Center for Industrial Software Development (InduSoft)

A PRIDCO Center of Excellence in
Communications and Information Technologies (C&IT)

A proposal submitted to PRIDCO under the Centers for Excellence Initiative
Focus Areas: A1, A2, A3, A4, A5 and A6

by the

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Executive Summary

This proposal requests the initial round of funding necessary to create InduSoft: a Center of Excellence in Industrial Software Development at the University of Puerto Rico at Mayagüez (UPRM). The center will be organized around six research and development (R&D) thrusts which span all six high priority focus areas (A1-A6) requested by the PRRCA RFP. The six thrusts are: a) Heterogeneous Database Integration, b) Medical Informatics, c) Intelligent E-government Systems, d) Adaptive Grid Middleware Systems, e) Secure Wireless Networking Systems, and f) Communications Digital Signal Processing. The different projects being proposed as part of these thrusts are specifically aimed to the development of software technologies with imminent high commercialization potential.

The mission of the InduSoft Center will include: fostering the development of novel, scalable and robust software products with high local and global commercialization potential; supporting the transfer of software technologies from research laboratories into commercial production; stimulating the development of new software products supporting the needs of Puerto Rico’s commerce and industry; and stimulating the creation of new communications and information technology industries and the consequent creation of high technology well paying jobs.

The proponents envision that InduSoft will become the principal knowledge and technical expertise hub in communications and information technologies in Puerto Rico, the Caribbean and Latin America. It will concentrate on the creation of new knowledge and the development of new technology. It will also provide support to its partners (academic institutions, collaborators, industry, and government) on matters of technology transfer, commercialization, and intellectual property protection. Once established, the Center will represent a unique opportunity to further inject economical support from industries, and from federal government agencies (NSF, DOT, DOD, etc.). We expected that InduSoft will become self-sustained after three years.

The InduSoft Center will be conformed by a group of professors from the University of Puerto Rico at Mayagüez with Doctoral degrees in IT and experience in the following areas: Distributed and Heterogeneous Database Systems, Fault Tolerant Distributed Systems, Programming Languages and Systems, Computer Networks, High Performance Computing and Grid Computing, Digital Signal Processing, Human Computer Interaction, Web applications, Web services including e-government and e-commerce, and Computer Algorithms.

The budget being requested under this proposal is to initially support the faculty that will direct the different research projects being described, as well as the graduate and undergraduate students to be involved in each of the projects described. It will also support the acquisition of the appropriate computational infrastructure to enhance our current computational capabilities. We believe that this proposal will help use develop InduSoft into a leader in IT R&D in Puerto Rico, Latin America and the Caribbean.
This proposal requests the initial round of funding necessary to create InduSoft, the Center for Industrial Software Development at the University of Puerto Rico at Mayagüez (UPRM). InduSoft will be created under the Puerto Rico Research and Commercialization Alliance (PRRCA) Communications and Information Technology Centers of Excellence initiative. The center will be organized around six research and development (R&D) thrusts which together will span all six high priority focus areas (A1-A6) requested by the PRRCA RFP.

**InduSoft Mission**
The mission of the InduSoft Center will include: fostering the development of novel, scalable and robust software products with high local and global commercialization potential; supporting the transfer of software technologies from research laboratories into commercial production; stimulating the development of new software products supporting the needs of Puerto Rico’s commerce and industry; stimulating the creation of new communications and information technology industries and the consequent creation of high technology high paying jobs. The Center will be supported by contributions from its industrial and academic partners as well as from grants (e.g. SBIR/STTR) submitted by its affiliated faculty. It is expected that InduSoft will become self-sustained after the three years of PRIDCO support.

**InduSoft Vision**
It is envisioned that InduSoft will become the principal knowledge and technical expertise hub in communications and information technologies in Puerto Rico, the Caribbean and Latin America with a focus on new knowledge creation, new technology development and providing support to its partners, collaborators, industry and government on matters of technology transfer and commercialization and intellectual property protection.

**How InduSoft Supports to the Goals of the PRRCA/CITI Centers of Excellence Initiative**
The main goal of the PRRCA/CITI program is to strengthen the role of academic member institutions in the creation, management, transfer, and commercialization of knowledge in the communications and information technology (C&IT) fields. The creation of InduSoft will stimulate and support the involvement of UPR C&IT professors in activities conducting to the conversion of novel ideas from the research laboratory into commercially viable products. InduSoft will provide an unprecedented level of support to this technology transfer process so necessary for the development of a Puerto Rican economy based on knowledge creation and information.

**Administrative Organization**
InduSoft will be administered by an eight (8) member InduSoft Administrative Board (IAB) comprised of, the Director of the Center, three (3) of its six (6) Co-PI’s, three members from the industrial community and 1 member appointed by PRIDCO. The Director will preside all IAB meetings and will be responsible for leading the development of the Center and the fulfillment of its mission and vision. Under the recommendation of the IAB, the director will make all decisions concerning allocation of funds to existing and new research thrusts and projects. Initially, the PI will serve as the center’s director. This appointment will last for a year and will
be renewable upon a satisfactory performance review by the IAB. The IAB will be responsible for appointing a new director in case a vacancy occurs. Some current UPRM collaborators have already shown interest in belonging to the IAB including: Eng. Julio Cajigas (Technium Products Inc.), Dr. Ann Marie Maynard (IBM) and Dr. Wayne Johnson (Hewlett Packard).

The IAB will provide advice, information, and recommendations to the Director on the Institute's research, development, and technology transfer activities. The Board will also participate in the evaluation of past work and will meet at least once a year during the Annual InduSoft workshop.

**Annual InduSoft Workshop**
Every year during the month of May InduSoft will host the *Annual InduSoft Industrial Software Workshop*. The workshop will serve to present the results of the various efforts supported by the Center. Participants will include faculty and students conducting R&D work for the Center as well as distinguished guests from industry and government interested in supporting commercialization of InduSoft technologies.

**Research and Development Thrusts**
InduSoft will be organized into six main R&D thrusts, each of which will have a leading Co-PI and an initial group of collaborators. However, each thrust may incorporate additional collaborators in the future as such opportunities appear. The Director of the Center will proactively seek and stimulate and active collaboration and sharing of expertise among the different thrust groups. The following table outlines the six thrusts, their Co-PIs and the PRCA priority focus areas expected to be initially impacted.

<table>
<thead>
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<th>R&amp;D Thrust</th>
<th>Co-PI</th>
<th>Impacted Focus Areas</th>
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<td>Database Integration</td>
<td>Dr. Manuel Rodriguez</td>
<td>A1, A2</td>
</tr>
<tr>
<td>Medical Informatics</td>
<td>Dr. Nestor Rodriguez</td>
<td>A1, A5</td>
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<tr>
<td>Egovernment/Ecommerce</td>
<td>Dr. Pedro I. Rivera</td>
<td>A1, A2, A3, A4</td>
</tr>
<tr>
<td>Adaptive Grid Middleware</td>
<td>Dr. Wilson Rivera</td>
<td>A1, A3, A4</td>
</tr>
<tr>
<td>Secure Wireless Networks</td>
<td>Dr. Yi Qian</td>
<td>A1, A3</td>
</tr>
<tr>
<td>Communications Signal Processing</td>
<td>Dr. Domingo Rodriguez</td>
<td>A1, A3, A6</td>
</tr>
</tbody>
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**InduSoft Expertise Bank**

*InduSoft* has a bank of expertise in IT that is unparalleled by any other academic institution in Puerto Rico. An important part of the *InduSoft* mission is to make this expertise available to companies, government agencies and other business. Our faculty experts can become consultants for established and start-up companies, and help these enterprises with their plans for developing and commercializing new technologies. In addition, *InduSoft* can serve as a tested-bed and recruiting site for these companies, given them access to the best IT students in Puerto Rico. We are very confident that we will establish productive partnerships with many of the IT companies conducting business in Puerto Rico. Moreover, this expertise bank can serve as a magnet to bring new IT companies to Puerto Rico, and increase the jobs and revenue for the Island. Our IT expertise areas are as follows:

- **Web Applications**: Development of Web Services (MS .NET) and Java, E-commerce, and E-government. Development of Search Engines technology and Web-based solutions.
- **High Performance Computing**: Development of High-performance computing algorithms and software libraries for Grid and cluster computing. Development of GRID Middleware Systems and distributed processing systems for evolutionary computation,
- **Signal Processing**: Implementation of digital signal processing algorithms for communications, sensor signal processing applications, development of algorithms for signal processing embedded systems.
- **Human-computer interaction**: Development of usable medical informatics applications, development of PDA applications, usability engineering, and usability testing.

**Outreach Plan**

The Director of the Center will be responsible for implementing a threefold outreach plan consisting of: proactive contacts with industries and governments that could potentially conduct collaborative product development with InduSoft; a broadly disseminated annual workshop open to the participation of key players in industry and government as well as to the general community; and finally the installation of a state-of-the-art website providing information about how to become affiliated with the Center.

**Proposal Organization**

The remainder of the proposal is organized as follows. First, a one page description of each R&D thrust is presented together with a brief description of the thrust’s flagship projects and their potential for commercialization. Due to space limitations only one flagship project will be described per thrust. However, it is expected that each thrust will serve as a knowledge and expertise hub within its particular focus areas, and as such will be constantly generating and testing new ideas in response to the needs of its markets. Second, the proposal presents a list of facilities and equipment available at the UPRM to support the center, followed by a three year Budget and Budget Justification. Finally, the proposal includes a list of most relevant references and a list of biographical sketches for the PI and each thrust CoPI.
Thrust 1: Integration of Heterogeneous Databases over the Internet

Co-PI: Dr. Manuel Rodríguez-Martínez
Collaborator: Dr. Jaime Ramírez-Vick

**Thrust Description:** Next-generation e-business, e-government and scientific applications will require access to very large databases that are located on geographically distributed enterprises. These databases will store millions of records from daily corporate operations, e-commerce transactions, personal customer data, drug design processes, documents from Government archives, and other types of data elements. Many of these databases will be connected to the Internet, and will have heterogeneous schemas, data processing capabilities, and strict administrative policies. Our research focus is aimed at designing novel Database Middleware systems that can be used to integrate these databases, and enable the deployment of valued-added solutions to harvest the targeted data. These middleware systems will also enable the implementation of transactional switches to monitor electronic transactions, thus helping end-users to track the status of product orders, monitor drug production lines exchange of documents with governmental agencies, and run many other inquires that now require a physical visit to a business office.

**Flagship Projects and Commercialization Plan:** Our trust is currently working on three main projects: a) **BioWeb** – integration system for Biological Databases, b) **TerraScope** – integration system for Satellite Image Databases, and c) **GaiaNET** – a software framework for developing middleware systems on-top of Web Services. We shall concentrate on BioWeb, which is our flagship project. BioWeb consists of a comprehensive set of software tools designed to ease the task of deploying new specialized biological data services requiring integration of multiple autonomous bioinformatics databases. One of the biggest challenges in bioinformatics and drug discovery today is data access and integration. This issue has become a major bottleneck to R&D productivity for many biotechnology and pharmaceutical companies. The challenge exists because biological data sources are geographically distributed, complex and heterogeneous in data types and structures, and are constantly changing. With the unprecedented growth of genomic, proteomic, and other types of scientific data, the challenge now is how large volumes of data can first be retrieved from multiple databases, transformed and integrated automatically and flexibly. IDC research predicts that by 2006, $38B will be spent on IT for bioinformatics. The BioWeb software will facilitate the deployment of novel biological information services by pharmaceutical and biotechnology companies. The BioWeb Middleware system will also facilitate the proliferation of third-party information providers supporting highly specialized biological data services.

<table>
<thead>
<tr>
<th>Database Integration Milestone Description</th>
<th>Year Achieved</th>
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<tr>
<td></td>
<td>Q1</td>
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<tr>
<td>1. BioWeb v1 – Local Sources</td>
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<td>2. Debugging/Release v1</td>
<td></td>
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<td>3. BioWeb v2 – Internet Sources</td>
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<td>4. Debugging/Release v2</td>
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<td>6. Debugging/Release v3</td>
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Thrust 2: Medical Informatics Systems

Co-PI: Dr. Néstor J. Rodríguez  Collaborator: Dr. José A. Borges and Dr. Javier Arroyo

Thrust Description: This research thrust focuses on the development of scientific knowledge that can help develop usable applications to support physicians and nurses on their clinical tasks. The research relies on scientific experimentation in human-computer interaction and the principles of usability engineering. It involves activities such as task analysis of clinical settings, development of novel user interfaces for prototypes of electronic patient record systems, and interaction experiments involving target users (physicians, nurses, etc.).

Flagship Projects and Commercialization Plan: We propose to conduct research that will foster the development of a patient tracking system for the ER (emergency room). This system will provide status on each and all patients as well as the load condition of each resource used in the ER. The system will show the location of the patients in the ER and the services, treatment and procedures awaiting them. It will provide warning messages on services, treatment or procedures that are approaching or exceeding a predetermined time to be rendered. This system will improve the flow of patients in the ER while improving quality of care of the patients. In Appendix B we provide a more detail description of the proposed system.

A task analysis of the ER will be conducted to gather information on the movement of patients through the different service points, the procedures followed by the clinical personnel, the tasks performed by them. A prototype of the system will be developed based on the finding of the task analysis, the preliminary patient tracking system described in [5], and the electronic patient record system prototype described in [6,7]. The prototype will be tested at the Ramon Emeterio Betances Hospital of Mayaguez. The system will be evaluated by conducting a performance study of the ER before the system is installed and two performance studies once the system is installed. The results of the evaluation will serve to demonstrate the effectiveness and viability of the system.

Technium Inc., a Mayaguez based Puerto Rican company, has expressed its interest in implementing a commercial version of the proposed system. This company will collaborate with the researchers in the installation and technical support of the system. The technology resulting from the proposed project will be transferred to Technium according to an existing memorandum of understanding between Technium and the University of Puerto Rico at Mayaguez. Technium will contribute $10,000 in technical support for the project and plan to invest $15,000 for its commercialization.

Projected Schedule of Specific Milestones

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<tr>
<th>Medical Informatics Milestone Description</th>
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<td>Funding Year 1</td>
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<tr>
<td></td>
<td>Q1  Q2  Q3  Q4</td>
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<tr>
<td>1. Task Analysis</td>
<td></td>
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<td>2. Prototype Development</td>
<td></td>
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<td>3. System Installation</td>
<td></td>
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<td>4. ER Evaluation</td>
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<td>5. New System Evaluation</td>
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Thrust 3: Intelligent E-government/E-commerce Systems

Co-PI: Dr. Pedro I. Rivera-Vega  
Collaborator: Dr. Bienvenido Vélez

Thrust Description. Internet-based electronic information systems have an unprecedented potential to improve the responsiveness of governments and businesses to the needs of the people that they are designed to serve. These E-government and E-commerce systems are already beginning to enable governments and businesses to more effectively comply with their responsibilities. Through this technology they are able to interact with their constituents or customers more effectively by allowing higher availability of services while at the same time reducing operational costs. The mission of this thrust is to investigate and create novel applications of information technologies to help take this automation process to the next level.

Flagship Project and Commercialization Plan

Paper-equivalent Forms and User Interfaces for CFR 21-Part11 Compliance: CFR21-Part 11 is a Federal Regulation stating the criteria under which an electronic record or signature would be considered equivalent to a paper record or signature. For instance, manufactures of medical drugs and devices must periodically submit information to the FDA to demonstrate that they keep sufficient information about their manufacturing processes to trace back any production problems to the production step that caused them. Paper media provides certain fidelity and authenticity guarantees that are much harder to provide electronically. Although paper-equivalence compliance is of utmost importance to medical companies, the same problem arises in many other contexts. For instance the lack of authenticity guarantees in electronic records and signatures is one of the reasons why governments often strongly resist adoption of paperless processes.

This project intends to explore alternative technologies capable of providing real paper-like reliability and trustworthiness to computer-stored data entered by users through electronic forms. The proponents envision a software system supporting the operational flow of crucial computer stored enterprise data, while guarding against inappropriate handling and forfeiting of this type of data. Data values entered to the system will never disappear. Instead, changes will be registered by storing new versions of the data values together with corresponding secure time stamps and authentic user identifications. Initially, the effort will be focused on developing paper-equivalent electronic forms by leveraging of existing encryption and other proven data security technologies. The system prototype will work on table PC and PDA technology and will be capable of incorporating available user authentication mechanisms (e.g. electronic fingerprints). The proponents have already begun talks with McNeil Pharmaceuticals in order to use the Las Piedras industry as a testbed for the new system.

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<tr>
<th>Intelligent E-government/E-commerce Systems Milestone Description</th>
<th>Year Achieved</th>
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<td></td>
<td>Funding Year 1</td>
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<tr>
<td></td>
<td>Q1</td>
</tr>
<tr>
<td>1. Develop PEF prototype 1</td>
<td></td>
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<td>2. Patent PEF</td>
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<td>3. Integration with authentication peripherals</td>
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<td>4. Pilot deployment to industry/government</td>
<td></td>
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<td>5. Develop PEF prototype 2</td>
<td></td>
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<td>6. Documentation and dissemination</td>
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Thrust 4: Adaptive Grid Middleware Systems

Co-PI: Dr. Wilson Rivera  Collaborator: Dr. Jaime Seguel

Thrust Description. Almost every organization is sitting on top of enormous, unused computing capacity, widely distributed: Servers being used something less than 10% of the time and most PCs doing nothing for 90% of a typical day. With Grid computing, businesses can optimize computing and data resources, pool them for large capacity workloads, share them across networks, and enable collaboration. Since the dynamics of distributed systems that includes load on resources varies over time, any static provisioning of resources is not sufficient to sustain the requirements of real time applications. What is therefore required is an intelligent middleware infrastructure that can adapt to varying systemic conditions, providing acceptable levels of service while shielding users from having to manually re-provision resources. Today, grid systems are still at the early stages of providing a reliable, well performing, and automatically recoverable virtual data sharing and storage. The main goal of this thrust is to provide proof of concepts and prototypes of adaptive grid middleware targeted to e-business on demand and digital publishing.

Flagship Projects and Commercialization Plan

E-business on demand: We will be developing prototypes of a scalable and secure meta-scheduler named OPeR-A which can manage variously configured collections of clusters and smaller grids. These schedulers will evolve to better schedule jobs, considering multiple resources. They will also extend their reach to implement better quality of service, using reservations, redundancy, and history profiles of jobs and grid performance. Our grid middleware prototypes will be built on the top of the existing standard referred to as Open Grid Services Architecture (OGSA). Previous work is discussed elsewhere in Rivera et al.

Digital Publishing: This project, in collaboration with Hewlett Packard Labs at Palo Alto and Hewlett Packard-Puerto Rico, will provide a testbed for digital publishing at the University of Puerto Rico. Development problems to be addressed include imaging systems and integration technologies with an emphasis on integrating multi-functional devices into business processes and automating complex publishing workflows.

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<tr>
<th>Adaptive Grid Middleware Milestone Description</th>
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<tr>
<td></td>
<td>Funding Year 1</td>
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<tr>
<td></td>
<td>Q1</td>
</tr>
<tr>
<td>1. OPeR-A v1</td>
<td></td>
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<tr>
<td>2. Debugging/Release OPeR-A v1</td>
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<tr>
<td>3. OPeR-A v2</td>
<td></td>
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<tr>
<td>4. Debugging/Release OPeR-A v2</td>
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<tr>
<td>5. UPRM-DP System</td>
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Thrust 5: Secure Wireless Networking Technologies

Co-PI: Dr. Yi Qian  Collaborator: Dr. Isidoro Couvertier

Thrust Description. Future generation wireless packet networks will support multimedia applications with diverse quality-of-service (QoS) requirements. Because the wireless access channels are usually the bottleneck of the end-to-end communication links for next generation wireless packet networks, there is a need to develop resource management and traffic control schemes for wireless channels that provide QoS guarantees for heterogeneous traffic. The QoS control schemes also need to be simple to implement and manage. So there is a need to develop QoS control schemes for different wireless packet networks. In the wireless networking area, network security is also very important particularly because of the broadcasting nature of the radio transmissions. There are many security issues in wireless networking area. The most important ones are confidentiality, data integrity, authentication and key management issues.

Flagship Projects and Commercialization Plan: Wireless multimedia systems and the medium access control schemes will be examined at first, then several particular wireless QoS control schemes and protocols will be developed that will fit the next generation wireless networks. Wireless network security issues will also be examined in details. Frameworks and algorithms will be proposed to solve the authorization and key management, and confidentiality and integrity issues of different wireless networks for network service providers or enterprises. All the intellectual properties developed in the project will be patented. The proposed research topics in resource management and QoS control and network security areas will be applied to wireless local area networks, ad hoc mobile wireless networks, 3rd generation (3G) and 4th generation (4G) wireless networks. Simulation software and monitoring tools as well as performance evaluation methods will be used to evaluate the performance of the protocols, algorithms, and the frameworks developed. Then the new QoS control and network security protocols and algorithms will be implemented in lab environment. The tested lab software will be modified and proposed to be transferred to wireless systems and wireless service provider’s network management tools. The new technologies developed will be easily commercialized and transferred to local industries in Puerto Rico such as wireless service providers and high tech manufactures.

<table>
<thead>
<tr>
<th>Secure Wireless Networking Milestone Description</th>
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<td></td>
<td>Funding Year 1</td>
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<tr>
<td></td>
<td>Q1</td>
</tr>
<tr>
<td>1. Develop new wireless QoS schemes &amp; protocols</td>
<td></td>
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<tr>
<td>2. Develop new wireless security scheme protocols</td>
<td></td>
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<tr>
<td>3. Lab implementation wireless QoS schemes</td>
<td></td>
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<tr>
<td>4. Lab implementation wireless security schemes</td>
<td></td>
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<tr>
<td>5. Commercialization – wireless QoS</td>
<td></td>
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<tr>
<td>6. Commercialization - wireless security</td>
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Thrust 6: Advanced Communications Signal Processing Systems

Co-PI: Dr. Domingo Rodríguez  
Collaborator: Dr. Manuel Jiménez

Thrust Description: This project proposes the design and development of integrated configurable hardware/software embedded products for the automated processing of sensor-based signal data information generated in industrial and residential applications with access to wired or wireless communications networks. A unique novelty and advantage of the proposed design & development approach centers on the use of advanced digital signal processing algorithm techniques implemented on configurable, off-the-shelf, hardware processing units for the preprocessing of electronic sensor raw signal data information at the physical and link layers to be delivered in a proprietary coded signal data format to the network and higher layers of a communications network.

The coded signal data format utilized at the physical and link layers will be compatible with XML language format at the application and higher layers of a communications network to promote interoperability and spatially distributed multi-sensor data use in target applications at the internet services level. The signal data preprocessing performed at the lower layers will improve the efficiency of the data representation and information understanding at the higher inter-applications layers of a communications network. The proposed project will initially concentrate on the design and development of configurable hardware/software embedded units to be used in power line signal monitoring applications for physical systems power line security and power quality services.

Flagship Projects and Commercialization Plan: Digital signal processing algorithm prototypes are currently being developed for basic preprocessing operations on raw sensor signal data for preliminary evaluation of algorithm implementation techniques on configurable hardware processing units such as the Virtex unit from the Xilinx Corporation. Algorithm implementations are also being carried out on C6711 microprocessor unit from Texas Instruments. Expected potential commercialization of the developed embedded hardware/software products is foreseeing initially in the industrial power quality and power systems security sector where millions of dollars are lost locally and internationally each year due power line signal disturbances.

<table>
<thead>
<tr>
<th>Communications Signal Processing Milestone Description</th>
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<tr>
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<td>1. Electronic Sensors Characterizations</td>
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<td>3. Preprocessing Algorithm Development</td>
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<td>4. Configurable Hardware Prototypes</td>
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<tr>
<td>5. Web Level Software Applications</td>
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</table>
Facilities and Equipment Available at UPRM to Support InduSoft

Laboratories. The Institute for Computing and Informatics Studies (ICIS) is a new organization created at the UPRM to provide support for this and future R&D projects. ICIS is comprised primarily by four research groups: Advanced Data Management (ADMG), Parallel and Distributed Computing (PDCG), Automatic Information Processing (AIPG) and Software Engineering R&D (SEG). These four groups have laboratory space assigned amounting to 1,800 sq. ft. This space includes student desks, demonstrations areas, machine room, and a meeting area and is fully equipped with 1Gb fast Ethernet networking and a IEEE 802.11b wireless access point providing Internet service to laptops and handhelds.

Computers. The ICIS Computing Center provides over 12 Microsoft Windows 2000 workstations for graduate students working on research projects. The Amadeus Computing Center provides a pool of 50 Linux workstations for all students in the department. Amadeus is also used as an instructional laboratory to support the Computer Science and Computer Engineering courses. The CRAI Computing Center hosts over 60 Microsoft Windows 98 computers for general purpose use for all the students and faculty in the ECE Department. Software available includes: GNU C/C+++ and FORTRAN compilers, Forte for Java, Apache Web Server, TomCat, Microsoft Office XP, Microsoft SQL Server 2000, Microsoft Visual Studio .NET, Oracle 9i Enterprise Server, MATLAB, VISIO, and Macromedia FLASH. These facilities will be available to the students involved in InduSoft projects wishing to work while away from the labs. The ADM is in the process of acquiring one Dell server, 2 mobile Dell laptops and 2 Compaq Handheld IPAQs.

The Department is well connected to the UPRM campus network via a series of Cisco routers. The backbone of the campus network is made out of fiber optics, and has a T1 connection to the Internet. In addition, the campus network has a Gigabit link to the experimental University of Puerto Rico Internet 2 network initiative. The ECE Department has deployed a new wireless Ethernet network based on the IEEE 802.11b standard. This wireless network allows faculty, students, staff and visitor to connect to the ECE network from any location in the building, and surrounding areas.

The ECE Department recently acquired a 128-CPU IBM Linux Cluster, with 49GB of total memory and 1 TB of total disk space. This cluster will be available to all InduSoft projects.

Students Offices. Each graduate student conducting R&D for InduSoft will be assigned a desk and office space at one of the research group laboratories associated with ICIS. Funds from PRIDCO are being requested in this proposal to equip each student desk with a software development workstation devoted to InduSoft software development.

Administrative Offices. ICIS has a pool of three secretaries that provide assistance with travel arrangements, equipment purchases, workshop organization, publication of dissemination materials (i.e. brochures and posters), public relations, and preparation of NSF reports, among others. ICIS will be available to support this project. Initially, ICIS will share office space with InduSoft. During the first year, additional space will be allocated to accommodate InduSoft in a separate and more adequate space.
Most Relevant References


Biographical Sketches
Biographical Sketch for MANUEL RODRIGUEZ-MARTINEZ
Department of Electrical and Computer Engineering
University of Puerto Rico, Mayagüez
P.O. Box 9042
Mayagüez, PR 00681
E-mail: manuelr@acm.org

Professional Preparation
• B.S. in Mathematics (Magna Cum Laude), University of Puerto Rico, Rio Piedras, 1994
• M.S. in Computer Science, University of Maryland, College Park, 1996.
• Ph.D. in Computer Science, University of Maryland, College Park, 2001.

Professional Appointments
• 2001 - Assistant Professor, Department of Electrical and Computer Engineering, University of Puerto Rico, Mayagüez.

Publications

Synergistic Activities
1. Leader of the NetTraveler Research Project at University of Puerto Rico, Mayagüez (UPRM). This project seeks the development of a wide-area middle-tier infrastructure to allow data sources on mobile devices, such as PDAs and notebooks, to interoperate with enterprise servers and other devices with a fixed location. The goal is to provide ubiquitous access to the data sources residing in all these devices, and to allow for continuous data access regardless of movement over wide-area environments.
2. Development of the course CIIC 8015: Distributed Database Systems at the University of Puerto Rico, Mayagüez. This is an advanced graduate level course with
major emphasis on classic and state-of-the-art advances on distributed database technology.

3. Development of the course ICOM 6115: **Computer Networks and the World Wide Web**. This is a course that combines traditional networking concepts with novel Web technologies such as Web services.


5. NSF Panelist for 2002 SBIR/STTR IT proposals.

6. Founding member of the **Advanced Management Group** (ADMG) at UPRM. This is the first Database and Information Management Group formed at the Puerto Rico State University System.

**Collaborators and Other Affiliations**

1. Collaborators:
   a. **University of Puerto Rico, Mayagüez**: Jose R. Cedeño, Isidoro Couvertier, Agustin Irizarry, Efrain O’Neill, Pedro I. Rivera, J. Fernando Vega, Bienvenido Velez, and Miguel Velez

2. **University of Maryland, College Park**: Nick Roussopoulos

2. Graduate Advisors: Nick Roussopoulos (University of Maryland, College Park)
Biographical Sketch

Nestor J. Rodriguez

EDUCATION:  
BSEE, University of Puerto Rico, 1978  
MSEE, Ohio State University, 1981  
Ph.D., University of Wisconsin-Madison, 1988

PROFESSIONAL EXPERIENCE:  
1996 – present  Professor, University of Puerto Rico  
1991 – 1996  Associate Professor, University of Puerto Rico  
1988 – 1991  Assistant Professor, University of Puerto Rico

ACADEMIC INTERESTS:  
Human computer interaction, usability engineering, computer architecture

RESEARCH INTERESTS:  
My main research interests are in the areas of human computer interaction, medical informatics and usability engineering. My current work focus on the development of user interfaces for electronic patient record systems and studies of physicians and nurses interacting with these systems.

FUNDED PROPOSALS:  


MEMBERSHIP IN PROFESSIONAL ASSOCIATIONS:
Institute of Electrical and Electronics Engineers, (IEEE), Member
Association of Computer Machinery (ACM), Member

PUBLICATIONS:
Biographical Sketch for BIENVENIDO VELEZ-RIVERA
Department of Electrical and Computer Engineering
University of Puerto Rico, Mayagüez
P.O. Box 9050 Mayagüez, PR 00681
bvelez@acm.org

Professional Preparation
• B.S. in Computer Science (Distinction in all Subjects), Cornell, 1986
• M.S. in Computer Science, University of California, Berkeley, 1988.
• Ph.D. in Computer Science, Massachusetts Institute of Technology, 1999.

Professional Appointments
• 1989 - 1993 Instructor, Department of Mathematics and Computer Science, University of Puerto Rico, Rio Piedras.
• 1999 - Assistant Professor, Department of Electrical and Computer Engineering, University of Puerto Rico, Mayagüez.

Publications

Synergistic Activities
7. Participant of the NASA Earth Science Information Partnership (ESIP) for Global Land Cover Products. This project seeks to create innovative data products and computer technologies for Earth Science applications.

Collaborators and Other Affiliations
3. Collaborators:
4. Graduate Advisors: David K. Gifford, David Karger, Barbara Liskov (MIT)
5. Professional organizations: ACM, SIGPLAN, SIGMOD, SIGIR, IEEE-CS (RUM Faculty Advisor), IASTED.
Biographical Sketch for Pedro I. Rivera-Vega
Department of Electrical and Computer Engineering
University of Puerto Rico, Mayagüez
P.O. Box 9141
Mayagüez, PR 00681
pirvos@ece.uprm.edu

Professional Preparation

• Ph.D., Computer Science, University of Florida, 1990
• M.S., Applied Mathematics, University of Puerto Rico, 1980
• B.S., Mathematics, University of Puerto Rico, 1977

Professional Appointments

• 08/01-Present  Professor, Electrical and Computer Engineering, University of Puerto Rico, Mayaguez, PR
• 08/00-07/01     Professor, Department of Mathematics and Computer Science, UPR, Rio Piedras, PR

Publications


Synergistic Activities

• Member of the ACM and IEEE organizations
• Reviewer for articles submitted to:
  o 30th Hawaii International Conference on System Sciences (1996)
  o Parallel Processing Letters (1998)
• Reviewer for the following grant programs:
  o NSF – SBIR : review panelist during 2002

Collaborators and Other Affiliations

6. Collaborators:
   a. University of Puerto Rico, Río Piedras: Heeralal Janwa
7. Graduate Advisors: Shamkant B. Navathe (Georgia Tech) and Ravi Varadarajan
BIOGRAPHICAL SKETCH

Wilson Rivera

PROFESSIONAL PREPARATION

<table>
<thead>
<tr>
<th>Degree</th>
<th>Field</th>
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<tr>
<td>Ph.D.</td>
<td>Computational Engineering</td>
<td>Mississippi State University</td>
<td>2000</td>
</tr>
<tr>
<td>M.S.</td>
<td>Computational Mathematics</td>
<td>University of Puerto Rico</td>
<td>1994</td>
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<tr>
<td>B.S.</td>
<td>Mathematics</td>
<td>Universidad del Valle, Colombia</td>
<td>1989</td>
</tr>
</tbody>
</table>

APPOINTMENTS

2000-Present: Assistant Professor, Electrical and Computer Engineering Department, University of Puerto Rico, Mayaguez Campus.


1994-1996: Instructor, Mathematics Department, University of Puerto Rico, Mayaguez Campus.

PUBLICATIONS


SYNERGISTIC ACTIVITIES

1. Director of the Parallel and Distributed Computing Laboratory at UPRM.
4. Chair of the UPRM Workshop on Parallel and Distributed Computing to be held in November 10-11, 2003.
5. Voting member of the Gelato Strategy Council
6. List of Collaborators:
   a. Dr. Ioana Banicescu, Associate Professor of Computer Science, Mississippi State University
   b. Dr. David Kaeli, Professor Electrical and Computer Engineering, Northeastern University
   c. Dr. Jianping Zhu, Professor and Chair of Theoretical and Applied Mathematics Department, University of Akron
   d. Dr. David Deerfield, Pittsburg Supercomputing Center
   e. Dr. Fernando Colon, Professor of Computer Science, Worcester Polytechnic Institute
   f. Dr. Erik Goodman, professor of Electrical and Computer Engineering, Michigan State University
   g. Dr. Jaime Seguel, Director PhD Program in CISE, UPRM
   h. Dr. Domingo Rodriguez, Director PRECISE Project, UPRM
   i. Dr. Angel Lopez, Professor of Physics, UPRM
   j. Dr. Dorothy Bollman, Professor of Mathematics, UPRM
7. Graduate students under supervision:
   a. Mr. Jaime Yeckle, PhD
   b. Ms. Maria del Mar Alvarez, PhD
   c. Mr. Freddy Perez, MS
   d. Ms. Carmen Carvajal, MS
   e. Mr. Wilfredo Lugo, MS
8. Graduate advisors:
   a. Dr. Jianping Zhu, PhD Dissertation
   b. Dr. Pablo Tarazaga, MS Thesis
PROFESSIONAL PREPARATION

- B.S. in Mathematics, Suzhou University, Suzhou, China, 1982.
- M.S. in Mechanical Engineering, China Textile University, Shanghai, China, 1984.
- M.S. in Mathematics, Utah State University, Logan, Utah, 1991.
- Ph.D. in Electrical Engineering, Clemson University, Clemson, South Carolina, 1996.

PROFESSIONAL APPOINTMENTS

- 2001 Sr. Systems Engineer, Yotta Networks, Plano, Texas.
- 2003 - Assistant Professor, Department of Electrical and Computer Engineering, University of Puerto Rico, Mayaguez.

PUBLICATIONS


SYNERGISTIC ACTIVITIES
11. Developed new graduate level Advanced Wireless Networking, and Ad Hoc Mobile Wireless Networks courses for University of Puerto Rico at Mayagüez.

12. Reviewer for IEEE INFOCOM, DCRN, and VTC.


COLLABORATORS AND OTHER AFFILIATIONS

Collaborators
Isidoro Couvertier (University of Puerto Rico, Mayagüez), Bob Best, Hosame Abu-Amara (University of Texas at Dallas), Catherine Rosenberg (Purdue University), Miguel Labrador (University of South Florida), Rose Hu (Mississippi State University).

Graduate Advisors
John Spragins (Clemson University), David Tipper (University of Pittsburgh).

Professional Organizations
Sigma Xi, IEICE, IEEE Communications Society, Computer Society, and Vehicular Technology Society.
Name: Domingo Rodríguez

Academic Rank: Professor at the University of Puerto Rico, Mayagüez Campus


Other related experience—academic or industrial.

Jun/85 - Jul/88 Research Assistant, Center for Large Scale Computation, Grad. Center CUNY, NY.

Sep/84 - Jun/85 Lecturer, New York Inst. of Technology, Comp. Science Dept., Long Island, NY.

Jun/82 - Sep/84 Senior DPBX Systems Engineer, CONTEL – MCI, Long Island, New York.

Jun/79 - Jun/82 Communications Engineer, General Electric R &D Center, Schenectady, NY.

Grants or externally funded project active during the last five years: (FY 1998-99-- 2002-03)

GRANTS (CO-PI Participation)

“Tropical Center for Earth and Space Studies,” NASA, $5,500,000.00, July 1995 – June 2000


GRANTS (PI Participation)

“PRECISE: A Program for Research in Computing and Information Sciences and Engineering,” - Aug. 1999. Funded by CISE-NSF over a five-year period ($1,500,000.00), with 100% cost sharing.

Principal publications of last five years: (FY 1998-99 -- 2002-03)


Projected Supplementary Funding by Source

Active Grants
- NSF CISE Infrastructure – “PRECISE – A Program For Research in Computing and Information Sciences and Engineering”, $2.5M for five years of support ($500K remaining for the last year.)
- IBM Shared University Research (SUR) Grant – “CISE Terascale Facility“, $100,000 to purchase a 2TB Storage Area Network (SAN).
- NSF Digital Government Grant – “Multidisciplinary E-Government Research and Education as a Catalyst for Effective Information Technology Transfer to Regional Governments”, $750,000 for 3 years of support.
- NASA TCESS Exploratory Grant – “The TerraScope Image Retrieval System”, $14,000 to support exploratory research.
- Technium Inc. Donation in Kind- “Collaboration in Medical Informatics”, $12,000 to support exploratory research.

Grants under review
- NSG Next Generation Software System – “GaiaNET: A Peer-to-Peer Web Service Composition System for Supporting Wide-Area Scientific Database Applications”. Requested amount: $1M.
- Puerto Rico Louis Stokes Alliance for Minority Participation (PRLSAMP) – Funding for 1 undergraduate student per year per trust. Each student will get receive a $1,600 stipend, totaling 6 x $1,600 x 3 = $28,800 for the duration of the project.
- UPRM Industrial Affiliates Program (IAP) – Funding for 1 undergraduate student per year per trust. Each student will get receive a $1,920 stipend, totaling 6 x $1,920 x 3 = $34,560 for the duration of the project.

Total Active Supplementary Support: $1,376,000
Total Pending Supplementary Support: $1,561,360
Results of Prior Support for PI and CO-PI’s
Results of Prior Support for PI and CO-PI’s

Dr. Manuel Rodríguez-Martínez and Dr. Bienvenido Vélez-Rivera are participating as Co-PI’s of the NSF project entitled “Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks” (Award Number ECS-0224743), which is sponsored by the NSF/EPNES program and started on 10/1/2002. This is a multi-disciplinary project in conjunction with researchers from the Power Engineering Group at UPRM. This project seeks the development of a decentralized electric energy transmission network that is controlled by teams of computing devices called Intelligent Power Routers (IPRs). In the event of a major system failure at the central control center, the IPRs take over the power generation and transmission system, and work together to bring the system back into an operational state.

Dr. Bienvenido Vélez-Rivera, Dr. Manuel Rodríguez-Martínez, and Dr. Pedro I. Rivera-Vega are currently the PIs and Co-PIs of NSF EIA 0306791 grant: "Multidisciplinary E-Government Research and Education as a Catalyst for Effective Information Technology Transfer to Regional Governments”. This project has started during the current semester and it will last until July 2006, and has a total budget of $750,000.00. This is the first Digital Government grant award to the UPR System, and it features collaboration with the City of Mayagüez. In addition, these three professors are collaborating with the NSF ERC CenSSIS at UPRM. This collaboration consists of the development of a Web-based interface to exchange multi-spectral and hyper-spectral digital images between the various Centers associated with the ERC CenSSIS.

Dr. Domingo Rodríguez is the PI of the NSF EIA 99-77071 - PRECISE Project, from July 1999 to August 2004, and a total budget of $1,500,000.00. This project has 100% cost sharing from the University of Puerto Rico, for Computing and Information Sciences and Engineering (CISE) research infrastructure. He has concentrated on the fostering of infrastructure support of multidisciplinary research groups and in providing research assistantship support to graduate students. His research work has concentrated on design, development, and implementation of algorithms for the digital signal processing of active sensor signals.

Dr. Jaime Seguel and Dr. Wilson Rivera are the leaders of the PDC Group, whose research support comes mostly from the PRECISE Project. Under this project they have guided two (2) PhD students in Computing and Information Science and Engineering and five (5) MS students in Computer Engineering. Six (6) journal papers and (10) peer-reviewed conference papers have been published. Support also comes from the Advanced Technology Platforms Academic Grant Initiative Program of Hewlett-Packard. This project aims at exploiting the Itanium Linux platform to advance computationally intensive applications in computational engineering and information discovery, develop adaptive grid middleware, and enhance graduate course contents and education. Four (4) undergraduate students and two (2) graduate students will be supported under this project.
Appendix A. Integration of Databases over the Internet (Expanded Description)

Other Potential Commercial Projects and Prototypes:

*TerraScope*
The TerraScope Earth Science Information Management System is a system to integrate and federate heterogeneous satellite image collections stored at geographically distributed data centers. In addition, TerraScope will automate the process of finding, selecting and using adequate computational resources (e.g. computer cycles, disk storage) that might be available at cooperative sites. TerraScope is designed to support automated data ingestion, data cleansing, spatial indexing, dynamic image subsetting, parallel image processing, hypertext-based image visualization, and distributed data retrieval and query processing. We have designed TerraScope to be an open source system that is tightly coupled with the Web. TerraScope can be run as part of the Web server infrastructure available at a research site. TerraScope consists of the **Image Navigator Application**, **Search and Retrieval Engine**, **Feature Extraction Engine**, and **Parallel Data Processing and Storage Engine**. Figure 1 shows the architecture of the system, and shows a demo a of the Image Navigator.

![TerraScope Diagram](image)

*Figure 1: TerraScope Image Retrieval System*

**GaiaNET**
GaiaNET is a middleware system that will be used to integrate databases and computational resources on large-scale wide-area networks such as Internet 2. GaiaNET will provide applications with the abstractions of data services, computational services and software services that can be automatically combined by the middleware system itself to build applications that support complex scientific queries. Thus, services are composed dynamically to correlate and merge data from the providers. These services are implemented by autonomous server applications that are dispersed over a wide-area network. Services will be combined using an approach that we call *dynamic Web service composition*, where a service $S_1$ might combine its functionality with that of another service $S_2$ to provide a third service $S_3$ with new value-added features. GaiaNET is a Peer-to-Peer (P2P) system since any service can supply its functionality
on behalf of others. Moreover, peer sites exchange metadata (encoded with XML) about resources (e.g. databases, CPU time, software) that they have discovered, and this permits resources to be added or removed from the system without central control. It also removes the need for a centralized catalog that knows every aspect of the system. We will approach this problem in the context of Web services but, in contrast to today’s services with semantics hidden inside ASP or JSPs code, the emphasis will be in exposing the semantics of services via XML metadata. The issues that we will address include the semantics of service specifications, an algebra of service composition, the issues of composing heterogeneous scientific data, pipelining of data from one service to the next, and self-documentation of the resulting services and data. The ultimate goal of the project is to develop an architecture for an open source Peer-to-Peer GaiaNet where new data products and services are continuously added and becoming available.

NetTraveler

NetTraveler is a database middleware system to integrate data sources residing on PDAs, mobile laptops, embedded devices and enterprise servers. NetTraveler is designed to cope with dynamic wide-area environments where data sources go off-line, change location, have limited power capabilities, and form ad-hoc federations of sites that work together to complete a given task and then go about their business independently. Web services, XML-based profiles, and Peer-to-Peer (P2P) search protocols form the heart and soul of the novel approach being proposed here. The education plan will tackle three major areas: 1) research training and experiences for graduate and undergraduate students, 2) course development in topics related with database middleware and mobile computing, and 3) outreach to K-12 students and professionals to introduce research issues and opportunities in database middleware for mobile devices.

Assessment of Commercialization Potential

- **TerraScope/GaiaNET** – TerraScope is an end-to-end middle-tier solution that can be used by current and future missions of the NASA Earth Science Enterprise (ESE). TerraScope can be used to federate NASA Centers (e.g. Goddard), national research laboratories, universities, and private corporations. In fact, we plan to create a federation consisting of the NASA URC TCESS, partners from the NSF ERC CenSSIS and the Earth Science company Applied Coherent Technology (ACT). This federation will be a test-bed to experiment with novel visualization tools, image processing algorithms, and data processing schemes using realistic data sets on a realistic Earth Science environment. The technology can be sold to agencies, research laboratories, and universities world-wide.

- **NetTraveler** - NetTraveler could be used to establish dynamic federations (similar to workgroups) of machines on manufacturing plants, hospitals, business centers, disaster zones, combat zones, or schools. For example, police officers, firefighters and emergency personnel might have PDAs and laptop computers to keep track of their locations, current supplies, and the conditions on their working environments. During an emergency situation, these computing devices might form a content network that integrates the data from each unit to give field commanders a clear picture of the situation at hand, and prepare remote supporting units such as hospitals and shelters to receive victims. The technology can be sold to emergency agencies world-wide.
Appendix B. Medical Informatics (Expanded Description)

Patient Tracking System for the Emergency Room

1. Introduction

The objective of the Patient Tracking System proposed in this project is to improve the health care services by increasing the productivity of the resources used in the process. This system is not a replacement of the traditional Electronic Medical Record (EMR), but a complimentary system that can provide valuable information that is not envisioned in present systems. The system is based on patient flow and load behavior, and on information about resources capacity and availability. It strives to improve the flow of patients moving through the system and the assignment of resources to serve them.

2. The Patient Tracking System

The concept of the Patient Tracking System was originally conceived for the Emergency Room (ER) of hospitals. Many ERs are affected by the lack of information available on just why patients came, on what was done for them, and on the relative efficiency of the health care process. The objective of the Patient Tracking System will be to keep track and supervise all the processes in the ER. The system will be aware of the status of each patient from the moment they arrive at the ER until they are discharged or admitted to the hospital. This awareness includes: the physical location of the patient, each pending service and waiting time, and all other information regarding the patient's condition, treatment, and resources required.

The system will be able to provide the status of each and all patients as well as the load demand on each resource used in the system. This means that the Tracking System will be able to provide information such as how many patients are waiting or being served at X-rays, laboratories, therapy, and all other services. In order to provide auto-supervision of the processes, the system will analyze performance data, benchmark existing and self-improving standards, and provide warnings when any process is not performing as desired. The Patient Tracking System will be able to provide administrators with all kind of statistics about the performance of the system and the patients being served by the system. This will allow a better coordination, planning, and scheduling of the resources that could result in substantial productivity improvements.

3. Preliminary Prototype

Since the ER of many hospitals frequently operate at maximum capacity, the incorporation of a tracking system must not become a hindrance or obstacle for the personnel involved. Thus, the user interface is critical for the design of an acceptable system and usability engineering evaluations must be conducted at all stages of the development process. The interface must present a clear and understandable layout, and the desired information should be retrieved and managed with ease.

The graphical user interface of the preliminary prototype for the Patient Tracking System was designed in such a way that it could provide a visual indication of the quality of the different services provided to the patients of the ER. The main window of the interface of the prototype (Figure 1) is based on the two aspects that significantly affect the patients status in the ER: their physical location and the services they are receiving and/or waiting for. The main window basically consists of a list of patients and a group of icons associated to each patient. The icons indicate the area where the patient is located and the services that he/she is waiting for.

The icons that indicate the services that the patients are waiting for provide a visual indication on whether the specific services are within the pre-established quality parameters. In general, a quality parameter establishes the time limit within which a specific service should be completed. When a service approaches the lowest acceptable quality level (the maximum time prescribed for completion), the corresponding icon changes to a yellow color. When a service falls below the acceptable minimum level (exceeds the maximum time prescribed for completion) the corresponding icon changes to a red color. The yellow and red icons alert the health professional to take corrective action to improve the quality of the services provided to the patients. The collective reading of these warnings provides and indication on the quality of the service provided by the different departments and the ER as a whole.
In addition to providing a visual measure on the quality of service provided to the patients, the interface can also provide detailed information about the different services the patient is waiting for or provide access to the complete patient record. By clicking on one of the icons, a window will open that provides more detailed information about the specific service. For example, the icon representing a service of a clinical laboratory will open a window indicating the status of the specific analysis requested for the patient (see figure 1). By clicking on the patient’s name, the system can provide access to the complete patient record.

![Figure 1. Main window of the Patient Tracking System user interface.](image)

In order for the Patient Tracking System to be efficient and successful, all patient interventions and movements must be registered into the system. Thus we propose to monitor the flow of patients by strategically placing sensors in the different areas of the ER that provide services to the patients. Bar code labels ans scanners as well as PDAs will be used to register patients in the different areas and identify services administered. An electronic record will be created for each patient that is admitted to the ER as part of the intervention by the triage nurse and the physician. Thus, once the electronic record has been created, most of the information related to the status of the patients will be automatically entered to the system. Only in a few cases will this information be entered by a health professional (i.e. nurse or physician). This can be accomplished by selecting the appropriate icon from a group of icons placed at the right side of the interface (Figure 1).

The preliminary prototype demonstrated the viability of the system and was used to conduct preliminary studies on local hospitals to evaluate its operation, acceptability, and potential commercialization of the product. The complete version of the Patient Tracking System must include and integrate the following key components: 1) an admission system to record the triage's intervention 2) an electronic record system for the physician's intervention 3) a communication system to manage data from the sensors, bar code readers, and ancillary department interventions 4) the software that manages, integrates and displays all the information and the interaction with the users. The design and development process of the product will require various activities, including task analysis, application development, usability evaluations, system deployment and integration, and system evaluation.
Appendix C. Intelligent E-government/E-commerce Systems (Expanded Description)

Other Potential Commercial Projects and Prototypes:

**Electronic Government Systems:** A multidisciplinary group including researchers from the University of Puerto Rico-Mayaguez (UPRM) and personnel from the municipal government of the City of Mayagüez proposes to combine their talents in Public Administration, Computer Science, Engineering and Social Sciences, in order to: identify significant barriers to the effective transfer of information technology into government practices and their adoption by the public, engineer novel solutions to help overcome these barriers, and test their solutions in a real municipal governmental environment. The team from the city of Mayagüez will include experts on Information Systems, Engineering and Public Administration. The technical side of the UPRM group encompasses faculty members with expertise in Distributed Data Base Systems, Information Retrieval, and High Performance Computing. From the Social Sciences the UPRM group includes faculty members with expertise in Political Sciences and Psychology. This work will be supported by Grant NSF-EIA-0306791 until August of 2006.

**InforadarML Project (2000):** This project consists of extending the Inforadar system with the capability to process and serve multilingual document collections. The UPRM has proven to be an ideal environment for this type of experimentation due to the inherently multilingual life style in Puerto Rico. The project is currently focused on exploring alternative document ranking algorithms as well as on developing performance metrics suitable to assess the effectiveness of multi-lingual IR systems. The design of InforadarML is uniquely focused on users with equal proficiency in multiple languages. Most previous research efforts in multilingual information retrieval systems centered around the problem of query translation.

**TU-PIS Project (2001):** The TU-PIS pretends to develop a ubiquitous and interactive passenger information system for the brand new 16 Km subway system currently being deployed in the San Juan metropolitan area. The PIS integrates various state-of-the art information technologies including: world wide web, virtual reality, real time computing and interactive movie authoring environments. Completely developed in Macromedia Flash from scratch, TU-PIS offers an aerial vivid view of the real-time locations of the mass transit vehicles transiting in the 500 meters periphery of each train station. Flash allows the PI and his students to assess the suitability of interactive movie authoring environments for developing new types of applications.
Appendix D. Adaptive Grid Middleware Systems (Expanded Description)

Design and Implementation of High-Performance Schedulers

Experience with two decades of parallel and distributed computing applications indicates that scheduling is fundamental to performance. High performance schedulers employ predictive models to evaluate the performance of the application on the underlying system and use this information to determine an assignment of tasks, communication, and data to resources with the goal of leveraging the performance potential of the target platform. Because of the nature of the new generation of computational resources, high performance scheduling is particularly challenging:

1. Since deliverable performance of system resources and application resource requirements vary over time, predictions of execution performance must also vary over time;
2. Since computational infrastructure is dynamic, applications performance may vary dramatically over time and per resource;
3. Performance prediction models must be able to target distinct execution environments and adapt to the deliverable performance of the resources. Consequently, the challenge is to develop scheduling models capable of using dynamic information and dealing with adaptation, portability, efficiency, scalability, and multi-scheduling. The proposed research and development aims to address these problems through the development of algorithms and software tools for high performance computing scheduling.

The specific objectives of the research are listed as follows:

1. Design and implement efficient high-performance scheduling algorithms to deal with the dynamicity of the resources and the adaptability of the applications. The resulting algorithms and scheduling strategies will be incorporated into a flexible framework, which will provide adaptive functionality. The framework will be used as proof-of-concept demonstration so that the research findings can be integrated into state-of-the-art application level schedulers.
2. Integrate and apply the research results to the resolution of large computational problems of significant importance to society. The research results will be tested and validated through large-scale applications including e-business and digital publishing. Software prototypes will be delivered.

The criteria to perform scheduling vary according to the performance goals. System schedulers promote the performance of the system over the performance of individual applications. Job schedulers and resource schedulers, for example, optimize the number of jobs executed by the system and the resource utilization of the system, respectively. On the other hand, application schedulers (high-performance schedulers) promote the performance of individual applications by optimizing application-centric cost measures. It is unrealistic to expect system schedulers to optimize application performance. This proposal focuses on the development of high performance schedulers.

The high performance scheduling problem consists of the following steps: Selection of a set of resources on which to schedule the application (resource allocation); assign application tasks to compute resources (partitioning); distribute data and computation (data placement); order tasks on computer resources (computation scheduling); and finally order communication between tasks (communication scheduling). High performance schedulers are software systems that use scheduling models to predict performance, determine application schedules based on these models, and take action to implement the resulting schedule. A scheduling model consists of an application model, which abstracts the set of programs to be scheduled; a performance model, which abstracts the behavior of the application; and a scheduling policy, a set of rules for scheduling. We classify the research work to be undertaken in four areas: Application model, performance model, scheduling policy, and scheduler framework. Thus, the key challenges of this research and the approach taken by our methodology are as follow.

Application Model

Since deliverable performance of system resources and application resource requirements vary over time, predictions of execution performance must also vary over time. Consequently, application performance may vary dramatically over time and per resource. This phenomenon is captured in our approach by a flexible and dynamic application model. The proposed application model, referred to as the ARP Model, is built up three main profiles:

1. Application Profile: Specifies the application requirements that must be met by the target resources. An initial user-defined set of requirements is provided and then changed dynamically as the application execution evolves.
2. Resources Profile: Specifies dynamically a ranking of resources according the applications requirements.
3. Performance Profile: uses application intrinsic metrics to monitor application performance activities

Ideally the scheduler should handle any application by automatically parsing the ARP Specification file and thereby understanding the application requirements. Our research in this area will yield a scheme for producing and parsing the specification profiles and algorithms to change dynamically the ARP model based on a variety of circumstances such as performance degradation, performance contract violations, cancellation and/or suspension of application submissions, and failure of resource or network connections. The updating of the ARP model will be implemented through dynamic information provided by a monitoring system such as the Network Weather Service (NWS) and automatic configuration of scheduling policies. The NWS is a distributed monitoring system designed to track current resource and network conditions. The monitoring system will provide measures of CPU and memory utilization, bandwidth, and latency. An interface for translating the information provided by the monitor system to the ARP model will be also implemented.

Performance Model
Performance models must be sufficiently complex to represent the phenomena that impact performance but tractable enough to permit analysis and verification. In addition, performance models must be able to target different execution environments and adapt to the deliverable performance of the resources. Consequently, our research will produce performance models composed from constituent components that reflect certain specific performance activities such as execution time and memory usage. Our approach is to generate such model components using performance information represented by dynamic parameters combined with compiler analysis of the application source code. For example, a memory usage performance model may be easily generated using applications compiler analysis and dynamic information provided by the monitoring system. The research will produce performance models based on execution time and effectiveness. The effectiveness model is particularly interesting since provides a representation of maximum potential of a set of resources to deliver cost effective performance involving the parameters of the application.

Scheduling Policy
The current efforts in developing high performance schedulers utilize a number of scheduling policies. Our approach is a scheduling policy generator that allows automatic configuration of a number of scheduling behaviors.

Scheduler Framework
The scheduling mechanisms should adapt to a variety of applications and environments. Consequently, we need a highly modular framework that can be easily instantiated for specific applications. Our approach is a Grid-aware application model, which includes self-adapting functionality. Figure 1 describes the proposed decentralized and adaptive framework.

![Figure 1: High-Performance Scheduler Framework](image-url)