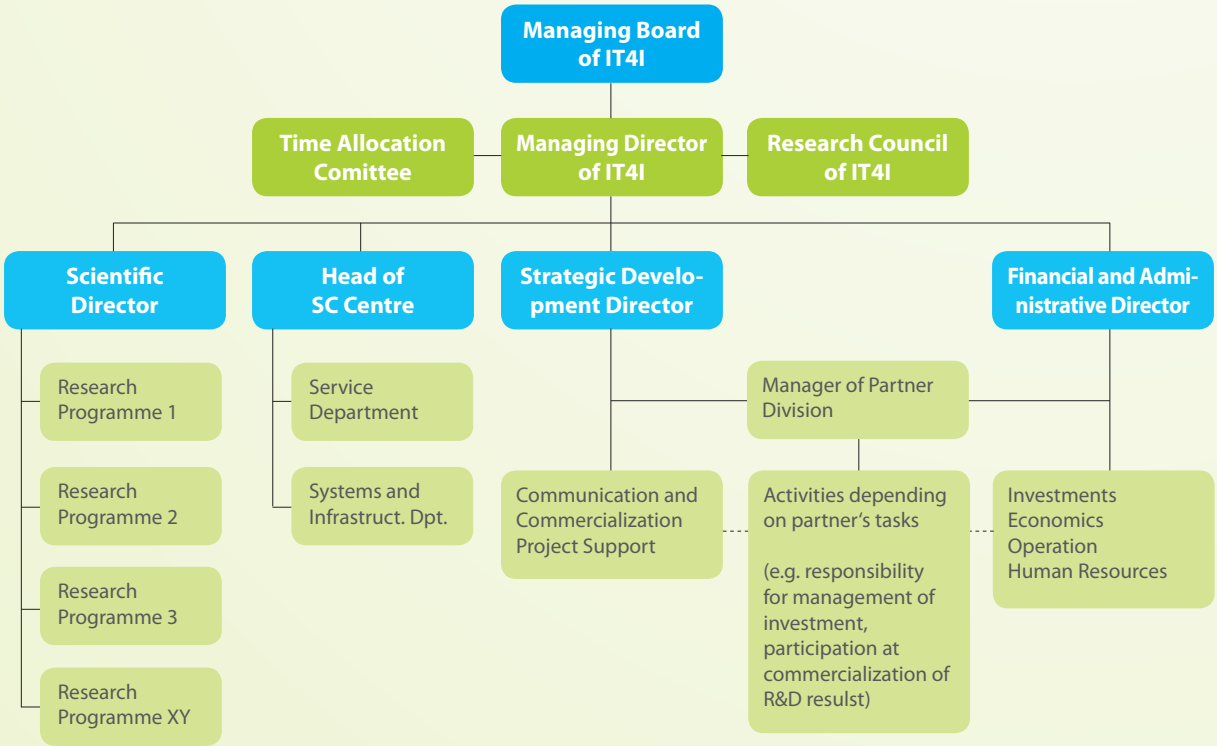
Key infrastructure

The key infrastructure of the project is the acquisition of high-performance computing systems integrated into a supercomputing centre, which will be first of its kind in the Czech Republic. The acquisition of supercomputing technology will be carried out in two phases – in 2012 will be purchased a mobile supercomputing solution (POD) to provide computing capacity for researchers before completion of the Supercomputing centre building at VŠB – Technical University of Ostrava. This mobile datacentre will contain a cluster-based computing system with estimated performance of circa 70 TFlop/s, GPU accelerated cluster, special-purpose computing system (SMP/NUMA) for climatology simulations, as well as necessary storage, networking, and other facilities. After the completion of the Supercomputing centre building in 2014, the original mobile solution will be relocated into the new building, together with acquisition of new technologies. Purchased will be a new cluster-based supercomputer with estimated performance around 1 PFlop/s, new SMP/NUMA computing system, visualization centre for preprocessing and postprocessing of calculations, and more storage and networking technologies.
The Supercomputing centre will play the role of a national supercomputing centre, providing its computing capacity to users from academic institutions, as well as to partners from application sphere.

Management of the Centre

Management of the IT4Innovations centre is set up on a model of centralized management of research activities through the Headquarters of IT4I, and decentralized management of investment and administrative part of the project through partner Divisions. Decisions of Headquarters of IT4I are subject to control of the IT4I Managing Board.
The Centre is not a single legal entity, but is formed by Divisions established within the partner institutions. The Headquarters of IT4I, executing the managing and administrative role towards the funding body (Ministry of Education, Youth and Sports) is established at VŠB – Technical University of Ostrava.

Management structure:



Managing Board is the highest authority of IT4I project management. Its task is to supervise and control project activities and project financial management. Managing Board consists of 9 members nominated by the project partners:

- Ing. **Evžen Tošenovský**, Dr.h.c. – Member of European Parliament
- Ing. **Petr Kajnar** – Mayor of the City of Ostrava
- prof. Ing. **Petr Noskievič**, CSc. – Vice-rector of VŠB - Technical University of Ostrava
- prof. RNDr. **Jiří Močkoř**, DrSc. – Rector of University of Ostrava
- Ing. **Petr Lukasík** – Managing Director of Tieto Czech
- Ing. **Zdeněk Bouša** – Vice-dean of Faculty of Information Technology, Brno University of Technology
- RNDr. **Petr Kantor** – Business Development Manager of Autocont
- prof. PhDr. **Rudolf Žáček**, Dr. – Rector of Silesian University in Opava
- prof. Ing. **Miroslav Tůma**, CSc. – Vice-chairman of Academy of Sciences of the Czech Republic

Research Council is an advisory body of Managing Director of IT4I CE in respect of realization and evaluation of research activities. The Council consists of top class experts operating outside of IT4I, in application sphere and internationally. Research Council plays a major role in formulating research activities of the centre as well as their subsequent control. The Research Council consists of 9 members:

- prof. **Juan Manuel Corchado** – University of Salamanca (Spain)
- prof. **Dr. Michael Cada** – Dalhousie University (Canada)
- prof. Dipl.-Ing. Dr. **Ulrich Langer** – Johannes Kepler University Linz (Austria)
- prof. **Radim Jiroušek**, DrSc. – University of Economics, Prague (Czech Republic)
- prof. Dipl.-Ing. Dr. techn. **Reinhard Viertl** – Vienna University of Technology (Austria)
- doc. RNDr. **Elena Gramatova**, Ph.D. – Slovak University of Technology in Bratislava (Slovakia)
- prof. **Alan G. Chalmers** – University of Warwick (UK)
- prof. **Ing. Petr Berka**, CSc. – University of Economics, Prague (Czech Republic)
- prof. **Dr. Peter Arbenz** – Swiss Federal Institute of Technology Zürich (Switzerland)

Facts about Ostrava

- Third biggest city of the Czech Republic
- 300.000 inhabitants
- 2 public and 1 private universities
- Distance to neighbouring cities – Prague (380 km), Vienna (300 km), Brno (175 km), Krakow (170 km), Bratislava (300 km)
- Elementary and secondary school available, with education in English and according to international standards

More information available at http://en.wikipedia.org/wiki/Ostrava

IT4Innovations project localities

Contact us:

IT4Innovations
VŠB - Technical University of Ostrava
17. listopadu 15/2172
708 33 Ostrava-Poruba
Czech Republic
info@it4i.cz

www.it4i.eu
www.facebook.com/IT4Innovations

MINISTRY OF EDUCATION, YOUTH AND SPORTS
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
INVESTMENT IN YOUR FUTURE
2007-13
OP Research and Development for Innovation