ERCIM-ESF Collaboration

Report of the ERCIM-PESC meeting

held at CWI, Amsterdam, May 30-31, 2002

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Foreword

Discussions between representatives from the European Science Foundation (ESF) and ERCIM led to a proposal for cooperation between the two organisations. Both organisations signed a memorandum of Understanding and organized an exploratory workshop to develop a joint vision for the future of e-Science. This workshop took place at CWI in Amsterdam on May 30-31, 2002.

The main thrust of the workshop was to investigate jointly a foresight for IT in Europe. Twelve experts from ERCIM and twelve from ESF were invited to discuss important spearhead areas for the future, analyse strengths, weaknesses, opportunities and threats for European research and make recommendations to ERCIM, ESF and the European Union. Four discussion groups were constituted to take into account the interdisciplinary and the applied aspects of computer science.

Executive Summary

Information and Communication Technology (ICT) has a huge impact on virtually all domains of our daily life:
- complex computations and computer simulations have fuelled the developments in many branches of science and will continue to do so at an accelerated pace;
- intelligence is embedded in all kinds of industrial tools (robotics) as well as in consumer electronics and utensils;
- ICT has enhanced communication and collaborative work
- ICT is changing the media and entertainment industry;
- ICT is changing also the way in which we generate and process information and knowledge;

Because of its importance for business and society there is a need to maintain a strong position for Europe in the field of ICT. Such a position has to be supported by research and continuous innovation.

In addition, there are the following reasons for research in this field:
- our dependence on ICT make us vulnerable: there is therefore a need to improve reliability and security of information systems;
- The need for sustainable growth and development with a growing and ageing world population puts high demands on optimisation, an increase of efficiency and progress in life sciences; demands which can only be met with the support of the best research in mathematics and informatics.

ESF and ERCIM will join forces and thus strengthen Europe's position in research in mathematics, computer science and 'e-science'. The joint ESF-ERCIM workshop was a first result of this co-operation and has resulted in a number of general recommendations (in addition to more specific ones which can be found in the following paragraphs), which lead the way for both organisations to fully exploit their joint potential:
- Research in ICT is a science in its own right; small, risky and fundamental research projects should be supported in order to sustain a basis for innovation in Europe.
- By joining the networks of scientists of ESF and ERCIM the position of mathematics and computer science within ESF can be strengthened, ESF can benefit of expert knowledge of ERCIM, and mutual participation in 6th FW projects can be stimulated.
- It is recommended to organise foresight workshops in order to develop roadmaps for research, which may be used for input for future European Union research programmes, as well as result in joint research actions of ESF and ERCIM.
- More specifically, joint actions are recommended in the following area's:
    o Optimisation
    o Mathematics for the next generation computing
    o Games
    o Intelligent web
    o Automatic translation

GROUP 1

Interdisciplinary between Mathematics and Computer Science

This group discussed the numerous interactions between the two disciplines. Logic plays a key role in semantics, in databases and in the design of modern programming languages. Probability and statistics occur in the modelling of networks, including the web, in data compression and in default analysis. Computing a realistic 3-D image or moving a robot requires a large amount of geometry. Modern cryptology relies on sophisticated methods provided by number theory. Discrete mathematics is at the heart of many algorithms. Numerical analysis, differential equations, optimisation and dynamical systems occur almost everywhere in scientific computing and their numerous applications. Perhaps more surprisingly, some concepts issued from computer science have deeply influenced modern mathematics. For instance, the famous P versus NP problem is one of the seven Millennium problems, and the concept of automatic group is directly issued from the notion of automaton, the simplest model for a machine.

Two lists of relevant subjects were first established. One for computer science (computer algebra and computer assisted mathematics, computational geometry, scientific computing, parallel computing, computational sciences, numerical methods, image analysis, software and hardware verification, signal analysis, algorithms and complexity, programming languages, software design, networks, robotics, cryptography, simulation techniques, data mining, data compression, visualisation and virtual reality, human computer interface, tomography, etc.), and one for mathematics (logic, geometry, dynamical systems, probability theory, optimisation, topology, algebra, differential equations, number theory, discrete mathematics - including graphs and combinatorics, games, etc.). The discussions also included most of the topics presented in the special theme "erciMathematics" of the ERCIM News July 2002 issue (number 50).

Three key areas emerged from the discussion:
1. Algorithms and Optimisation
2. Computational Science (Modelling, Analysis, Simulation)
3. Next generation computing

The first two topics were selected for their strong interdisciplinary aspect and their wide field of applications. Europe is very strong in both areas, and should built on this competence. "Next generation computing" is much more prospective in nature and includes recent fields like Quantum Computing, Optical networks, DNA computing, and computation models beyond Turing machines.

Recommendations

The group recommended to ESF to establish a scientific programme on Optimisation, a forward looking on Mathematics and next generation computing, and an exploratory workshop on Games.

General suggestions
1. Nominate IT experts for the PESC Standing Committee (ERCIM may help)
2. ESF may have activities devoted to Summer Schools
3. Information exchange between ERCIM and ESF on projects for the 6th FP

Specific recommendations
4. Consider an ESF-scientific program on Optimisation
5. ERCIM and ESF should federate the projects on the three spearhead topics
6. ESF-forward looking on "Mathematics and next generation computing"
7. Exploratory ESF (-ERCIM?) workshop on Games

GROUP 2

Emerging applications in sciences

1. The Vision

The group started with a wide-ranging discussion of the requirements and IT system architectures to support the requirements from the experience and knowledge of the group members. The group reached consensus on several key aspects:

(a) the user accesses an intelligent systems environment to assist in his/her work (and also social / personal) life: the environment is a natural part of a person's space

(b) the architecture must support the transformation from data to information (data structured in context) to knowledge (commonly accepted justified belief) thus providing insight (knowledge applied to the solution of human problems, scientific challenges or fundamental philosophical questions)

(c) the architecture must be implemented using open source or standards-conforming software and associated international standards for information interchange and access

(d) the (optimistic) target is to harness together the best of ICT with best of science

2. Method

The Group used their experience and knowledge to extract from the scientific area some example discussions on requirements. From these requirements the group identified advanced areas of ICT development with wide applicability in science.

According to the following criteria:

(a) Benefit to science – important applications (ESF)

(b) Advanced ICT – strategic technology (ERCIM)

(c) Benefit to Europe – areas of strength

The ICT areas can be clustered into three topics.

3. Three Topics

The three major requirements that lay at the intersection of advanced ICT and important and urgent scientific requirements are:

1. Provision for the user of easy access to facilities – data, software, computers, detectors / instruments all with intelligent assists

2. Provision to the user of a homogeneous view of heterogeneous data with analytical / visualisation /modelling tools

3. Provision to users of ICT supported cooperative working among scientists in different disciplines and geographical areas

4. Justification

The justification for this choice of topics of ICT to benefit science is based on (by topic):

1. Europe is already strong in this area with excellence in user interface design, intelligent agents, multilinguality, thesauri, domain ontologies, language syntax and semantics. Developments in this area are needed to improve further the productivity of scientists

by allowing them to interact with and use ICT systems 'at the speed of their own thought processes'

2. Europe is also strong in this area; not only in variety of representation (multilinguality, multimedia) but also in technologies to provide interoperability by information exchange (e.g. XML-based scientific data exchange) or by uniform access over disparate sources (web-based information portals). Further development in this area is needed to ensure that the scientist has a uniform view of information from all sources so making the information easy to use and increasing the soundness of the scientific work with maximal completeness, accuracy and precision. Furthermore, such interoperability encourages and stimulates scientists to move from a multidisciplinary group of experts to an interdisciplinary group – and it is likely that important new discoveries are to be found by an interdisciplinary science approach

3. Europe is also strong in this area – the commonly used open standard software was developed in Europe and the US-developed Access Grid technology uses this European software. Further developments are needed to assist scientists in different disciplines & geographic areas in cohesive working, building teams with appropriate and complementary expertise to achieve more for Europe than local, regional or national teams could achieve.

Some selected examples of scientific applications, which would benefit considerably from developments in these three topics, are:

- Post genomics R&D leading to understanding vulnerability to disease with direct application in healthcare
- Development of realistic models for the simulation of tumour growth & therapy leading to replacement of experiments in vitro or with animals with in silico experiments
- Material characterisation and non-destructive evaluation for improving e.g. air safety and economy
- Intelligent transportation systems resulting in economy and environment impact
- Environment: global warming analysis and simulation leading to prediction of effects on agriculture, tourism

4. Actions / Instruments

The Group made the following recommendations:

1. Foresight: ESF & ERCIM provide the EC with foresight to influence the EC work programme
2. Community Building: should be improved by e.g. workshops, Eurocores
3. Advancement: ESF scientists should be invited to join ERCIM FP6 NoEs when desirable / feasible
4. Evaluation of proposals: ERCIM to provide a list of willing persons to ESF; this could lead to ERCIM scientists applying for funds to ESF
5. Joint action on publicity, education and training to attract and provide skilled staff with scientific and ICT ability which is in short supply in Europe.

GROUP 3

ICT services for user communities

Information and Communication Technologies had already a huge impact on many domains of our daily life, where large databases can be used for the retrieval of information or the execution of appropriate actions.

Obvious applications can be found in *libraries*, where large bibliographic databases and extensive digital collections of text and multimedia materials are nowadays widely used. The academic world sometimes dreams of constructing one day the ultimate knowledge database, in which all human scientific discoveries and wisdom should be deposited in a highly structured and easily retrievable way.

On a smaller scale, various forms of *knowledge management* are often used in order to control and preserve the knowledge acquired by a given group of people. Such knowledge must again be stored in a structured way that allows for continuous growth, and it should be easily accessible for extraction of required materials.

Official organisations are using their specific form of knowledge management for informing the public of all kind of useful information about the rules, laws and rights that govern the society. This domain of *e-government* has been extended with several electronic services and actions, going from the possibility to submit official electronic forms for all kinds of interaction between public and government up to more revolutionary ways of e-voting and web-supported decision making (e-democracy).

The private sector, finally, is using more and more Internet technology for all kinds of commercial transactions, leading to *e-business* and *e-commerce*.

We have tried to identify, throughout all these domains where ICT is applied by these specific user communities, what are the common problematic aspects where ICT is of vital importance for the performance of the system, and where we can expect that more research could be performed in order to arrive at a more efficient functioning of these systems. As main aspects we have listed:

- The management of complex and dynamically evolving databases.
- Authentication (security and privacy for e-business and e-government, quality control for digital libraries,...).
- Fast and reliable retrieval systems.
- Context sensitive behaviour of the system: it should, e.g., be possible to personalise the information retrieved from the system or the actions performed, according to the customer or depending from other external circumstances.
- ….

The following spearhead areas were finally selected:

A. Complex interacting systems

In all fields described by our group (digital libraries, knowledge management, e-business, e-government…) we are in some way or another faced with a complex software system. This complexity can be either

- Structural complexity (e.g. complex database), or
- Dynamical complexity (change of behaviour of the components).

The system can be composed of many interacting sets on distributed autonomous components.

Important aspects to be studied are:

- The ICT foundations
- Interdisciplinary aspects (sociological, economical, game theoretical, ecological or psychological influences, …)
- Design and construction of the database
- Quality control of the content
- Its scalability and dynamical evolution
- Applications and examples (e.g., e-democracy and group decision making,…)

European strength: In some of these subfields, there was once European leadership; overall experience in Europe is still strong.

Importance for Europe: Cultural diversity requires the construction of a complex database for the knowledge management of its cultural heritage. E-government is more complex in Europe than elsewhere, due to the large variety and many layers of political systems.

Recommendation 1: Create a roadmap for intensive research in this area.

B. Intelligent retrieval

In all fields, intelligent retrieval of the relevant data is of primary importance for the usage of the system. Efficient new search algorithms need to be developed that can take advantage of the particularities of the data. Intelligence is needed in order to get the relevant data required by users with different cultural, intellectual and linguistic background. Therefore we need:

- Context awareness
- Multilingual queries
- Automatic natural language translation
- Semantic description of data
- Multimedia queries and retrieval by content and context
- Ontologies
- Intelligent search engines

European strength: Some of the first search engines were built in Europe. Furthermore, there is a longstanding tradition in natural language translation.

Importance for Europe: We are a multicultural society, and therefore there is a need for equalitarian treatment of all members of our society. Arranging methods for easy retrieval of data may help removing access barriers in many fields.

Recommendation 2: A lot of work in intelligent retrieval is already going on; collaboration through networking would enhance their efforts.

Recommendation 3: High-quality automatic translation is still a problem and extra efforts are needed. The possibility of creating an interdisciplinary research program at the European level (with the collaboration of linguists and computer scientists) should be encouraged.

As a final remark, attention should be drawn to the very profound analysis of the research needs with respect to *Digital Libraries*, performed by the DELOS Network of Excellence on Digital Libraries during their workshop at San Cassiano, Alta Badia in Italy, June 2001. The results were published in their *"DELOS Brainstorming Report"*, ref. ERCIM-02-W02.

GROUP 4

Advanced communication technologies and scientific computation

The demand for communication and computation solutions has been fuelled by the proliferation of wireless communication and information devises, the proliferation of the Internet, the proliferation and acceptance of e-tools as indispensable communication and computation tools, the competitive necessity of "when-ever, where-ever" access to any communities, in particular scientific.

A key factor in delivering solutions that can accommodate all the above demands are the computation and communication systems that are employed. With more people communicating remotely in more locations than ever before, and people having to deal with ever increasing amounts of information, the challenges faced in providing everyone with the right tools to make it more productive and effective, are great. Industry is leading the research for the near future, but the scientific research has a key role for investigating and discovering relevant new areas. Therefore, it is essential, in Europe as everywhere else, to promote the scientific research and to stress the co-operation among scientists. Additionally, the scientific research will be better off considering the information and communication technology (ICT) as a science itself - and not simply as a tool for supporting other scientific work.

Next generation solutions for advanced information and communication technologies will be driven by the acknowledgement of the above demands. Next generation solutions will evolve to the following characteristics: Global access and integration to e-tools "when-ever, where-ever" for supporting e-collaborations and e-communication, fast-deployment of emergency and critical communication.

In line with this vision, we identified the following areas as key and illustrative areas of ICT research, which exploit several areas of communication and computer science, as well as the integration with other scientific disciplines:
- The quest for e-collaboration among scientists, whenever, wherever you are;
- Meeting the challenge of distributing and integrating simulation, model and visualisation;
- The need of co-operation and decision in complex /critical situations.

For each of these areas, we identified some specific communication and computation aspects, as well as some application example, as follows.

E-collaborations for large scientific communities: whenever, where-ever

- Multi-media - QoS - traffic control
- Networking: wireless mobile technologies
- Overlay network protocols as opposite of new network protocols
- Use of GRID
- Resource management
- Data acquisition and elaboration

- Collaborative work among scientists and ICT-scientists

Examples
- E-support for cross-fertilisation
- E-museum (joint with Group 3)

Co-operation and decision in complex /critical situations

- Easy and fast deployment
- Sensor networks / mobile ad hoc
- Co-operation and security
- Socio-economic model

Examples

- Eco-systems: (Control of pollution, control of agriculture, etc.)
- Weather detection and forecasting systems
- Health systems

Distribution and integration of simulation, model and visualisation

- Overlay network
- Mobile access
- Graphics elaboration
- Distributed modelling and simulation

Examples

- Meteorology: integration of different models with possibility of accessing information at different scale

This working group established some common baselines for further activities and proposed them in form of recommendations to ESF, ERCIM, as well as to EC:

Recommendation 1 - It is clear that ICT cannot simply take the role of tools for the other science, but rather need to be considered as a science for itself (and this point is mainly for ESF: to promote ICT strength inside ESF)

Recommendation 2 - New areas and challenges can be discovered only by means of a visionary approach. The support to industry-based research will output results for the next few years. Together with that, it is mandatory to provide support to small risky projects more based on the scientific research, which will provide the guidelines and the directions for the future years.

Recommendation 3 - Support and promote interdisciplinary research, and the exchange of information among disciplines. Be aware of problems from other disciplines, which solutions could be re-used somewhere else.

Conclusion

A common recommendation by the four discussion groups was to assist ESF in IT by using ERCIM's pool of experts. It was also agreed that ESF and ERCIM jointly offer their expertise and advice to the European Commission. Scientists from ERCIM and ESF domains should also cooperate on projects in the sixth EC Framework Programme.

This meeting was a first step towards in the ESF – ERCIM cooperation in the fields of computer science and applied mathematics. This report will be presented to ESF's PESC Committee and Executive Board and to ERCIM's Board of Directors, as well as to Philippe Busquin, the European Commissioner for Research. The report will be accessible on ERCIM's website.

The ESF has welcomed the opportunity to work closely with ERCIM, and to explore the greater interaction with the IT research community that this brings. The first concrete action under this cooperation, the Workshop at CWI, has raised a number of interesting scientific and science policy issues which will be debated over the coming months, with a view to identifying actions. In identifying issues, the Workshop achieved its objective for ESF. The key factors now for ESF, and ERCIM, are to digest the recommendations, identify topics and issues to be addressed, and to take these forward.

<center>**Appendix III: Program of the workshop**</center>

May 30

0900-0930: Welcome, coffee
0930-1030: Presentation on ESF
1100-1200: Presentation on ERCIM
1200-1230: Discussion on objectives of the workshop, agenda, and expected outcome
1400-1530: Breakout Groups: brainstorm on future developments
  1. Interdisciplinary between Mathematics and Computer Science (Computer algebra, Computational geometry, Image understanding, Signal processing, Computer-assisted mathematics, etc.)   **Chair person**: Jean-Eric Pin (ERCIM)
  2. Emerging applications in sciences (medical informatics, bio-informatics, applications in astronomy, physics, etc. **Chair person**: Keith Jeffery (ERCIM)
  3. ICT services for user communities (Digital libraries, knowledge management, e-commerce and e-business, e-government. **Chair person**: Raf Dekeyser (ESF)
  4. Advanced communication technologies and scientific computation (Communication networks, mobile and wireless computations, protocols, simulation, virtual reality, GRID...) Chair **person**: Silvia Giordano (ESF)
1600-1730: Plenary session: results of Breakout Groups, agree on list of spearhead areas
2000-2200: Dinner

May 31

0900-1100: Breakout groups (one for each spearhead area)
1115-1300: Conclusions and agreement on main results of the foresight exercise, preparation of a report outline and an agreement on actions to finalize the report.

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Appendix IV: List of participants

ESF participants:

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