VeriLab

THE VERIZON MASS MARKET BROADBAND SERVICES RESEARCH CENTER

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EXECUTIVE SUMMARY

The Internet and the World Wide Web have empowered us with access to very large amounts of data, information services, multimedia applications, and other types of technologies that have changed the way we perceive the World and how we fit on it. Applications such as electronic mail, World Wide Web, network meeting, and video conferencing are beginning to break the distance barrier, bringing people together to work in multi-disciplinary teams, making geographical separation less of a problem. Most of the current Research and Development (R&D) efforts have been oriented towards the development of Internet-based applications for large institutions, such as universities, government agencies and large businesses. Typically, these institutions can afford to deploy expensive, high-speed, state-of-the-art network technologies and their highly-qualified supporting personnel. Considerably less R&D effort has been allocated to address the needs of small businesses, K-12 schools, and the homes of common citizens.

We propose the establishment of the **Verizon Mass Market Broadband Services Research Center** (*VeriLab*) at the University of Puerto Rico, Mayaguez. The mission of this center will be to develop next-generation Internet-based applications and services for traditionally overlooked, but nonetheless massive markets. Examples of such markets include: a) professional (e.g. medical, legal) services, b) small and home businesses, c) K-12 educational institutions, and d) family homes. We argue that such markets represent a profitable business opportunity that has not been exploited to its full potential by the relevant Internet Service Providers (e.g. Verizon), and third-party developers.

The mission of the VeriLab is to become the primary research and development center in Puerto Rico and the Caribbean dedicated to the exploration of new and exciting applications and services exploiting to their maximum capacity the potential for human interconnectivity and information sharing made possible by state-of-the-art networking technologies. In particular, the mission of the center will focus on the application of those technologies to the improvement of the lives of ordinary citizens.

To fulfill its mission, VeriLab will serve the following roles:

- ? R&D Center for Mass Market Broadband Services and Applications.
- ? Educational Laboratory for advanced courses in Networking and Distributed Systems.
- ? Training Center for Networking Systems Professionals.
- ? Technology Awareness Center for K-12 students and the community at large.

The Verizon's VeriLab at UPRM has enormous potential to help bridge the existing gap between the "have" and the "have-not's" of Internet access and technology in our society. Moreover, VeriLab will become an incubator of innovative ideas, products, and services with the potential to improve the quality of life for all the members of our society.

Background

The University of Puerto Rico at Mayagüez (UPRM) was founded in 1911 and is the only College of Engineering within the Puerto Rico State University System. UPRM offers six Engineering programs. At present 4,527 students from all over Puerto Rico are enrolled in these six Engineering programs. Female students account for 36% of our Engineering students while males account for 64%. Females outnumber males in two Engineering disciplines (Chemical and Industrial Engineering). Over 99% of UPRM students are Hispanics and therefore, minority students. UPRM is the 11th largest Engineering school in the nation in terms of graduating engineers and the largest in the nation in terms of graduating minority engineers. There is no other school with a larger number of women and Hispanic US citizens enrolled in Engineering. In fact, UPRM accounts for almost twenty five percent (25%) of the Hispanic engineers joining the US workforce each year. It is thus easy to see that this proposal will have an enormous impact on many individuals from underrepresented groups.

The Electrical and Computer Engineering Department (ECE) of the University of Puerto Rico – Mayagüez is home to over 1400 undergraduate students, 200 graduate students, and 45 tenured/tenure track faculty members. Of these 45 faculty members, 35 (77%) hold a PhD degree. The department offers two (2) different undergraduate bachelors in sciences degrees: one in Electrical Engineering (BSEE) and another in Computer Engineering (BSCpE), and three (3) graduate degrees including two (2) Masters degrees and the Ph.D. in Computer and Information Science and Engineering.

The BSEE has five (5) specialization areas available to the students: Communications and Signal Processing, Controls, Electronics, Applied Electromagnetism and Power. Students pursuing the BSCpE degree can specialize on either Software or Hardware. Within the curricular revision we are working on several areas of specialization that are being proposed within the BSCpE. Steps have also been taken to develop a Networking option within the BSCpE.

Recognizing the importance of the Computer Science field, the department has already proposed the creation of two new undergraduate degrees: one in Computer Science and another in Software Engineering. The proposal is currently being considered by UPRM's Academic Senate.

PROJECT DESCRIPTION

1. Introduction

The Internet and the World Wide Web have empowered us with access to very large amounts of data, information services, multimedia applications and other types of technologies that have changed the way we perceive the World and how do we fit on it. Applications such as electronic mail, World Wide Web, network meeting, and video conferencing are beginning to break the distance barrier, bringing people together to work in multi-disciplinary teams, making geographical separation less of a problem. Most of the current Research and Development (R&D) efforts have been oriented towards the development of Internet-based applications for large institutions, such as universities, government agencies and large businesses. Typically, these institutions **can afford** to deploy expensive, high-speed, state-of-the-art network technologies and their highly-qualified supporting personnel. Considerably less R&D effort has been allocated to address the connectivity needs of small businesses, K-12 schools, and the homes of common citizens.

Novel broadband Internet technologies, such as DSL, hold the promise of affordable high-speed Internet access for small businesses, schools and the public at large. Broadband technology represents a new business opportunity to satisfy the Internet connectivity needs of these traditionally overlooked markets. To fully realize the potential of broadband technologies, it is necessary to develop new applications that take full advantage of the broadband bandwidth to provide users with a useful and enriching experience. It is also necessary to prepare professionals to manage and service the broadband networks that will be deployed over metropolitan areas and suburban neighborhoods. Clearly, these goals can only be met with a cooperative effort between the telecommunications industry and universities, aimed at producing next-generation broadband applications, services, and training.

We propose the establishment of the **Verizon Mass Market Broadband Services Research Center** (VeriLab) at the University of Puerto Rico, Mayagüez. The mission of this center will be to develop next-generation broadband applications and services for traditionally overlooked, but nonetheless massive markets. Examples of such markets include: a) professional service providers (e.g. medical and legal offices), b) small and home businesses, c) K-12 educational institutions, and d) family homes. We argue that such markets represent a profitable business opportunity that has not been exploited to its full potential by the relevant Broadband Internet Service Providers (e.g. Verizon), and third-party developers.

Each market has potential for the deployment of an exciting set of new services and applications, but it will be necessary to create new networking technologies to realize these services and applications. This proposal presents detailed examples of several applications targeted towards the diversity of markets previously suggested.

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1.2 Research and Development Agenda

To explore the broader technological, economical, and social implications that Mass Market Broadband technologies can have on our society, we propose to establish the **Verizon Mass Market Broadband Services Research Center** (**VeriLab**) as a state-of-the-art facility for research, development, education and training on all technologies related with Broadband Services. The VeriLab will serve as an R&D and technology transfer center serving the need of the research, academic and professional Networking communities in Puerto Rico.

The first goal of the VeriLab is to establish an infrastructure to design and implement novel broadband services, and tools that serve as the foundation for building next-generation Internet software solutions for homes and small business. These activities will be carried at the **Networking Technology Center (Net Center)**, which will be the main R&D facility within VeriLab The researchers associated with VeriLab will actively seek funds from government agencies (i.e. PRIDCO), industry, and other businesses to establish partnerships that can help shape a research agenda with direct impact on the local economy of Puerto Rico. Our goal is to carry out high-impact applied research that produces software products and services that enable novel solutions for e-Business, Digital Government, education, entertainment, and security domains, among others.

In terms of networking facilities, VeriLab's Net Center will be a state-of-the-art Gigabit networking facility (1Gbps and 10Gbps) to be used by our faculty, students, and Network Engineers for case studies, simulations, networking research, and for both undergraduate and graduate coursework. In conjunction with the NetCenter, we will develop the **Technology Assessment and Demonstration Center (Demo Center)**, featuring portable computers, a series of intelligent Internet appliances, and a high-speed Internet connection. The Demo Center will be used as a test-bed and showcase area for the broadband technology developed at VeriLab. The Net Center may be used to model for the kind of *network operations centers* that will be required to support Broadband Services used by groups of homes and small businesses located in a given city, as shown in Figure 1. We believe that the deployment and maintenance of the network

inside small businesses and homes can be another opportunity for a service that companies such as Verizon can provide.

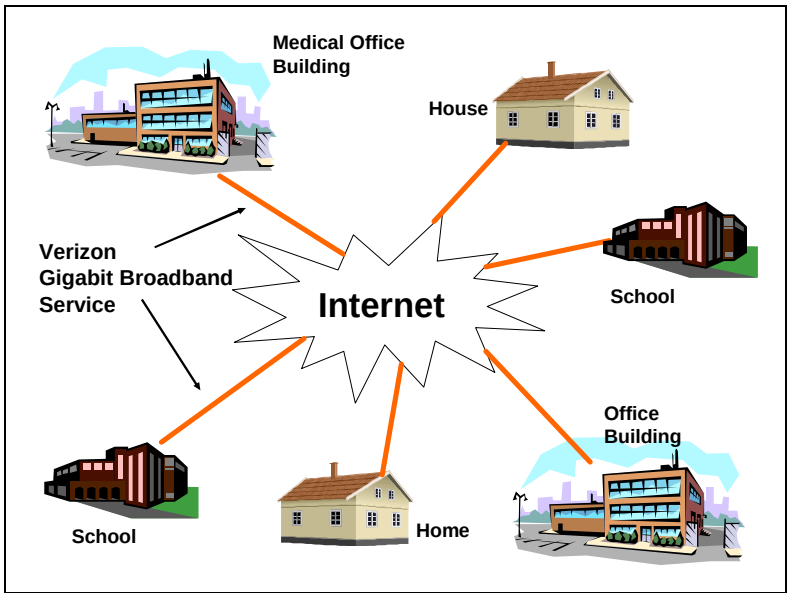

Figure 1: Several homes, schools, and small businesses connected via a Gigabit link

The VeriLab will also have a **Technology Center (Tech Center)** that will operate as a facility to disseminate knowledge by organizing seminars, mini-courses, tutorials, and publishing sample applications. These activities are designed to allow students (levels K-12 through college), teachers, network engineers, and other professionals to become aware of current networking technologies advances. Ultimately, we would like our audience to acquire proficiency in the development, deployment and management of networking systems.

Every year, we will organize a full-day conference and open house to invite industry partners, government agencies, universities, schools and the public at large to a day of presentations, demonstrations, and tours designed to expose the technology developed at the VeriLab. We plan to schedule this conference during the anual **Industrial Affiliates Week** currently held by the Electrical and Computer Engineering Department at UPRM. Other activities, such as seminars and mini-courses will be organized around the academic year and will emphasize practical activities such as a network programming courses, demonstrations of devices, and training on usage of production software. In summary, the Tech Center will serve as a training facility for faculty, students, and industry personnel that must be well-prepared to meet the technical challenges that will be encountered as network technology becomes more widespread into every facet of our daily lives.

We argue that the **Verizon Mass Market Broadband Services Research Center** will foster interdisciplinary activities involving areas such as Computer Science, Computer Engineering,

Electrical Engineering, and Social Sciences among others. Disciplines such as Networking, Database Systems and Human-Computer Interaction will certainly play a key to this project. The Broadband Services feeding the NetCenter and Demo Center will require novel network protocols to enable **self-configuration** of appliances, and to protect the security of the data in the equipment connected with the service. In the case of broadband services designed for the home, it will be necessary to have databases to keep track of data items such as movies rented, bills to be paid, family pictures, and many other items that the tenants might want to archive. Finally, novel graphical remote control interfaces will be needed to provide a universal control device to manage all appliances in a home or a small business.

The power of communication that a Broadband service can provide to a person must be thoroughly studied in the context of its psychological and societal implications. Issues such as personal isolation from others, on-line gambling, personal privacy, and "Internet addiction" must be considered and documented. For example, if a government agency taps into the network deployed at a given house, and accesses personal computer records in search for illegal activities, would that be a violation of the constitutional protections against unreasonable searches? These are the type of social issues that our project must also study in order to assess the feasibility and conditions under which it would be attractive for homeowners and small businesses to utilize the Broadband technology.

In summary, the main objectives of our VeriLab project proposal are:

1. Determine the feasibility and conditions under which it would be attractive for homeowners and small businesses to utilize state-of-the-art broadband communications technology at their homes or place of business.

2. Provide the infrastructure necessary to study and research state-of-the-art networking communications (interfacing, routing, protocols, traffic, VoIP, etc.) at both undergraduate and graduate levels. This infrastructure will also be available to the industry for case-studies and training purposes.

3. Develop novel network applications that leverage on broadband technologies to provide a rich user experience. These applications will serve to help mass market the use broadband services.

4. Provide researchers with a test-bed to study the impact of broadband technology on everyday life of common citizens.

5. Train students and working professionals to produce talented and well-motivated network specialists that can meet the challenges encountered while deploying and maintaining state-of-the-art networks.

2. Next Generation Broadband Applications and Services

The fundamental issue that we plan to address through this R&D effort is the development of Broadband Applications and Services that can provide homes or small business (i.e. Autonomous Dwelling Units) with a Gigabit Broadband network connection to the Internet to feed their Dwelling Local Area Networks (DLAN). The Autonomous Dwelling Units and DLAN are discussed in another section of this proposal. Researchers in the Networking community agree that having a high-speed network connection, with no bottlenecks, would definitely encourage people to take advantage of the available bandwidth, as long as there are novel applications that interest them, and there is little effort in configuring and maintaining the network at home. Examples of these applications are:

1. **Remote Home Access and Surveillance-** Suppose that you called a plumber to fix some pipes at your home. Shortly after arrival, the plumber calls you over the cell phone because he needs access to the second floor of your house. Thanks to the DLAN, you simply let him in by remotely unlocking the front door from the desktop computer at your workplace. As a bonus feature, you can then interact with him via Internet voice and video until he finishes the job, so you can be sure the problem was fixed as you requested. This latter service can be enabled thanks to the Gigabit Broadband Service that feeds the DLAN.

   Another important service for home owners can be a home surveillance system. For example, a married couple might go out for a romantic date, leaving their 2-year old child with a babysitter. To ensure proper care, a Personal Digital Assistant (PDA) can be used to establish a link with a digital camera at their home and watch what is a happening at home. The broadband service can enable this application thanks to the high bandwidth that is available to stream the video data over the network.

2. **Distance Learning** - In the education domain, Distance Learning is a very good example of another application that could interest many people because they could take courses live from their own homes. They can use video conference applications to interact with their teachers, send school homework, and participate in study sessions with their peers. The reliability and high speed of a Gigabit Broadband Service can make Distance Learning an important service to help workers complete advanced degrees, by enabling them to design study programs around their work schedules.

3. **Home Entertainment –** Having a Gigabit broadband service can enable a user to download movies, TV shows, soap operas and other programming from the convenience on their home, and without the downside of not finding the movie they wanted at the local rental store. This service can become very convenient during times of bad weather, severe traffic conditions, or unscheduled "movie nights" when a relative or friend unexpectedly comes for a visit. A smart DVD player can contact the video server at the local video outlet, and download all the programming requested by the home tenant. The video server simply charges the proper user accounts, and bulk transfers the multi-media data over the high-speed link.

   By combining Digital Video Cameras, Network Video (NV) applications and a Gigabit Broadband Service it could be possible for common citizens to broadcast their own

content over the Web. Some user might simply want to show others their memorabilia, such as images from a vacation, or a video of a birthday. Other citizens might choose to broadcast their own "talk shows" about diverse topics such as politics, religion, child care, crime awareness and environmental concerns. In fact, many religious organizations might be able to leverage on this technology to broadcast inspirational programs to members of their community, especially those very ill and unable to attend the regular weekly services.

4. **Business to Business (B2B) Data Exchange** – Small business can leverage on affordable Gigabit Broadband to deploy E-commerce solutions on their premises. Hardware stores, Drug Stores, Restaurants, Autoparts, Law Offices, and many other businesses can setup E-business applications to advertise or sell their services, and to acquire goods from their suppliers. In any business, reliability and security are a major concern at the moment of deploying E-business solutions. The Gigabit Broadband Service can offer a solution for fast, reliable, 24x7 on-line connectivity from and to the mission-critical servers located on the DLAN of these businesses.

5. **Remote Network Management –** Since small businesses and homes cannot afford to hire a dedicated staff of engineers to run their DLAN, it will be necessary for the Broadband provider to offer a network management service to the customers that require it. This service can be another source of revenue for the Broadband provider (e.g. Verizon). The Broadband service should provide protocols and other mechanisms to securely access the DLAN from computers located at the operations center of the Broadband provider. This will allow authorized personnel to access the faulting devices at the remote DLAN to try to repair them remotely. In addition, technicians might visit the premises of the customer to fix any problems that cannot be solved from the operations center. The idea is to make network management and maintenance similar to the maintenance of a phone service.

   The Broadband provider can also lease equipment such as routers, firewalls, network storage systems, Internet-ready phones, or other devices for use at the DLAN. This scheme is similar to those used by Cable TV providers that rent antennas, signal converters, receivers, cable modems, and other equipment required to watch their programming. The Broadband provider can make several types of packages, priced at different rates, to customize the networking needs of the customers at the Autonomous Dwelling Unit (ADU).

There are many other applications and services that will emerge as a result of added network bandwidth arriving to the homes of common citizens. It is the goal of this project to actively seek, develop and test novel applications and services that rely on broadband technology, and provide convenience and comfort to the subscribers of the broadband service.

3. The Verizon Mass Market Broadband Services Research Center

3.1 Mission

The mission of the center is to become the primary research, development and education center for Broadband and Networking Applications in Puerto Rico and the Caribbean. The center will be dedicated to the exploration of new and exciting applications and services exploiting to their maximum capacity the potential for human interconnectivity and information sharing made possible by state-of-the art networking technologies. In particular, the mission of the center will focus on the application of those technologies to the improvement of the lives of ordinary citizens.

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3.2 Administrative Structure

The VeriLab will be associated with the Department of Electrical and Computer Engineering at UPRM and will be administered by a board formed by the PI and Co-PI's. The board will appoint one of its members to the position of Administrator on a yearly basis during the month of August, beginning the year where the funding gets approved. The administrator will be responsible for the approval, coordination and execution of all purchases made with funds allocated to the center. The administrator will also represent the center in all public relations activities where such representation is requested.

Initially, the PI of this proposal will serve as administrator of the project on an interim basis until the first official administrator gets elected.

3.3 Organizational Structure

VeriLab will comprise three major physical facilities as shown in Figure 2: the Networking Technology R&D Center (Net Center), the Technology Transfer Center (Tech Center), and the Technology Assessment and Demonstration (Demo Center). These facilities will all be interconnected via high capacity broadband networking technology. Ideas born from the synergistic efforts of students, faculty and industrial affiliates are translated into prototypes at the Net Center. These prototypes are tested for performance, reliability and user acceptance at the Demo Center. Finally, once a proof of concept passes the necessary tests and proves to be a worthwhile concept, the ideas get disseminated through several channels including conferences and workshops offered at the Tech Center. We now provide more details about the role each facility will play within VeriLab.

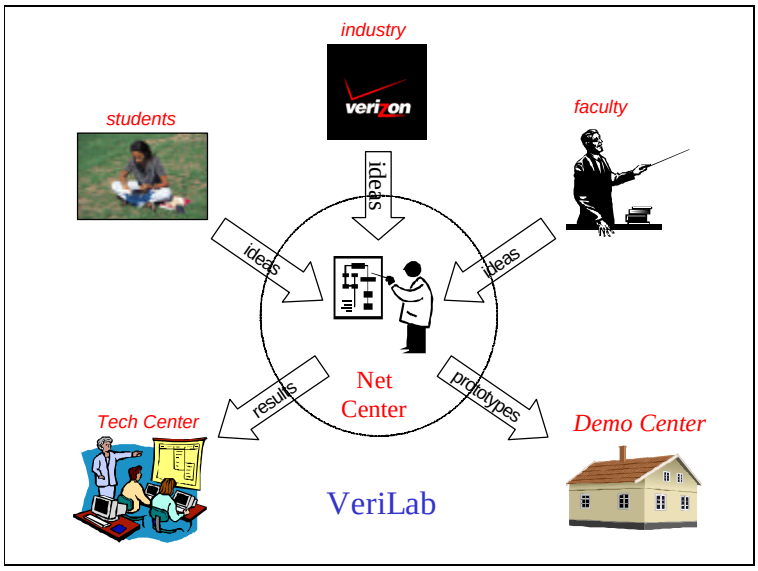

Figure 2: VeriLab Organizational Structure

3.4 The VeriLab Networking Technology R&D Center (Net Center)

The core element of VeriLab is the Networking Technology R&D Center. This center will accommodate designers and developers of the mass-market broadband applications and services invented at VeriLab. It is here that the ideas born from the synergistic efforts of students, faculty and industry personnel are translated into prototypes. The Net Center facility will include development workstations and meeting facilities for researches to share and develop ideas.

The Net Center will also house the networking equipment used to provide high-speed Internet connectivity to the Demo Center as well as the equipment implementing its internal networks. To this end, the Net Center will be equipped with the latest in networking technology. As shown in Figure 3, we propose to connect VeriLab to the Internet through Verizon's Gigabit Internet Access Service.

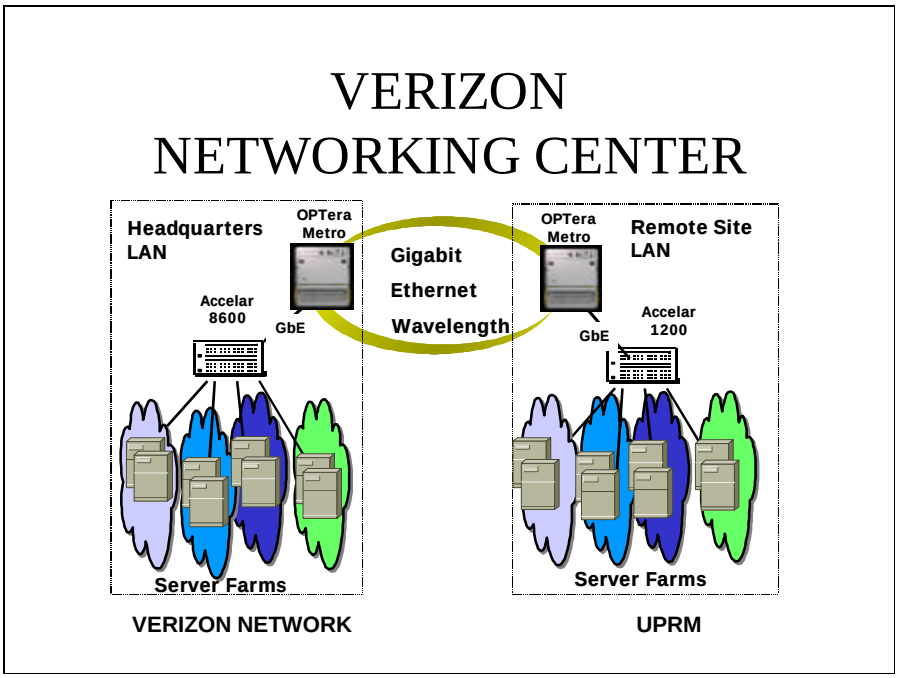

Figure 3: Verizon Network Center at UPRM

Once adequately equipped, the Net Center will become one of the first and few places in Puerto Rico where state-of-the-art networking technology and services offered by Verizon could be seen at work. So we envision the Net Center becoming an important networking technology diffusion agent in conjunction with the Tech Center.

The Net Center will also satisfy the urgent need at UPRM for a training center for engineering students wanting to specialize in network systems. While the numbers from the Government of Puerto Rico reflect that the unemployment rate among computer professionals will be –8% (negative 8 percent) nobody seems to realize the enormous importance of having properly trained Network Engineers/Experts. It does not seem obvious to anybody that the advanced distributed computer applications are as good as the network that connects them and that managing a network requires skills and knowledge currently affordable only by industry. Therefore, it is the responsibility of UPRM to prepare a talented and well-motivated workforce with an in-depth expertise in network systems.

The Net Center objectives go well in hand with the objectives of the Electrical and Computer Engineering Department at UPRM. The ECE department is currently proposing a new program in Computer Science and Software Engineering. VeriLab will serve as a catalyst to the development of a Networking specialization option within the Computer Science and Engineering degree. The new programs are currently being considered by the UPRM Academic Senate and already include a course entitled "Computer Networks and the World Wide Web".

Section 6 (Education and Outreach Impact) discusses our plans for further curricular developments.

The Network Center will not only support the curricular development of our undergraduate and graduate Computing programs, but it will serve as a vehicle for collaboration among UPRM and industry. With the bandwidth that will be available the Center could be remotely used by the industry for simulations, for downloading data to be analyzed at UPRM, for training purposes, videoconferencing, distance learning, and many other collaborative opportunities.

To provide a more concrete example of the uses of the Network Center, suppose that a Company A wants UPRM to analyze some data they have gathered in order to determine some course of action. The analysis of the data requires extensive and continuous transfer of data from within the network. This lab would greatly ease this problem regardless of whether we access the data remotely or the data is copied to our machines. Another example would be the case in which Company B wants to remotely use the Center in order to carry out some simulations. Videoconferences and Distance Learning courses could also be offered using the available bandwidth.

3.5 The VeriLab Technology Transfer Center (Tech Center)

A very important part of this proposal is having the infrastructure in-place for UPRM to fulfill its roll as facilitator in the transfer of the knowledge acquired with this project both in research and technology. This transfer of knowledge and of technology will be imparted by the researchers to the academic community at UPRM, visitors from other universities and schools, networking professionals, and the community in general. This infrastructure will also be available to the networking industry for them to train their human resources and that of their partners.

We propose the creation of the Verilab Technology Transfer Center (Tech Center). The VeriLab Technology Center will be an education and training classroom equipped with networked personal computers and projection equipment. The classroom will host all activities pertaining to education, training and technology transfer associated with VeriLab. It will also serve as a room where VeriLab visitors can meet to get briefed about VeriLab's facilities and ongoing projects before they tour the rest of the facilities.

The Tech Center will be located at the UPRM campus in a space allocated for this purpose within the Department of Electrical and Computer Engineering. The ECE Department will also be providing the computers, networking infrastructure, furniture and display equipment for the Tech Center. The Tech Center will be identified as "Verizon: VeriLab Technology Transfer Center".

The establishment of the Tech Center will spawn activities that foster the development of networking professionals within Puerto Rico and the Caribbean in general but more specifically within the western and southern parts of the island. This will positively affect the number of networking professionals and especially networking engineers with the necessary expertise to tackle any kind of situation they may encounter in their field. This in turn will contribute to meet

the expected increase of these professionals in the US during the present decade as reported by the 2001 US Bureau of Labor report.

4. Online Autonomous Dwelling Units: Our Vision of Future Small Businesses and Homes

A recent article from the IEEE Communications Magazine estimates that 60 percent of U.S. homes have a PC, either a desktop or a portable notebook purchased by the employer of one of the tenants. In fact, many homes might have more than one PC as is the case of affluent citizen, or homes where one of more kids are in high school or college. Likewise, many professional service providers (e.g. law offices), small businesses and home business have PCs to run their accounting applications, or to maintain databases with information regarding customers, patients or legal cases.

Still, PC prices are simply too high for many families to afford a computer, thus leading a social phenomenon known as the *digital divide*, where one segment of the population is being left-out of the Internet revolution. Similarly, for some small businesses (e.g. restaurants) there is little incentive in acquiring computer equipment to manage their accounting and purchasing activities. As a result, many small businesses are missing out on the vast array of opportunities to go "online" and purchase merchandise from distributors that offer substantial discounts. This fact has prompted efforts by computer vendors, government agencies and other advocacy groups to produce more affordable computing equipment that can be used by small business and low-income families to access the rich resources available on the Internet. Perhaps the best known example of such product is the WebTV console, which allows users to browse the Internet from their TV sets.

Interestingly enough, having common appliances (e.g. TV, radios, DVD players, and cash registers) that can access the Internet offers an attractive solution for citizens in all social spheres, as they can seamlessly go online to find the kind of content they prefer using the devices that best suite their needs. For example, a teenager listening to the radio might want to turn to Internet radio stations that specialize on alternative music, and offer *free downloads* of selected MP3 files from featured artists. Likewise, a pediatrician might want to use her Personal Digital Assistant (PDA) to access her online medical databases to find references regarding appropriate treatment options for a complex case she is currently handling. Even a restaurant owner could use a cash register to place *bid requests* for the purchase of meats, poultry, vegetables and other supplies from online warehouses. Clearly, having ubiquitous Internet access from anywhere in a place of business or a home presents a very attractive and convenient option for a large segment of the population.

We argue that the problem of providing affordable access to the Internet for small business, K-12 schools, and family homes should be approached as the problem of connecting an *Autonomous Dwelling Unit* (ADU) to the Internet. An Autonomous Dwelling Unit is a physical location occupied by persons to carry out a specific activity, such as living, teaching or practicing a profession. The word *autonomous* is used to emphasize that the location is owned (leased) by a person or group of persons that operate as a self-contained independent entity, rather than a branch of a larger corporation. The notion of a *Dwelling Unit* is used to encompass not only a

home, but also a location with similar dimensions that has been rented or purchased to host the facilities of a small business. In fact, it is very common to find professional offices, restaurants, day care centers, private schools, or other similar businesses that occupy a commercial space that used to be a house. Thus, our categorization is aimed at modeling this reality, and grouping all small businesses, K-12 schools, and homes into a group with similar networking need: high-speed Internet connectivity at an affordable rate.

One of the principal characteristics of an Autonomous Dwelling Unit (ADU) is a Local Area Network that connects a diverse array of Internet-ready devices such as computers, home theaters, video game consoles and photo copiers. We call this network the Dwelling Local Area Network (DLAN), and we argue that it provides the foundation to build the network infrastructure of small businesses, schools and homes. Each ADU will have its own private DLAN that is **distinct** and **unrelated** with those networks of nearby units. We can expect the DLAN for a small business to be based on wire-based Ethernet technology. However, the DLAN for a home should be based on wireless technology (e.g. IEEE 802.11b) to allow free movement of devices (e.g. Internet Phone) around the home.

The Dwelling Local Area Network (DLAN) represents a major departure from existing LAN systems, in which a team of highly-trained Network Engineers maintains the network, configuring all the networking devices and applications. Common citizens simply cannot afford to have a dedicated staff to maintain their DLAN. Likewise, it would be unreasonable to assume that every person is a "techie" capable of setting up their networks. Thus, each DLAN must be easy to setup, operate, and it must allow for remote troubleshooting from the facilities of the Broadband Internet provider (e.g. Verizon).

The Dwelling Local Area Network is also a major departure from current Dial-Up Services, as these would be too slow and inefficient to carry the traffic of many devices through a 56Kpbs phone line. Thus, Broadband Services provide the best solution to provide Internet connectivity for the homes and small businesses of the future. Unfortunately, existing solutions such as DSL and Cable modems are mainly targeted at connecting one PC at the home or office, thus requiring extra lines and more fees whenever new machines are to be connected. Although many vendors provide routers to share Broadband connections, these routers hide the devices inside these networks, which makes it difficult for users to place servers that can export the kind of content that the people might want to publish. For example, a family might want to establish a video conference with relatives living in another country so they can watch the private wedding ceremony of a relative.

The previous scenario also depicts another important departure from existing solutions: dwelling units could become important *content providers*, generating considerable amounts of traffic in the upstream direction of their Internet link. Existing Broadband services were designed on the principle of *asymmetric data delivery*, where the users download more data than what they publish. However, the ability to publish video, audio, and images, or to host Internet video games requires a link that has very high bandwidth in both the upstream and downstream directions.

In our view, the missing part of the Internet connectivity puzzle is a Broadband Service capable of delivering a Gigabit speed link to the DLAN of a dwelling unit. Such Gigabit Broadband

Service should also provide an array of communication protocols, tools and services that allow the devices to configure themselves within the DLAN. Moreover, this auto-configuration should not be limited to low-level parameters such as Internet addresses and name servers, but it should go all the way to the application level, letting users setup their video servers, E-mail applications, games, Internet radio and other applications, by having to set just a few simple parameters. Finally, the Gigabit Broadband Service should include the infrastructure to permit remote monitoring, troubleshooting, and maintenance of the DLAN by the network engineers working at operations centers for the Broadband Internet provider (e.g. Verizon). We argue that any successful Gigabit Broadband Services must provide this core set of features.

5. Research and Development Agenda

In this section we describe our R&D agenda, which we plan to channel through the Net Center at VeriLab. We plan to develop networking protocols, novel graphical interfaces for hand-held devices, algorithms for distributed data processing, mechanism to implement security mechanism, and tools for remote networking management, among other projects. We expect to develop prototype systems to validate all our ideas, thus making a stronger case for their widespread adoption. We expect to have students, and industry collaborators actively involved in all the activities mentioned below.

5.1 Connected Devices and Appliances

It is widely accepted that a big share of the end-user equipment will be used in dwelling units. Most of this equipment will neither be traditional computers nor will they necessarily have the flexibility exhibited by them or require the expertise needed to install and fix both their software and hardware. The vast majority of these connected devices will be composed of home appliances.

Not every appliance available today is equipped with the interface necessary to connect it to the Internet whether directly or through some middleware. Part of the work to be performed in this research project is to endow these network unaware appliances with the interface that will allow them to be connected to the dwelling area network. We will be testing the concept using off-the-shelf internet-ready microprocessors/microcontrollers and at the same time work towards the development of our own application specific integrated circuit (ASIC). The ASIC will be designed using the tools available in the Integrated Circuits Design Lab (ICDL) and later be implemented in the Rapid Systems Prototyping Lab (RASP). This technique is widely used since it optimizes the performance of the interface.

We will first start by implementing a minimal set of the Transport Control Protocol/Internet Protocol (TCP/IP) to test our work and then move on to the development and test of our own protocols in order to be able to compare our results with existing techniques. Choosing the correct technology at this stage is crucial to this project since its success relies heavily on minimizing the use of wires and providing the means for automatic configurations. Whatever is decided at the end must be very inexpensive and must not require user intervention.

Dr. Isidoro Couvertier will be leading this effort of finding the best way to endow devices and appliances with network capabilities and deciding on the best way to have them talk to each other and then putting everything into a chip.

5.2 Middleware for *Autonomous Dwelling Unit* Interconnectivity

We can view the *ADU* as a system with diverse data sources located in different rooms, and accessible from either the DLAN or the Internet. In this environment, *heterogeneity* in terms of hardware devices, software components, network connectivity and system configuration will be a fundamental characteristic of the data sources. In fact, these data sources will manifest themselves as desktop computers, mobile laptop computers, hand-held devices, intelligent sensors and appliances, or embedded computer system. An important issue that our project must address is the deployment, and maintenance of control software that is used to manage the devices in the *ADU*, or in a group of *ADUs*. Clearly, end-users with little expertise on Computer Science and Engineering, will feel helpless if they need to troubleshoot the software and devices in the *ADU*. In addition, we must provide an environment for user to specify actions, or request (queries) that must be satisfied by the coordinated effort of one or more devices, that might need to communicate with other sites located over the Internet.

With this proposal we seek to develop a middleware architecture that helps devices configure themselves, and obtain software fixes, and solve user queries with help from their peer devices. We envision a software framework in which control of query processing and software distribution is released to a device, which based on the requested task, decides where to return the result of its execution. Each receiving device will perform a part of the whole execution task running on its local environment and local store. Both input and output produced by each device have enough control information in order to route the next execution stage. The simplest example of such a software framework is the search for files or documents in a Peer-to-Peer (P2P) architecture. The control information specifies a well-defined and non-flooding route to turn the output.

Another equally attractive area for our propose system is that of “service composition”. Services are composed to produce larger and more valuable services some of which may be Web, cache, and aggregation services. An example would be to coordinate amongst several calendars of family members people to have a family meeting with a dinner. A composed service would read the individual calendar programs of each participant, the scheduling activities at their homes, and organize a family meeting with a dinner in which their favored food is prepared or ordered from a restaurant. The key issue is that coordination cannot be done by a single device, but rather by the coordinate effort of the devices in the *ADU*. A peer device receives a description of the “larger service” to perform, it executes its own service, adds it to the output, and forwards it to the next service provider without having to be synchronized by a single coordinating site. The larger service is obtained through the cumulative effort of each service site.

Providing the software framework for composition and unchaining the impediment of tight control is the fundamental premise of P2P architectures. In the proposed research, Dr. Manuel Rodríguez-Martínez and Dr. Pedro I. Rivera will lead an effort to develop the principles for composition, explore XML-based self-describing structures for specifying both properties of data types and Java classes, and control structures for such composition language.

5.3 Interfaces for Intelligent Devices

The proliferation of intelligent devices inside the *ADU* will substantially increase the need for uniform and user friendly interfaces. Today such user interfaces, commonly implemented via cumbersome remote controls or embedded control panels, have a rather ad-hoc nature. It is often the case that a person must learn a different language for interacting with every new home device or appliance that he/she buys. This makes seemingly simple tasks like programming your VCR hard even for technically oriented people. These interfaces lack seamless integration and are often manufacturer specific.

As shown in Figure 4, we propose a two-part approach to supporting adequate interfaces for intelligent devices:

- ? Develop programmatic interfaces (aka API's) abstracting away details about underlying communication protocols and device-specific controls
- ? Implement device-specific user interfaces for controlling intelligent devices on general purpose portable devices on top of the new programmatic interfaces.

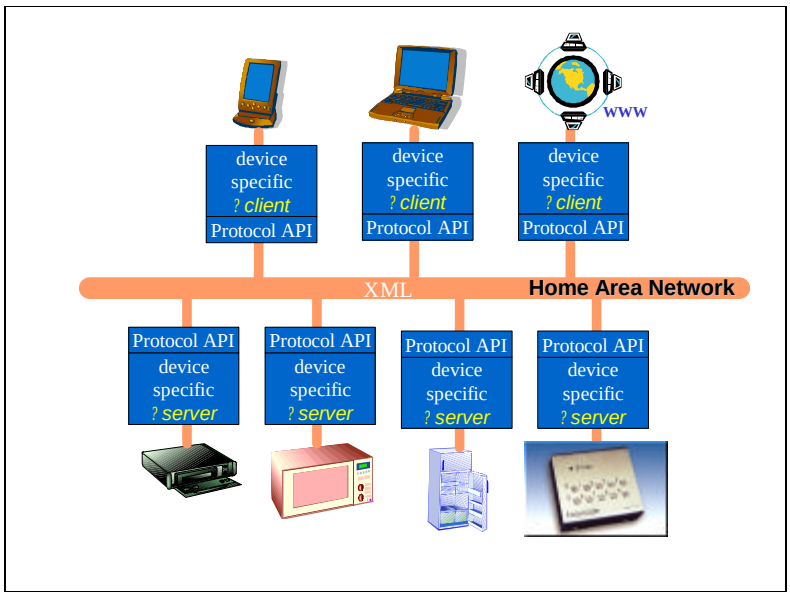

Figure 4. Interconnected Inteligent Devices inside an ADU

One of the *ADU* project objectives is ubiquitous access to dwelling units devices and appliances. Toward this goal, we plan to develop web accessible interfaces that will enable people to access and control their home information and devices remotely via the web. One of the most difficult issues that will need to be addressed is that of security. It is clear that any system capable of

providing remote access to a home must provide adequate levels or privacy and must guarantee that only authorized users are granted access.

Our initial ice-breaking project will involve the development of a PDA-based programmatic interface for home entertainment devices.

Dr. Bienvenido Vélez will leverage on his background in software development and programming language design and implementation to lead this R&D effort within the UPRM *ADU* project.

5.4 Digital Libraries

The concept of Digital Library plays an important role at home, mainly in entertainment and educational activities. The digital library, as an organized yet distributed repository of information and knowledge in many different forms and formats enables access to video, still pictures, music and sound information, computer games, software, encyclopedias, are other types of documents that are part of home daily life.

The research and development in digital library include topics such as access control, advanced information storage and search mechanisms, copyright protection, issue and expiration dates for digital objects, among others. These topics are relevant for new businesses such as video, game, and audio rental. A video rental store can handle on-line enrollment and membership renewal; catalog search with rated and controlled preview, on-line rent, download permission and expiration of video rental, in a similar way that these stores currently provide a limiting date for video cassette return. The advantage of the Digital library concept is that it may not need to limit the number of available copies of each movie, or be limited to geographic location or language, thus increasing business options depending on demand. This technology can also be applied to rental of music and other types of information.

Similar options can be offered for encyclopedias, electronic books, and other types of documents in which access can be provided and charged on a per-use basis. The concept could be extended to video, audio and videogame sale. For example in music, a customer could select individual songs or pieces, interpreters and versions, pay for each one separately and download them to his/her own personal collection. This technology may also promote access and use of more diversified sources of information for education purposes, from children's to scientific literature, newspapers, magazines, home-improvement, health and medical advice, and many others. In all cases, access to information may not need to be limited by the number of physical copies of these documents, geographic location, or language. This type of access may lead to the development of new marketing models and strategies. Similarly, home-improvement, basic health and first-aid advice may become personalized by providing access to expert system technology that analyzes each case, providing individual and personalized advice. This type of software may be searched and accessed through a unified user interface and search mechanisms. A context-sensitive help system is another important component to include in the system.

Dr. José F. Vega will lead the effort to investigate, design and implement a prototype digital library to prove the concepts previously exposed. These may include on-line information services similar to pay-per-view, or downloadable services for "anywhere anytime" use such as

movie rental. We will design the user interface, the search and information access mechanisms and user help systems. The user interface and help system design will be based on ethnographically informed studies, where user preferences and expectations will be taken into account by direct observations of the interactions that take place between users and clerks of the different types of services. This approach is oriented to make the user interface as friendly and natural as possible. This may require the use of technologies such as expert systems for the user interface and help system implementation. With this view, the digital library concept promotes opportunities for the development of new products, services and market strategies for a variety of existing and new businesses.

5.5 Dwelling Intelligent Database Management System (DIDMS)

The proper integration and operation of the different devices found at the *ADU* intelligent environment requires an efficient network connection to allow the proper communication and interchange of information among them. The architecture of this network and of the different devices required for the communication is an important component of the investigation on this proposal.

One essential component of this system has to be a computer server, responsible of coordinating the different aspects that make feasible the proper functionality of the whole system. This server will be the host of an intelligent database, which we call "Dwelling Intelligent Database" (DID), and it will be used to maintain relevant data associated with the configuration of the various devices at the *ADU*. Among other things, it will be useful to automatically reconfigure devices when events, like power failures, occur.

Among the contents of the DID, we have identified essential information that this intelligent environment requires; it includes the following:

1. **Information about the different devices**: this include the particular information that the device manufacturer provides with the particular device drivers: this allows the proper automatic configuration of the different devices
2. **Device configurations**: this contains the different configurations that each component actually has
3. **Personal preferences**: for each user of the system (of at least one particular device) we have to keep the personal preferred configuration. This will allow every user of the system to get his/her preferred configuration whenever using a particular device.
4. **Personal details**: contains information about the different users of the system, including information for security purposes and to facilitate the proper configuration or reconfiguration that best fits the user needs.

There are different issues that will need to be investigated to properly implement the DID. Some of these issues have been previously investigated in the context of the area of database technology in general. But those same issues will need further investigation in order to better fit into this particular type of database. We have identified the following important issues:

1. **Design**: we will identify design issues that are relevant to the design of this type of database.

2. **Implementation**: the implementation of the DID will have to consider important aspects of this type of system; among them: amount of memory in each device, power consumption of each device, the architecture of the network, and access statistics.
3. **Information retrieval**: the DID Management System (DIDMS) will include an attached system to implement different access methods. This will include user-friendly interfaces that allow casual users to be able to use the system without extreme effort. This component will tightly work with the security component and the deductive component described below.
4. **Security**: the DIDMS also includes a security component, which guarantees authorized access to the system, as well as supervising different operations. The system has to offer security to avoid external intruders and the execution of non-authorized operations by the users of the system.

The DIDMS will also include a deductive component. The main goal of this component is, based on the preferences that the particular user has already established with other components, or based on his/her personal details, allow the system to intelligently suggest possible configurations for other devices; i.e., configurations that better match with the current knowledge that the system has about the user.

Another important issue to be investigated is the one concerning the distribution of information. We propose an architecture in which each device contains partial information, the minimum required to properly function in agreement with current user preferences. This may include data or knowledge about other components in the system. For example, we may have the situation in which other components may automatically initiate some actions based on possible actions that have been directly required to a particular component. One of the major goals of this distribution is to achieve efficient retrieval of relevant information that a particular device may require.

In summary, our task here will focus on the issues that are relevant to investigate in order to efficiently implement the DIDMS. We will also provide an implementation for this system. Also, a middle-ware component will be required to integrate the DID to other different databases that the system may have pertaining office (or office-like) work that each user of the system may have. We also propose to work on the implementation of this intermediary component.

5.6 Social Issues

The success of this kind of project depends, among other factors, on the environmental and social impact assessment of the technology developed. Mass market broadband services will have positive impacts such as new business opportunities for small and new companies, together with their associated creation of new jobs. Accessible and affordable broadband communication services will propel the generation and strengthening of small businesses with more opportunities to be competitive in a global economy. By being developed and tested first in Puerto Rico, this project will provide a unique benchmark for the acceptance by minorities of this kind of technologies and services and a realistic test for actual participation of these communities in newer forms of businesses. It is also expected to have positive environmental impacts, since in many cases, many work issues could be handled from home by: affordable and wider use of videoconference; fast access to business applications and information; remote retrieval, renting

and purchase of videos, e-books, and games; and expanded social interaction and participation in debates and forums, al these with a corresponding reduction in commuting.

Educational impacts are also expected from these new services since more and more varied forms of educational materials, that are currently considered too bandwidth-consuming, will be more widely accessible and customizable according to the user needs. These users may include many schools and education institutions that do not currently have adequate bandwidth or access to the Internet. This “digital divide” has not promoted the massive sharing of expertise, lessons learned, knowledge and educational materials among these institutions and thus, has limited their potential for collaboration, knowledge generation and innovation, along with the potential improvement in quality education. The results of this research project will enable these forms of collaboration. Simultaneously, Verilab will become a center for the education of highly needed talented and well-motivated network specialists that can meet the challenges encountered in deploying and maintaining state-of-the-art networks.

We also recognize that associated with these newer services there may be social risks and negative social impacts which will have to be assessed, compensated and mitigated. Thus, this project can become an important scenario to observe, and study the emerging forms of interpersonal relationships and cultural behavior, as well as to develop methodologies to evaluate, propose, test and implement compensation and mitigation measures for the risks and negative social impacts.

How to keep privacy and security by avoiding external cybernetic intruders is an important issue that needs to be fully addressed for this type of technology to be accepted by our society. We need to be convinced that sufficient security can be established before we convince others of the advantages of this technology.

We also expect this project to become a multiplier of social and environmental research projects with the participation of different schools in the University of Puerto Rico and other higher education institutions. Verilab will help to increase the population awareness of the impacts of these technologies, and promote participation in the discussion of this important issue. Certainly, more issues may arise as the project progresses, and, therefore, we will be open to discover new issues to be addressed.

We believe that this type of technology and its associated services are of benefit to our society, but we must develop the educational strategies required to make it attractive and beneficial.

6. Education and Outreach Impact

This section describes the impact that the Verizon Verilab could have on the educational programs at UPRM, and how can Verizon leverage on the work force produced by these programs. We begin by briefly describing the programs currently offered by the ECE Department. We then propose a number of new courses whose creation would certainly be catalyzed by the VeriLab project. Finally we present a plan for outreach and dissemination of results.

6.1 Existing Educational Programs at UPRM

The Department of Electrical and Computer Engineering (ECE) at the UPRM currently offers two undergraduate degrees:

- B.S. in Electrical Engineering, with five (5) specialization areas: Control Systems, Power Systems, Electronics, Communications and Digital Signal Processing, and Applied Electromagnetism.

- B.S. in Computer Engineering, with two specialization areas: Hardware Systems and Software Systems.

Anticipating the demands for an even increasing number of highly-skilled computer professionals, the ECE Department is currently developing two new undergraduate programs:

- B.S. in Computer Science and Engineering, with emphasis on Networking, Database Management Systems, Operating Systems, Programming Languages, Digital Libraries and Computer Architecture.

- B.S. in Software Engineering, with emphasis on Software Engineering, Human-Computer Interaction and Usability Engineering.

These four undergraduate programs are complemented by three advanced graduate programs:

- M.S. in Computer Engineering, with two (2) specialization areas: Hardware Systems and Software Systems.

- M.S. in Electrical Engineering, with five (5) specialization areas: Control Systems, Power Systems, Electronics, Communications and Digital Signal Processing, Applied Electromagnetism.

- Ph.D. in Computer and Information Science and Engineering, with emphasis on Networking, Database Management Systems, Operating Systems, Programming Languages, Digital Libraries and Computer Architecture, Digital Signal Processing, Software Engineering, Human-Computer Interaction and Usability Engineering.

We argue that the ECE Department has the kind of academic programs, students and faculty that can make the VeriLab project a success. Moreover, Verizon can capitalize on the pool of professionals produced by these programs to further enrich its workforce (**Workforce Development: Education**) with very talented and motivated engineers that can help the company to deliver high-quality services to its costumers. The relevance of this project is very high.

New Networking Courses Supported by VeriLab

Unless the U.S. is able to keep up with the ever-growing demand for computer professionals, it will not be able to maintain its actual leadership in computer technology and computer developments. Therefore, the pursuit by young professionals of computer related careers is of utmost importance to the U.S. Unfortunately, the number of people pursuing computer related careers is not enough to satisfy the demand according to a 2001 U.S. Bureau of Labor and and 2000 ASEE report. Puerto Rico is no exception. The Commonwealth of Puerto Rico has announced that the unemployment rate for computer professionals will be –8% (negative eight percent) by 2003. In order to solve this problem it is necessary to attract more people to computer related careers and to keep them in the field once they enter school. These people must come from both the mainstream population and underrepresented minorities. According to the 2000 ASEE report, the number of people from underrepresented minorities pursuing engineering degrees is about (6%). This corresponds to half of their share of the population, which is 13%. It is worth noting at this time that the University of Puerto Rico-Mayagüez (UPRM) ranks first in the number of engineering degrees awarded to Hispanics, third in the number of engineering degrees awarded to women, and 14th in engineering undergraduate enrollment. Thus, UPRM is in an extremely good position to increase the number of computer professionals from underrepresented minorities.

This effort is needed to prevent the shortfall of American scientists and engineers that has been widely forecast for the coming decade. The percent of increase in the number of computer related occupations has been forecast to be from 60% to 100% according to the U.S. Bureau of Labor. This proposal addresses this issue.

The following is a non-exhaustive list of the networking courses and topics that we plan to offer in our academic programs. These courses cover a wide range of topics and are just an example of the potential benefits of the establishing of Verilab through this project. Our idea is to develop networking options within the programs currently offered in our Department as well as future programs. Courses at the 4000 level are junior/senior level undergraduate courses. Courses at the 6000 and above are graduate level courses.

ICOM 4XXX Computer Networks and the World Wide Web
Background and history of networking and the Internet, network architectures, the range of specializations within net-centric computing, network standards and standardization bodies, the ISO 7-layer reference model in general and its instantiation in protocols such as TCP/IP, circuit switching and packet switching; streams and datagrams; physical layer networking concepts; data link layer concepts; internetworking and routing; transport layer services; authentication protocols; digital signatures; web technologies; characteristics of web servers; role of client computers; nature of the client-server relationship; web protocols; support tools for web site creation and web management; developing Internet information servers; publishing information and applications.
Course Level: Undergraduate
Text: Computer Networks, 3rd ed, by Andrew S. Tanenbaum, Prentice Hall, 1996.

ICOM 4xxx Advanced Network Programming
Advanced TCP/IP programming. Study and implementation of traffic scheduling, buffer management, flow control and new TCP congestion control techniques. Analysis of interior and exterior routing protocols with emphasis on the implementation of quality of service technology, wireless access, mobility, multi-media and adaptive applications. The student MUST be extremely fluent in C/C++ with good knowledge of BSD kernel API and Protocol Families (PFs).
Course Level: Advanced Undergraduate

ICOM 4xxx Wireless Networks

Introduction to wireless networking protocols and applications. Treatment of the various technologies and specifications for wireless networking. Case studies of the different proposals and implementations.
Course Level: Advanced Undergraduate

ICOM 6XXX Computer Network Design

Treatment of the design issues, performance tradeoffs and implementation strategies for developing and deploying Computer Networks. Physical Level Design, Fiber Optics, Wireless Communications, Digital Phone Networks, Asynchronous Transfer Mode (ATM), Digital Cellular Networks, Satellite and Hybrid Networks, Gigabit Ethernet, Wireless Ethernet, SONET, DSL, Cable Modem, DirecPC, Bluetooth. Network Layer Design, Internet Protocol (IP), routing, switching, Multicast protocols, Mobile IP, IPv6, VoIP, ATM Traffic Shaping, ATM Cells, Connection Signaling protocols, Quality of Service (QoS), Resource Reservation Protocols (RSVP), Network Video. Transport Layer Design, Transmission Control Protocol (TCP), Flow Control, Congestion Controls, ATM Adaptation Layer. Application Layer design, network services, computer security, application programming interfaces, sockets, RPC, CORBA, RMI, multimedia applications, WWW.
Course Level: Graduate
Text: Computer Networks: A Systems Approach, 2nd ed., by Larry Peterson and Bruce Davie, Morgan Kauffman, 2000

ICOM 6XXX Special Topics in Computer Networking

This course will allow the instructor to expose students to the latest developments in networking, communications equipment, protocols, and algorithms. Students will be required to make a presentation of a topic of their interest as well as developing a project as a proof of concept. This course is developed in such a way that both our graduate students and our advanced undergraduate students will be able to enroll in it up to two (2) times. In this way we believe the students will be able to have ample time to develop their project and their research.
Course Level: Graduate
Text: To be determined by the instructor based on course scope and interests.

ICOM 6xxx Network Design and Evaluation

The purpose of this course is to give students hands-on experience building networking software. An example of a project will be the design, implementation, and evaluation of a network protocol. The design will specify the requirements, protocol specification, and success criteria. The deliverables will have to work over an actual network, and the evaluation will evaluate whether the success criteria will be met. Students will work in teams and will have a choice from a small number of projects.
Course Level: Graduate
Text: To be determined by the instructor.

ICOM 6xxx Principles of Broadband Networks

This course provides an understanding of the principles of broadband communication networks. The broadband communication networks differ from currently existing communication networks in many aspects and these issues will be dealt with in the course. Broadband networks are designed to support many different services, ranging from low bandwidth (telemetry) to high bandwidth applications (digitized video). The course will cover the underlying concepts of the broadband communication networks, and expose the research problems in BISDN (Broadband Integrated Services Digital Network). Many concepts (Asynchronous Transfer Mode, SONET, fast packet switching, high-speed network control, and traffic control) will be discussed. The current research results in broadband networks will be introduced through the student seminars in the last weeks of the course.
Course Level: Graduate
Text: To be determined by the instructor.

ICOM 6xxx Distributed Network Programming

Abstractions and implementation techniques for design of distributed systems; review of distributed algorithms, distributed server design, network programming, naming, storage systems, security, and fault tolerance.
Course Level: Graduate/Advanced Undergraduate

ICOM 6xxx Network and Computer Security
Techniques for achieving security in multi-user computer and network systems. Topics: physical security; discretionary and mandatory access control; biometrics; information-flow models of security; covert channels; models for integrity; elementary cryptography; logic of authentication; electronic cash; viruses; firewalls; electronic voting; risk assessment; secure web browsers.
Course Level: Graduate/Advanced Undergraduate

ICOM 6xxx Cryptography and Cryptanalysis
A rigorous introduction to modern cryptography. Emphasis on the fundamental cryptographic primitives of number and group theory, public-key encryption, digital signatures, pseudo-random number generation, and basic protocols and their computational complexity requirements. Algorithm design and implementation techniques.
Course Level: Graduate/Advanced Undergraduate

ICOM 6xxx Network Modeling and Performance Analysis
Modeling of the control processes in conventional and high-speed data communication networks. Develops and utilizes elementary concepts from queuing theory, algorithms, linear and nonlinear programming to study the problems of line and network protocols, distributed algorithms, quasi-static and dynamic routing, congestion control, deadlock prevention. Treats local and wide-area networks, and high-speed electronic and optical networks. Several network simulations and a term paper.
Course Level: Graduate/Advanced Undergraduate

ICOM 6xxx Network Optimization
Network models for industrial logistics systems, transportation systems, communication systems, and other applications. Emphasizes a rigorous treatment of algorithms and their efficiency -- algorithms for shortest routes, maximum flows, minimum cost flows, traffic equilibrium, and network design. Implementation issues. Semester-long project and paper.
Course Level: Graduate/Advanced Undergraduate

ICOM 6xxx Advanced Topics in Cryptography
Recent results in cryptography and interactive proofs. Lectures by instructor, invited speakers, and students. Semester-long project and paper.
Course Level: Graduate

ICOM 6xxx Advanced Network Design
Topics on the engineering and analysis of network protocols and architecture, including: architectural principles for designing heterogeneous networks; congestion control; unicast and multicast routing; wireless and mobile networking; network quality of service; router design; network security; streaming and multicast applications; naming; content distribution; and peer-to-peer networking. Readings from original research papers, industry white papers, and Internet RFCs. Semester-long project and paper.
Course Level: Graduate

6.2 Outreach and Dissemination Plan

The outreach and dissemination plan encompasses the following activities:

? An Annual VeriLab Congress

- ? Short Courses and Seminars
- ? Field Trips from Industry, Schools and the Community at Large
- ? Publication of Results on the ECE Web-based Tech Report Server and in Refereed Conferences
- ? Publication of Results on Refereed Conferences

A brief description of each activity now follows.

The Annual VeriLab Conference

The annual VeriLab conference will provide a scientific forum for the discussion of the latest VeriLab ideas and results. During the congress, every project associated with VeriLab will be required to offer a report on its present and future outlook. The Conference will present VeriLab accomplishments to the general community as well.

During the conference period VeriLab will hold several open houses where the facilities will be open to scientific visitors and the general public. One of the major goals will be attracting the best students from our campus and from the different high schools in Puerto Rico to Computing fields in general and to our academic programs in particular.

The conference will become an important and recurrent event during the IAP Week an annual meeting organized by the ECE Industrial Affiliates Program (www.ece.uprm.edu/iap) of which Verizon is one of the member companies. This will provide an additional opportunity from industrial partners from diverse disciplines to meet and share ideas with the students and faculty with VeriLab projects. The first VeriLab conference (VeriLab'2003) will be held during the month of April of 2003.

Short Courses and Seminars

VeriLab will offer short (1-2 day) courses and seminars every semester that will not only help promulgate VeriLab's achievements, but will also serve to train VeriLab personnel on latest technological developments in computing and networking equipment and tools. Thus, short courses and seminars will constitute a two-way information channel on technological advances of relevance to VeriLab research agenda. In this way we will be meeting the need of students and faculty who must keep abreast with technology as it evolves.

VeriLab's short courses and seminars will be offered by researchers and invited industry partners and will use the facilities of the VeriLab Tech Center (see section 4.6). We have already started conversations with industry and they have shown their interest and willingness to work along with us. These short courses will be approached from a practical rather than academic style. In order to meet the needs of the participants the short-courses will be offered as a one-day course. As explained above, these short-courses will be tailored for the networking professional who needs to be exposed to state-of-the-art technology. The best example of the type of short-courses that will be offered by Verilab is Network Security.

Using the equipment available at Verilab the participants of the short-courses will be able to work on a network that could easily be adapted to behave as a DSL, Fiber, T1/2/3, and other types of connections. Different load conditions could be treated and the participants will learn the different techniques available to keep their network running under different conditions. This type of exposure will allow them to better understand the significance of upgrading their networks and what to expect from them in terms of speed, collisions, quality of service and maintainability.

The development of these and other courses in networking is a subject of active discussion at the ECE Department. In particular, we envision the eventual development of an official networking systems track within the Computer Sciences and Engineering degrees within the next two years.

The proposed courses will be greatly benefited by the infrastructure that the Verilab will bring to the UPRM. We envision class projects were students develop novel applications to be tested on the VeriLab facilities. For example, graduate students can work on a semester long project designed to implement self-configuration protocols to intelligent applications. At the Net Center, Students taking the undergraduate course could develop novel multicast protocols to support delivery of live news to hand-held devices and other appliances located inside the *ADU*. Also, the Network Center can be used as a location to provide hands-on experience with the configuration and operation of networking equipment such a switches, routers, wireless access points, and fiber optics equipment.

Notice that we have designed an undergraduate networking course, and a graduate course that can be taken by both undergraduate and graduate students. The undergraduate course was designed as a means to introduce students to the Networking discipline, whereas the graduate course will allow both undergraduate and graduate students to obtain an in depth study of networking equipment, protocols, new technologies, and research trends. Other courses will be added in order to provide students with all the necessary tools to complete a Networking Option or Track within our programs of study. We believe that the above courses will provide a good head start to the development of the pool of knowledgeable students and faculty that would be required for more advanced courses yielding a well prepared professional.

Field Trips

VeriLab will coordinate regular visits from K-12 schools and community groups to fulfill its role of technology transfer agent.

Publications

We already have a technical report server in place which will greatly ease the job of keeping track of technical reports sequence numbers and the associated effort by outsiders of trying to get hold of the TRs. It is worth noting our commitment with disseminating and sharing our findings with the K-12 population. This represents part of our effort to help increase both the awareness of what the Computer Science discipline is along with the number of underrepresented groups pursuing degrees in this discipline. Among these groups we include both Hispanics and women.

Some other publications include the development of manuals, presentations in technical conferences, and online technical reports.

7. Budgetary Information

In this section, we present our proposed budget to design, implement and experiment with the activities related with this project. Table 1 depicts projected budget for the project, assuming a five year support period.

	Year 1	Year 2	Year 3	Year 4	Year 5
Senior Personnel					
PI: Dr. Isidoro Couvertier	$15,000	$15,000	$15,000	$15,000	$15,000
Co-PI # 1: Dr. Manuel Rodriguez	$15,000	$15,000	$15,000	$15,000	$15,000
Co-PI # 2: Dr. Bienvenido Velez	$15,000	$15,000	$15,000	$15,000	$15,000
Co-PI # 3: Dr. Jose F. Vega	$15,000	$15,000	$15,000	$15,000	$15,000
Co-PI # 4: Dr. Pedro I. Rivera	$15,000	$15,000	$15,000	$15,000	$15,000
Co-PI # 5: Social Sc. Faculty	$15,000	$15,000	$15,000	$15,000	$15,000
Secretary	$13,984	$13,984	$13,984	$13,984	$13,984
Graduate students	$93,600	$93,600	$93,600	$93,600	$93,600
Undergraduate students	$17,613	$17,613	$17,613	$17,613	$17,613
Fringe benefits	$12,077	$12,077	$12,077	$12,077	$12,077
Travel	$2,000	$2,000	$2,000	$2,000	$2,000
Supplies and Other Materials	$8,050	$7,300	$7,300	$7,300	$7,300
Consultant Fees	$4,000	$4,000	$4,000	$4,000	$4,000
Indirect costs	$72,089	$71,723	$71,723	$71,723	$71,723
Tuition (other)	$12,155	$12,155	$12,155	$12,155	$12,155
Equipment	$278,000	$4,200	$3,200	$3,200	$2,000
TOTAL Verizon Investment	**$603,568**	**$328,652**	**$327,652**	**$327,652**	**$326,452**
Total UPRM Cost Sharing Level	**$115,339**	**$115,339**	**$115,339**	**$115,339**	**$115,339**

TOTAL Verizon 5yrs		**$1,913,977**
TOTAL UPRM 5yrs		**$576,696**

Budget Justification

Senior Personnel: Principal Investigator (PI), Co-PI´S, Faculty and Other Senior Associates

This is the cost associated with having the researchers working on the project during the summer period. A flat rate is used for each researcher fees.

Other Personnel:

Graduate students

Graduate students will be paid $1,330 per month for 12 months.

Secretarial

The cost of a full time Administrative Assistant per year will be $13,894.

Fringe Benefits:

This is the cost incurred in paying benefits such as workers insurance, and health plan to the faculty, staff and hourly-worker undergraduate students.

Cost = (Senior Personnel Cost) * 0.092 + (Administrative Assistant Cost) * 0.252 + (Undergraduates Cost) * 0.0155

Permanent Equipment

This is computer equipment, furniture, appliances and other devices that will used to realize the VeriLab Net Center.

	Year 1	Year 2	Year 3	Year 4	Year 5
Home Furniture	$ 6,000				
Home Appliances	$ 5,000				
Home Electronics	$ 3,000	$ 3,000	$ 2,000	$ 2,000	$ 2,000
Desktop Computers	$ 20,000	$ -	$ -	$ -	$ -
ePC's	$ 3,600	$ -	$ -	$ -	$ -
PDAs	$ 9,000	$ 1,200	$ 1,200	$ 1,200	$ -
Server System	$ 5,000	$ -	$ -	$ -	$ -
20" Touch Screen Displays	$ 6,400	$ -	$ -	$ -	$ -
42" Plasma displays	$ 20,000	$ -	$ -	$ -	$ -
Networking Equipment	$200,000				
TOTAL	**$278,000**	**$ 4,200**	**$ 3,200**	**$ 3,200**	**$ 2,000**

TOTAL	**$290,600**

Computer Equipment

ePCs, PDAs, servers, desktops, touch-screens, plasma displays

Computer Communications Equipment

Giga-Routers, Giga-Hubs, Giga-Boards, Wireless Access Points and boards

Refer to Appendix A for sample quotes

Other Equipment

Home furniture, appliances, electronics

Travel Expenses

Domestic Travel

Cost of researchers traveling within Puerto Rico and the United States.

Supplies and Other Materials

	Year 1	Year 2	Year 3	Year 4	Year 5
Internet connection	$ 7,050	$ 6,300	$ 6,300	$ 6,300	$ 6,300
Office Supplies	$ 500	$ 500	$ 500	$ 500	$ 500
Books	$ 500	$ 500	$ 500	$ 500	$ 500
TOTAL	**$ 8,050**	**$ 7,300**	**$ 7,300**	**$ 7,300**	**$ 7,300**

TOTAL	$ 37,250

Office Materials and Supplies

Books, Software licenses, paper, ink cartridges, toner, labels, etc.

Publication Costs

Workshop costs, publication costs, etc.

High Speed Line Lease

The cost of a T1 line.

Tuition

Tuition costs = Number of graduate students * (18 credits per year * 75 per credit + 2*35 construction fees + 1012 per year for health plan)

Indirect Costs

Indirect costs at the University of Puerto Rico-Mayagüez are calculated at a 48.8% rate.

Indirect costs exclude: equipment, assistantships, and participant support costs.

Indirect Costs = (Total Direct Costs - Equipment - Assistantships - Participant Support Costs)*0.488

Consultant Services

This is the cost for an external (Non-UPR) professional decorator for the Demo Center.

Cost Sharing

These are the expenses incurred by UPRM due to the faculty release time granted to the researchers to work on this project during the two semesters of the academic year. Each faculty member will receive 3 credits of academic release time to work on the Verizon VeriLab project. This represents 25% of the academic load that a faculty must fulfill during the academic year. In addition, one of the Faculty members involved will be appointed project director on a yearly basis and will receive an additional 3 credit release time.

Cost Sharing = Number of faculty * (Faculty Salary * 0.25 + Fringe Benefits)

FACULTY PROFILES

Isidoro Couvertier-Reyes, Ph.D.

Associate Professor

Department of Electrical and Computer Engineering
University of Puerto Rico – Mayagüez
PO Box 9042
Mayaguez, PR 00681-9042

Ph.D, Electrical Engineering, Louisiana State University-Baton Rouge 1996
Dissertation title: Automatic Data and Computation Mapping
Advisor: Jagganathan Ramanujam

RESEARCH INTERESTS

Computer Networks, High Performance Computing, Programming Languages, and Engineering Education.

PROFESSIONAL EXPERIENCE

2001	Associate Director for Administrative Affairs, University of Puerto Rico-Mayaguez, Electrical and Computer Engineering Department, Mayaguez, Puerto Rico
2000	Associate Professor, University of Puerto Rico-Mayaguez, Electrical and Computer Engineering Department, Mayaguez, Puerto Rico
1996 – 2000	Assistant /Associate Professor, University of Puerto Rico-Mayaguez, General Engineering Department, Mayaguez, Puerto Rico
1989 – 1991	Assistant Professor, Department Head, Computer Center Director, University of Puerto Rico-Arecibo, Computer Science Department, Arecibo, Puerto Rico
1985 – 1989	Instructor, University of Puerto Rico-Aguadilla, Electronics Department, Aguadilla, Puerto Rico
1983 – 1985	Product and Design Engineer, Hewlett Packard Company, Aguadilla, Puerto Rico and Roseville, California

PUBLICATIONS

Davila, Liza M., C. A. Charles, and I. Couvertier (2002) Java's Remote Method Invocation, PRJrTech, University of Puerto Rico-Arecibo

Solá, Juan and I. Couvertier (2002) Routing Offloading on an Intelligent Network Interface Card Simulation, PRJrTech, University of Puerto Rico-Arecibo

Ayuso, Xohara, N. Rentas, R. Rodríguez-Cruz, R. Rodríguez-Colón, R. Quintero, E. Navarro, and I. Couvertier (2002) On the Capabilities of the PowerPC Architecture, PRJrTech, University of Puerto Rico-Arecibo

Alequín, J., L. Muñoz, Y. Pérez, M. Zayas-Bazán, D. Rivera, D. Báez, and I. Couvertier (2002) Transport Control Protocol/Internet Protocol (TCP/IP), PRJrTech, University of Puerto Rico-Arecibo

Santiago, R., A. Bon, M. Jiménez, and I. Couvertier (2001) Wireless Voting System, PRJrTech, Catholic University of Puerto Rico-Ponce

Couvertier I. and J. Santos (1999) The Academic Excellence Workshop: A new look to an old and reliable tool 1999 *Frontiers in Education Conference (FIE'99*

Bienvenido Vélez Rivera, Ph.D.

Assistant Professor
Department of Electrical and Computer Engineering
University of Puerto Rico – Mayagüez
PO Box 9042
Mayaguez, PR 00681-9042

EDUCATION

Massachusetts Institute of Technology
Ph.D. in Computer Science – September 1999
Minor – Finance and Statistics

University of California-Berkeley
M.S. in Computer Science – December 1988

Cornell University
B.A. in Computer Science – May 1986
With Distinction in All Subjects

EXPERIENCE

Assistant Professor
University of Puerto Rico - Mayagüez
Department of Electrical and Computer Engineering
January 2000 - presently

Assistant Professor
University of Puerto Rico – Río Piedras
Department of Mathematics and Computer Science
August 1999 – December 1999

Research Assistant
Massachusetts Institute of Technology – Laboratory for Computer Science
Programming Systems Research Group lead by Prof. David K. Gifford
June 1995 – July 1999

Teaching Assistant
Massachusetts Institute of Technology – Laboratory for Computer Science
CS 6.821 – Graduate Course on Programming Languages
Taught by Professor David K. Gifford
Fall 95

Teaching Assistant
Massachusetts Institute of Technology – Laboratory for Computer Science
CS 6.001 Structure and Interpretation of Computer Programs
Taught by Professor Gerald J. Sussman
Spring 95

Instructor of Computer Science
University Puerto Rico – Río Piedras
Department of Mathematics and Computer Science
Fall 89 - Summer 93

RESEARCH INTERESTS

Distributed and Parallel Software Systems
Distributed Multimedia Information Retrieval Systems
Software for Computer Clusters

SELECTED PUBLICATIONS

Interactive Query Hierarchy Generation Algorithms for Search Result Visualization
Bienvenido Vélez and Jairo E. Valiente
To appear in Internet and Multimedia Systems Applications (IMSA 2001)

Anticipatory User Interfaces for Search Result Visualization using Query Lookahead
Bienvenido Vélez and Juan A. Torres
*To appear in Americas Conference on Information Systems (AMCIS 2001***)**

Query Lookahead for Query-Based Document Categorization
Ph.D. Thesis
Massachusetts Institute of Technology
September 1999

Fast and Effective Query Refinement
Bienvenido Vélez, Ron Weiss, Mark Sheldon and David K. Gifford
ACM Conference in Research and Development in Information Retrieval (SIGIR 97)

HyPursuit: A network search engine exploiting concent-link similarity
R. Weiss, B. Vélez, M. Sheldon, C. Namprempre, P. Szilagy and D. K. Gifford..
ACM Conference on Hypertext (HyperText 96)

TALKS

Evaluating the Accuracy of Query Refinement
MIT/LCS Student Workshop on Computing
Cambridge, Massachusetts

Fast and Effective Query Refinement
ACM Conference in Research and Development in Information Retrieval (SIGIR 97)
August 1997 – Philadelphia PA

Manuel Rodríguez-Martínez, Ph.D.

Assistant Professor

Department of Electrical and Computer Engineering
University of Puerto Rico – Mayagüez
PO Box 9042
Mayaguez, PR 00681-9042

EDUCATION

- Ph.D. in Computer Science, University of Maryland, College Park, 2001
- M.S. in Computer Science, University of Maryland, College Park, 1996
- B.S. in Mathematics, University of Puerto Rico, Río Piedras, 1994

RESEARCH INTERESTS

Database Management Systems, Database Middleware Systems, Computer Networks, Distributed Query Processing.

PROFESSIONAL EXPERIENCE

- 2001 : Assistant Professor, Department of Electrical and Computer Engineering, University of Puerto Rico – Mayagüez

- Summer 199 : Database Systems Consultant, Polaroid Caribbean Corporation.

- 1996 – 2001 : Graduate Research Assistant at Database Research Group, Department of Computer Science, University of Maryland, College Park.

- 1994 – 1996 : Graduate Teaching Assistant for the course Computer Science 1 (CS1), Department of Computer Science, University of Maryland, College Park.

PUBLICATIONS

1. Manuel Rodríguez-Martínez, Nick Roussopoulos, "MOCHA: A Self-Extensible Database Middleware System for Distributed Data Sources", In *Proceedings of the ACM SIGMOD International Conference on Management of Data*, Dallas, Texas, May 2000.
2. Manuel Rodríguez-Martínez, Nick Roussopoulos, "Automatic Deployment of Application-Specific Metadata and Code in MOCHA", In *Proceedings of the 7th Conference on Extending Database Technology* (EDBT 2000), Konstanz, Germany, March 2000.
3. Manuel Rodríguez-Martínez, Nick Roussopoulos, "MOCHA: A Database Middleware System Featuring Automatic Deployment of Application-Specific Functionality", In

Proceedings of the ACM SIGMOD International Conference on Management of Data, Demonstrations, Dallas, Texas, May 2000.

SYNERGISTIC ACTIVITIES

1. 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.
2. Referee for the research papers sessions of the 1999 ACM SIGMOD Conference, 2000 IEEE ICDE Conference, 2001 VLDB Conference, and 2001 ACM SIGMOD Conference.

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J. Fernando Vega Riveros, Ph.D.

Education

Ph.D. in Electrical Engineering, Syracuse University, Syracuse, NY, USA 1984-1989

M.Sc. in Electrical Engineering, Syracuse University, Syracuse, NY, USA 1982-1983

B.Sc. In Electronics Engineering, Javeriana University, Bogotá, DC, Colombia 1973-1979

Most Recent Professional Experience

Associate Professor and Associate Director for Academic Affairs Current
Department of Electrical and Computer Engineering
University of Puerto Rico, Mayagüez, Puerto Rico

Professor and Department Chairman 1990-2001
Department of Electronics Engineering
Javeriana University, Bogotá, DC, Colombia

Awards Received in the last 5 years

- Academic Vice-rector's Mention of Honor, Javeriana University. For the research project "Education and Information Technologies", Oct 8 1999.
- Diamond Award; 2nd Asia-Pacific Forum on Engineering and Technology Education. For the best Forum Paper. Sydney, Australia, July 4-7 1999.
- Gold Award; 1st Asia-Pacific Forum on Engineering and Technology Education. For the third best Forum Paper. Melbourne, Australia, July 6-9 1997.

Recent Publications

Vega Riveros, J.F. On the architecture of Intelligent Tutoring Systems and its application to a Neural Networks course. In *Innovative Teaching Tools for Neural Networks, Fuzzy Systems and Genetic Algorithms.* Physica Verlag, Heidelberg, Editor L. C. Jain, 2000.

Vega Riveros, J. F.; Marciales Vivas, G. P.; Martínez Melo, M. Concept Maps in Engineering Education. (Invited). Unesco Intnatl. Center for Eng. Education. *UICEE Global Journal Eng. Education*. Vol. 2 No. 1, 1997, pp 21-27.

Homkes, R.and Vega-Riveros, J.F. Mirroring industry through international student projects. Keynote conference. *Proc. of the 2nd Asia-Pacific Forum on Eng. and Tech. Education*. 4-7 July 1999, Sydney, Australia, pp 33-36.

Vega Riveros, J. F.; Marciales Vivas, G. P.; Martínez Melo, M. Conceptual Maps in Engineering Education: a Case Study. *Proc. 1st Asia-Pacific Forum on Eng. and Tech. Education.* July 6-9 1997, Clayton, Melbourne, Victoria, Australia, pp 63-66.

Related projects

Principal Investigator project "Digital Library from Colombia". Funded by a grant from the Colombian Institute for Science and Technology "Colciencias", from 1998-2000.

Pedro I. Rivera-Vega, Ph.D.
Professor
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Mayaguez, PR 00681-9042

1.Professional Preparation:

Ph.D. In Computer Science, University of Florida, 1990
M.S. In Mathematics, Unversity of Puerto Rico, San Juan, 1980.

2. Appointments:

August 2001 - present :Professor, Department of Electrical and Computer Engineering, UPR_Mayaguez

1990 - July 2001: Professsor, Departmenet of Mathematics and Computer Science, UPR-RP

3.Publications:

a. (with P. Salzberg and A. Rodriguez) "Network Flow Model for Binary Tomography on Lattices," International Journal of Intelligent Syestems, Vol. 9 (1998), pp. 147-154.

b. (with I. Dehter and A. Rosa) "On the Decomposition of Complete Graphs into Cycles of the Same Length," Journal of Combinatorial Mathematics and Combinatorial Computing, Vol. 16 (1994), pp. 129-152.

c. (with Ravi Varadarajan and Shamkant B. Navathe) "Scheduling Data Transfers in Fully connected Networks," NETWORKS, Vol. 22 (1992), pp. 563-588.

d. (with Ravi Varadarajan and Shamkant B. Navathe) "Scheduling Data Redistribution in Distributed Databases," Proceedings of the 6th International Conference on Data Engineering, February 1990, pp. 166-173.

4.Research Interests:

Distributed and parallel algorithms, and databases.

5.Professional Activities:

Member of the ACM and IEEE.