REPORT

ICT research in Brazil

Prepared by:

Mr. Gustavo Robichez de Carvalho
Dr. Raul Martins
Mr. Eduardo Tadao Takahashi
Prof. Dr. Carlos Lucena, Computer Science Department, Project Leader

1. INTRODUCTION: THE SITUATION OF R&D ON ICT IN THE BRAZIL

Since September 2000, there is an Information Society Plan, called “Livro Verde” that indicates a proposal that includes action descriptions of the “Programa Sociedade da Informação”, composed of planning, budget, execution and monitoring statements and projections. It is a public document that can be downloaded (http://www.mct.gov.br/index.php/content/view/18940.html). This plan aims to cover every relevant aspect of the Information Society in Brazil, from R&D to applications, from government to private sector, from technologies to social impact.

ICT R&D is very important in Brazil. There are regulatory milestones and laws that were proposed specifically to ICT R&D in Brazil. For instance, Brazil has 15 funds to finance R&D (Science and Technology Sectorial Funds), and one of them is specific to ICT R&D. Since the last president, ICT is one of the priorities on PITCE (Política Industrial, Tecnológica e de Comércio Exterior).

The PITCE (Política Industrial, Tecnológica e de Comércio Exterior) consists in a plan of action of Brazilian Governement that aims to increase the productive efficiency, increase the capacity of innovation of Brazilian companies and the expansion of exportation. It is considered the base to increase the insertion of Brazil in international trade, stimulating some sectors where Brazil has greater capacity or demands to develop competitive advantages.

The Science and Technology Sectorial Funds, created in 1999, are project financing instruments for domestic research, development, and innovation. Initially 15 Sectorial Funds were created. Among them, it is worth mentioning one that is directed at university-business cooperation, and another at supporting public higher education and research institutions’ infrastructure. These funds originate from contributions according to companies’ invoicing and/or from the earnings arising from the exploitation of natural resources belonging to the Federal Government. With the exception of the Fundo para o Desenvolvimento Tecnológico das Telecomunicações – FUNTTEL (Sectorial Fund for the Technological Development of Telecommunication), managed by the Ministry of Communication, amounts from the remaining Funds are attributed to FNDCT and managed by FINEP, its Executive Secretary, in partnership with CNPq. FINEP is the executive body responsible for the management of the Sectorial Funds under the orientation of the Managing Committees, which specify annual investment guidelines and plans, monitor implementation of action plans, and assess results. Participants of the Managing Committees include the Ministry of Science and Technology – MCT and other ministry representatives connected to the industries covered by each Fund, besides FINEP, CNPq, regulating agencies and scientific, technology, and business communities. This shared management ensures a clear and transparent process. In general, Sectorial Funds are directed to selected projects by means of calls for proposals, which are published in the MCT, FINEP and CNPq websites. In special cases, funding may take place through requests, as determined by the Managing Committees.

2. THE MAIN ACTORS AND PROGRAMMES FUNDING ICT R&D

The main funding public organizations that Brazilian researchers can access are: CNPq, CAPES, FINEP, MCT (SEPIN), and Local State Agencies (FAPs).

Ministry of Science and Technology (MCT) – http://www.mct.gov.br

The Ministry of Science and Technology has the mission of planning, co-coordinating, supervising and controlling activities of science and technology, activities of research and development in priority areas and the formulation and implementation of information science and automation policy.

The basic structure of the MCT consists of five secretariats, three national research institutes, two research centers, and two development agencies - The National Council for Scientific and Technological Development (CNPq) and the Studies and Projects Funding Body (Finep). It further consists of two collegiate bodies which exercise advisory functions and have deliberative responsibilities: National Council for Science and Technology (CCT) and the National Council for Information Technology and Automation (CONIN).

CCT plays a central role in defining the directives and objectives of national and technology policy and in co-coordinating the federal plans and programmes in the S&T area. As for CONIN, this is the highest body in the definition of policies for the information technology sector.

Among the programmes directly co-ordinate by MCT, the following are worthy of note: Programme of Support for Technical Training in Industry (PACTI), the objective of which is to support, guide and link actions relating to the technological training of industry, seeking to increase competitiveness of goods and services produced in the Country.

The strategy of PACTI is decided by the National Technology Training Committee, subordinated to CCT. Eight sub-committees were set up in the structure of PACTI for the following areas: Line of Financing, Purchasing Power, Technological Mobilization, Technology Management and Education, Technology Infrastructure, Technology Information, Technology in Education and Employment and Sectoral Linking. The sub-committees involve over 70 institutions, covering representatives of companies, agencies of the Federal and State Government, universities, foundations, technology institutes, professional associations and representatives of the working class. Other matters, such as Tax Incentives, Business Data Base on investment in S&T and the Study of Competitiveness of Brazilian Industry are also developed under guidance from the National Committee.

Still within the scope of the Technology Development Secretariat (SETEC) we must add the Basic Industrial Technology Programmes (TIB - scientific and industrial metrology, industrial technological information, standardization and certification, technology of management and studies of industrial technology policy) and Specialization in Quality Management (PEGQ). SETEC co-ordinates the Brazilian part of the Specialist Science and Technology Meeting.

Policies for the information technology sector are conducted by the Information Technology and Automation Policy Secretariat (SEPIN), the mission of which is to propose, co-ordinate and monitor the measures necessary for the execution of national information technology and automation policy, in addition to analyzing proposals for the granting of tax incentives and projects in the information technology and automation sector. The General Committee on Information Technology and Microelectronics is responsible for conducting work in Micro-information Technology, Automation and Tele-information Technology, Strategic Mobilization and Priority Programmes, General Co-ordination of Software, Services and Application of Information Technology in Information Systems, Research and Development in Information Technology and Software and Services.

In the Special Programmes Advisory Service (ASPE), attached to the Executive Secretariat of MCT, the general committee on sub-programmes administers the Scientific and Technological Development Support Programme (PADCT) with the definition of the following priority areas: Chemistry and Chemical Engineering, Biotechnology, Geo-sciences and Mineral Technology, New Materials, the Environment, Instrumentation, Science and Technology Management, Maintenance and Information. PADCT is intended to increase, improve and consolidate the national technical and scientific competence in the field of universities, research centers and companies by means of financing for projects producing an impact for scientific and technological development.

The Scientific Development Secretariat (SEDEC) co-ordinates and supervises the following programmes: Humid Tropics Programme, aimed at the transfer and adequate utilization of useful knowledge for the sustainable promotion of development for the Amazon Region; a Programme for Training Human Resources for Technological Development (RHAE), contributing to human resources training at all levels, in priority areas for the technological training of the Country; Pilot Programme for the Protection of Tropical Forests in Brazil (PP-G7) and the Pilot Programme in Marine Sciences.

The Monitoring and Assessment Secretariat (SECAV) promotes studies and prepares subsidies for the preparation of directives, standards, plans and budgets relating to national Science and Technology policy. SECAV participates in the Co-ordination Committee of MCT. It manages the Programme for Monitoring the Weather, Climate and Water Resources and co-ordinates work on formulating Science and Technology Indicators.

CNPq (Conselho Nacional de Pesquisa e Desenvolvimento Tecnológico) http://www.cnpq.br

The National Council for Scientific and Technological Development (CNPq) is a development agency linked to the Ministry of Science and Technology (MCT), to support Brazilian research. Since it was set up, CNPq has always been one of the major public institutions for the support of Science, Technology and Innovation (ST&I), contributing directly to the training of researchers – masters, doctors and specialists – in the various fields of knowledge. All CNPq's actions are established in the Federal Government's Pluriannual Plan, with programs from the Ministries of Science and Technology (MCT), of Defense (MD), of Mining and Energy (MME) and of Development, Industry and Foreign Trade (MDIC).

Today some 30,000 active professionals hold a doctorate, and at least 22,000 of them gained their PhD with the help of CNPq. These investments contribute both to the increase in the production of knowledge and to the generation of new growth opportunities for the country.

FINEP (Financiadora de Estudos e Projetos) http://www.finep.gov.br

Financiadora de Estudos e Projetos — FINEP (Research and Projects Financing), also known as the Brazilian Innovation Agency, is a publicly owned company subordinated to the Ministry of Science and Technology — MCT. It was founded on July 24, 1967 with the purpose of financing scientific and technological research and graduate courses in Brazilian universities and research institutions, as well as research and development in companies. In 1971, FINEP became the Executive Secretary of the newly created Fundo Nacional de Desenvolvimento Científico e Tecnológico — FNDCT (Funding for Scientific and Technological Development).

Since its foundation, FINEP has had a double role: it provides grants to non-profitable institutions, such as universities and research centers, and it lends money to companies. FINEP has encouraged intense mobilization in scientific and business circles, funding the implementation of new research groups, the creation of specific programs, the growth of science and technology infrastructure, and the institutional consolidation of post-graduate activities. It has also stimulated the increase in supply and demand for technology, by mobilizing universities, research centers, consulting firms and contractors of services, products, and processes.

In recent years, FNDCT was reinvigorated with new sources of funds from the so-called Science and Technology Sectorial Funds. The ability to finance the entire Science, Technology, and Innovation – S, T&I system – by combining reimbursable and nonreimbursable funds, as well as fiscal incentives, has afforded FINEP a great capacity for inducing activities aimed at developing this field, essential in increasing Brazilian manufacturing industry's competitive edge.

FINEP encourages and finances innovation and scientific and technological research, which might contribute to extend knowledge and/or generate positive impacts in Brazilian social and economic development, with a view to extending and improving the National S, T&I System, encouraging the production of knowledge and the improvement of scientific and technological skills in the country; stimulating and supporting activities that encourage the expansion of innovation, generation, and adaptation capacity in technological and scientific knowledge, for the production of goods and services; and cooperating towards success of the targets established by the Federal Government's public policies.

Areas of activity - FINEP acts in accordance with the policies set forth by the Ministry of Science and Technology, in strict cooperation with Conselho Nacional de Desenvolvimento Científico e Tecnológico — CNPq (National Council for Scientific and Technological Development).

While CNPq provides scholarships and grants to individuals and research groups, FINEP supports S, T&I activities to institutions, public or private. FINEP's operating procedures are oriented towards extending knowledge and skills to human resources in the National Science and Technology System; research, development, and innovation of products and processes in the business community; increasing quality and value-added of products, processes, and services in the domestic market, targeting improving the quality of life of the population and the selective replacement of imports; increasing competitive edge of products, processes, and services in the international market, with a view to increasing exports; promoting social inclusion and reducing regional contrasts; and adding value to installed scientific and technological capacity to Brazil's natural resources.

Grants and loans - FINEP provides grants, i.e. non-reimbursable funds, and loans. FINEP supports every stage and dimension of the scientific and technological development cycle: basic research, applied research, product, service, and process innovation. FINEP also supports incubation of high-tech firms, implementation of technology facilities, structuring and consolidation of research processes, development and innovation in established companies, and market development.

Non-reimbursable funds are granted with FNDCT funds, currently formed largely by S, T&I Sectorial Funds. They are intended for non-profit institutions, for programs and fields specified by the Funds' Managing Committees. FINEP also supports the organization of events, and continuously accepts requests according to the terms and guidelines as displayed in its website.

Reimbursable loans are made with FINEP's own funds or through on-lending from other sources. Those businesses or organizations interested in receiving credit may submit their applications to FINEP at any time. The first step is to remit an Advance Consultation which, after being qualified, should be followed by a Loan Application to FINEP.

Recently, FINEP has created new instruments to support nascent high-tech firms. Some have been developed in the Inovar Project, supported by the Inter-American Development Bank (IDB). This includes venture capital, provided mainly through risk capital funds. Another instrument is the Programa de Apoio à Pesquisa em Empresas – PAPPE (Program for Supporting Research in Enterprises), a program to provide research grants to individuals in small companies, similar to the Small Business Innovation Research Program (SBIR), existing in the U.S.

Non-reimbursable grants - Grants to public institutions or non-profit private organizations in order to undertake scientific, technology, or innovation research projects; undertake projects in partnership with companies, including as counterparts to FINEP financing; provide studies or events, conferences, meeting or workshops, aiming at interchanging knowledge among researchers. Financial support is granted by FINEP by means of an agreement with the applying organization, specifying objectives, returns expected, working plan, performance indicators, disbursement schedule, and deadline for submission of the technical report and financial summary.

Terms: Applications for research or innovation projects are accepted for examination only in response to requests or calls for proposals, which contain the conditions for qualification and terms. Applications for holding events are constantly accepted and submitted according to the calendar; guidelines and application forms are available at the FINEP site.

Loans to institutions require demonstration of tangible garantees and conditions to develop S, T&I projects. The grace and repayment periods as well as financial charges vary in accordance with the nature of the project and the borrowing institution. Loans are of the following types:

Fiscal Incentives - Granted to companies that run approved Programa de Desenvolvimento Tecnológico Industrial – PDTI (Program for the Development of Industrial Technology) or Programa de Desenvolvimento Tecnológico Agropecuário – PDTA (Program for the Development of Agriculture Technology).

Financial research subsidies - Non-reimbursable resources granted to selected companies among those that run approved PDTIs or PDTAs in order to cover part of the expenses involving research, development, and innovation during the previous fiscal year.

Venture Capital - The acquisition of securities (shares, convertible debentures, and subscription bonds) issued by companies, whether directly or by means of risk capital funds regulated by the Comissão de Valores Mobiliários – CVM (Stock Exchange Commission). Offerings of liquidity instruments (call and put options) in order to increase the attractiveness of private investments in risk capital funds.

PAPPE - PAPPE, a newly created program similar to the American SBIR, is conducted in partnership with the S&T Foundations in 18 States, which select projects to be funded locally and provide matching funds. Besides fostering the interaction between researchers and high-tech based firms for developing innovative projects, it is expected that PAPPE will contribute for the convergence and consolidation of the local and national innovation systems.

Cost reduction for cooperative projects - A reduction achieved as a result of project development involving participation in a consortium of non-profit research institutions, qualified for non-reimbursable loans.

Company qualification for risk investments - An action intended to qualify entrepreneurs for negotiating with Risk Capital investors, as well as creating an atmosphere favoring transactions.

RHAE Grants - A program that grants scholarships to businesses or institutions that undertake scientific and/or technological activities aiming at employing experts to work in short term projects (approved by FINEP and operated by CNPq).

Mandatory Private Actors http://www.mct.gov.br/sepin/

According to “Lei de Informática”, every IT company is obliged to fund and promote research. In this sector, the main actors are: Dell, HP, Samsung, LG, Siemens, Motorola, Nokia, among others. This regulatory land mark includes the Science and Technology Sectorial Fund , the project financing instruments for domestic research, development, and innovation in Information and CommunicationTechnology. This is the specific Fund to finance ICT research. Beside it, it is worth mentioning one other that is directed at university-business cooperation, and another supporting public higher education and research institutions’ infrastructure. These funds originate from contributions according to companies’ invoicing and/or from the earnings arising from the exploitation of natural resources belonging to the Federal Government.

3. THE MAIN ACTORS AND PROJECTS ACTIVE IN ICT R&D

The actors include private companies, government institutes, NGOs, private and public universities. The main actor is represented by public universities that have most of the resources to finance their research program. The funds from the "Lei de Informática" are distributed in a mandatory rule:

- 54% could go to private sector (industries and development centers)
- 10% must go to FNDCT (government fund for research)
- 36% must go to Universities and Research Centers

Main actors in ICT R&D are some key Universities:

- Universidade de Sâo Paulo (Sâo Paulo) –http:// www.usp.br
- Universidade Estadual de Campinas (Campinas) – http://www.unicamp.br
- Universidade Federal do Rio de Janeiro (Rio de Janeiro) – http://www.ufrj.br
- Pontifícia Universidade Católica do Rio de Janeiro (Rio de Janeiro) – http://www.puc-rio.br
- Universidade Federal do Rio Grande do Sul (Porto Alegre) – http://www.ufrgs.br
- Universidade Federal de Pernambuco (Recife) – http://www.ufpe.br
- Universidade Federal de Santa Catarina (Trindade) – http://www.ufsc.br
- Universidade Federal de Minas Gerais (Pampulha)- http://www.ufmg.br
- Universidade do Estado do Rio de Janeiro (Rio de Janeiro) – http:// www.uerj.br
- Universidade Federal Fluminense (Rio de Janeiro) – http:// www.uff.br
- Pontifícia Universidade Católica do Rio Grande do Sul (Porto Alegre) – http://www.pucrs.br

And some companies or NGOs that do research on ICT like:

- CESAR - http://www.cesar.org.br/
- Instituto Eldorado - http://www.eldorado.org.br/
- Wernher von Braun Center for Advanced Research – http://www.vonbraunlabs.com.br/site
- LABELETRON - http://www.cbpf.br/cat/elt/labeletron.html

4. THE MAIN ICT R&D THEMES

The Brazilian Computer Society, starting from the model of the international events, organized the Brazilian workshop of Grand Research Challenges in Brazil: 2006-2016. The goal was to produce five Grand Challenges for Computer Science in Brazil, together with a specification of a clear and concise view of how to treat the corresponding problem. The formulation of each challenge involved discussion of the following issues: i) specification of the benefits of searching for a solution to the problem, ii) description of how to measure the success of the research undertaken to solve this problem, iii) discussion of difficulties and barriers to achieving success in this research and iv) proposal of actions to be undertaken to meet the challenge in a 10-year period. The five challenges, described in the subsequent sections, were:

1. Management of information over massive volumes of distributed multimedia data
2. Computational modeling of complex systems: artificial, natural, socio-cultural, and human-nature interactions
3. Impacts on Computer Science of the transition from silicon to new technologies
4. Participative and universal access to knowledge for the Brazilian citizen
5. Technological development of quality: dependable, scalable and ubiquitous systems

Below, there are five examples of leading institutions in the themes mentioned

- Universidade de Sâo Paulo (São Paulo) – http://www.usp.br
- Universidade Estadual de Campinas (Campinas) – http://www.unicamp.br
- Pontifícia Universidade Católica do Rio de Janeiro (Rio de Janeiro) – http://www.puc-rio.br
- Universidade Federal de Pernambuco (Recife) – http://www.ufpe.br
- Universidade Federal de Minas Gerais (Pampulha)- http://www.ufmg.br

The Brazilian Computer Society foresees some specific future development in the country:

1. <u>Management of information over massive volumes of distributed multimedia data</u>
   - Computational modeling of complex systems: artificial, natural, socio-cultural, and human-nature interactions Briefly, some of the big technical and scientific problems that must be considered to face this challenge include:
   - Reduction (abstraction and summarization) of massive data volumes, by means of computational modeling, simulation and others;
   - Definition and use of the notion of context for information retrieval, considering factors such as user location, profile and requirements, among others;
   - Design and implementation of multimodal content descriptors and of algorithms to extract and index these descriptors, to support multimodal mining;
   - Use of distributed and dynamic indexing peer-to-peer structures;

- Studies in models and mechanisms to integrate data characterized by a large degree of heterogeneity;
- Treatment, while storing and retrieving data, of factors inherent to the heterogeneity in their capture, such as cultural and temporal issues, but also technological characteristics of captors, such as sensors, cell phones, PDAs, among others;
- Study of alternative means of presenting information, including new kinds of interfaces;
- Consideration of data availability and validity, and intellectual property;
- Formulation of conceptual models to specify genres or domains involved in digital entertainment applications, development of methods and implementation of systems to manipulate plots and their experimental use in various applications;
- Study of adaptable and intelligent infrastructures to process distributed information;
- Development of models and techniques to ensure data and information persistence over long time periods, for historical archiving;
- Development of models, structures, interfaces and algorithms for construction of large distributed digital libraries, to manage multimedia information.

2. Computational modeling of complex systems: artificial, natural, socio-cultural, and human-nature interactions Computational modeling involves several levels of specific challenges, such as:
   - Real time processing of very high speed data streams, generated by thousands of sensors – e.g., in the study of natural catastrophes (such as floods) or in urban emergency evacuation systems given artificial disasters (such as nuclear events). This demands research in, for instance, distributed processing, new database architectures, or networks to support such data streams;
   - Design of new requirement elicitation techniques and novel kinds of algorithms and mechanisms to collect and process data, so as to capture variables on social and socio-cultural interactions;
   - Devising storage structures to record the computational models and the factors associated with their tuning and execution in a parallel and distributed environment;
   - Development of tools for the collaborative construction of models, supporting their execution and modification in real time, so that the model can react to changes in the world while it is executed;
   - Creation of new algorithms and techniques in scientific visualization, to support visually capturing the complexity of modeled objects and their interactions – for instance, to help understand the dynamics of a tornado or the evolution of erosion caused by improper human occupation of a region;
   - Research on the impact, in software engineering, of the collaboration between computer scientists and those scientists in other domains;
   - Management of problems that arise from the increase in scalability and dimensionality (number of variables in a problem), which contributes to exponential processing times;
   - Adoption of parallel processing involving heterogeneous resources, such as in computational grids;
   - Studies in extensible multimodal interfaces to help in understanding the phenomena being modeled, and to facilitate the dynamic configuration of the models; and

- Integration of algorithms, data structures and models that have been created by distinct scientific domains using their own methodologies.

3. Impacts on Computer Science of the transition from silicon to new technologies
   - Conduct research in Software Engineering to support requirements at all abstraction levels. These abstractions should capture the verticality needed by physical optimization of computational systems, ranging from low-level issues such as performance and power consumption, to the high-level abstractions needed to support the growing automation of software development processes.
   - Create a more general notion of component-based development, so as to also take non-functional characteristics into account, such as performance, power consumption and dependability.
   - Develop new testing and verification techniques, to account for permanent and transitory failures, and for the interactions among silicon-based and nonconventional processors;
   - Design mechanisms where the implementation of operating systems and middleware tasks alternates between software and hardware, so as to minimize and control power consumption and dissipation in a context of varying workload;
   - Design compiling techniques that can enable compilers to automatically map fragments of code onto highly optimized hardware modules, like audio and video engines;
   - Combine efficiency in power consumption with high performance requirements in parallel heterogeneous systems;
   - Design new languages that efficiently exploit parallelism for massively heterogeneous and parallel systems, subject to strict power consumption constraints;
   - Develop scalable software for multilevel parallel heterogeneous systems, and which takes advantage of the architecture to ensure the desired concurrency level;
   - Integrate multiple parallelism levels: on-chip (multi-core), multi-thread, and internode (clusters, grids);
   - Provide support to the development of scalable computational systems;
   - Quest into new computational models, as well as new architectures and machines to implement them;
   - Investigate the possibility and perspectives of using biological mechanisms to solve problems;
   - Create languages and methods to develop programs in machines that implement non-conventional computing models.

4. Participative and universal access to knowledge for the Brazilian citizen
   - Design and development of new hardware and communications infrastructure;
   - Experimentation with human-centered content, and content modeling, taking into account social dynamics and socially aware systems;
   - Creation of back-office systems – the internal infrastructure needed to provide services to citizens, which can include long-term processes, involving several entities and thus issues of interoperability;
   - Creation of the necessary infrastructure for allowing the citizen to interact with the processes conducted in the back-office;
   - Development of supple mechanisms and structures for retrieval and storage of the content continuously generated by the user communities;

- Design and implementation of flexible and extensible ontological structures, to allow interoperability across knowledge domains and interactions among people of different vocabularies and cultural practices;
- Creation of e-learning platforms to allow efficient integration of communication tools to be used in electronic learning;
- Definition of means to ensure the appropriate administration of copyrights and of intellectual property in general, so as to allow a wide variety of experiments in knowledge production, administration and use; and
- Design and construction of new devices to support universal accessibility – e.g., helping physically handicapped users to fully interact with software and hardware systems.

5. Technological development of quality: dependable, scalable and ubiquitous systems.
   - Development and evaluation of models and modeling tools for software systems that rely on a solid theoretical basis;
   - Development and adaptation of technologies and all kinds of tools to support implementation and evaluation of software that is dependable by construction;
   - Development of tools to support the process of software implementation and evolution;
   - Specification and analysis of new algorithms and techniques for data and system security, including cryptography and secure communication protocols; and
   - Construction of mechanisms and tools to support fault tolerance, permanent availability and scalability;
   - Considering the need for ubiquity in systems design and development, including distinct work environments and varying requirements.