Provost’s Learning Innovations Grant for Faculty
(Full Proposal)
2004-2005

Project Title:
Enhance Multi-Disciplinary Undergraduate Wireless & Mobile System Learning With Experimental Bluetooth & Sensor Kits

Track #1 Proof-of-concept

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Enhance Multi-Disciplinary Undergraduate Wireless & Mobile System Learning With Experimental Bluetooth & Sensor Kits

(Proof-of-Concept)

1. Project Description:

Dr. Leonard Kleinrock, a famous computing scientist, the Inventor of Internet Technology, clearly pointed out that the age of Pervasive Computing is coming. Pervasive Computing includes the following three components: Wireless Computing/security, sensor-based Smart Spaces, and Data Management. Based on the feedback from our students’ Co-op companies, we deeply realize the importance of introducing Pervasive Computing to our curriculum to adapt to the urgent career requirements of excellent wireless engineers in thousands of US computing companies.

The Goal of this multi-disciplinary project is to seek to improve undergraduate students’ learning in Pervasive Computing (especially wireless and mobile computing) through the development of innovative lab and teaching materials in Computer Science and Computer Engineering programs. This will enable the students at RIT to contribute to Pervasive Computing related industry initiatives. In order to achieve the above goal, this project will mainly focus on the following two objectives: (1) Provide an integrated Pervasive Computing environment: This project will emphasize the seamless integration of wireless Internet and data management in mobile computing platforms. It will not only help Computer Engineering students to understand networking protocols in different hardware platforms but will also educate Computer Science students with these topics apart from distributed databases and data management in sensor networks; (2) Strengthen the institute Co-op program: RIT has a very strong cooperative education program that greatly enhances the students’ abilities to apply their classroom learning to industry experiences. Based on the feedback information from our IAB (Industrial Advisory Board) members, we recognize that more and more companies are interested in integrating wireless communication in products. This project will help make our corresponding curriculum in two departments more suitable to the current career.

Before we came up with the novel concept of Pervasive Computing education at RIT, we have substantially investigated the design principle, facilities and performance of a dozen of wireless labs at other universities including Wireless Network LAB (WINLAB) at Rutgers University, Wireless Networking Lab (WNL) at Cornell University, and Mobile NETwork (MONET) Group at University of Illinois. They have shown strong interests in our concept and encouraged us to immediately develop teaching materials on wireless and mobile systems for computing undergraduate students.

This one-year project will contain the following three components:

1) Wireless & Mobile system labs: Hardware-based course labs are very important to help students form a ‘visible’ understanding of Pervasive Computing. In this project, we will create the following undergraduate course labs: ad hoc routing protocols, wireless CDMA communication, Bluetooth communications, data collection from sensor networks, sensor energy measurement and wireless Internet integration. These labs cover the fundamentals of wireless and mobile systems. The department head of Computer Engineering will provide budget to purchase networking simulation software to support those class labs, and Computer Science department will provide hardware platform.

2) Network Security in wireless system: US government puts network security as the first priority among all computing technologies. Although security in wireline-based network (such as Internet) is becoming mature, security in wireless systems has not been paid enough attention to in most schools even though it
is becoming more and more important. This project will develop a new course called *Network Security in wireless systems* for 3/4/5\textsuperscript{th} year students. The content of this course will include major security schemes for wireless mobile and ad hoc networks. The PI has rich network security research experience.

(3) *Wireless-based Data Management:* For a period of many years Computer Science education has focused on data management in traditional relational databases. However, with the coming of *Pervasive Computing*, more and more information is collected from large-scale, distributed, low-cost, low-memory and low-power sensor networks. We should therefore not only teach our undergraduate students the traditional topics in database management but also provide them with an exposure to the data management issues in pervasive computing environments. As we mentioned in the first paragraph, *Pervasive Computing* includes data management. In this project, we will develop a course, *Distributed Data Management*, which will concentrate on data query implementation/optimization, objective data collection and distributed database management in *Pervasive Computing* environments.

2. **Targeted learners & the number of students who will be affected:**

The targeted learners of this multi-college project are junior/senior/5th-year students in two departments at RIT (Computer Engineering in the College of Engineering and Computer Science in the College of Computing & Information Sciences) who may want to take our two newly proposed courses: (1) *Network Security in wireless systems*; (2) *Distributed Data Management*.

Currently we have over 300 junior/senior/5th-year students in two departments. The above two courses will be offered once each academic year (possibly in Summer Quarter). The average class size for each of these courses will be around 35 students per class. In addition, it is estimated that about 5~10 senior students per year who are interested in wireless ad hoc networks will possibly utilize the developed lab materials as the basis of their senior projects.

3. **Anticipated impact on teaching/learning.**

This project has a *multi-disciplinary* nature and will contribute to two majors in two colleges at RIT as follows: (1) On one hand, many of our students who go to Co-op or other career opportunities find out that they are extremely short of knowledge on *Pervasive Computing*, including wireless networks, sensor networks and distributed data management. On the other hand, for a long term, our Computer Engineering (CE) program is lack of the *wireless computing* and *sensor networks* education resources. (2) In addition, Computer Science (CS) program at RIT also needs *Pervasive Computing* curriculum. Right now it has only a basic *data communication* course. Moreover, current CS data management teaching is based on abstract theoretical principles and traditional central-database based systems.

The proposed activities will provide multiple types of *Pervasive Computing* networks and *Smart Spaces* platform, and its integrated wireless-cum-wired platform is an ideal software-exploring environment. Additionally, this project will allow us to teach our CS students ‘visible’ information management and software programming methodology in an integrated hardware/software pervasive networking environment. The results will not only have a deep impact on the *computing* course learning but will also provide rich topics for *senior project* designs such as Sensor Networks, Wireless Communications, FPGA/VHDL Design for Bluetooth networks, and Data Mining/Database Design in wireless environments.

An additional contribution from this work is in the direct mapping of the course syllabus, procedures and activities into the ABET accreditation criteria. The proposed wireless labs will encourage group work and creative software engineering activities, which corresponds to IEEE Computing education goals.
4. **Impact on student success and retention at RIT**

This project will provide the students with the opportunity of learning one of the most important technical fields today, *Pervasive Computing*, from three different perspectives, i.e., wireless class labs, wireless security and wireless data management. Additionally, the latest wireless sensor network labs should result in a more effective way of communicating and instructing, as well as improved students’ knowledge retention and assimilation. A higher level of student’s motivation and involvement is one of the expected outcomes since the interactive teaching through hardware should be more appealing to our students.

Once this project is successfully finished, RIT will become one of the few universities that have a set of effective education materials to help the students to adapt to the Wireless Networking career requirements and then to create more Co-op freelance. On the other hand, when our students get involved in the wireless labs and network security learning, they will have better understanding of current wireless products such as cell phones and wireless base-stations, and they will have stronger motivation to learn other computer engineering and computer science courses.

5. **Project evaluation and results dissemination:**

There will be two distinct inputs to the evaluation of this project: (1) **IAB**: i.e., members of our *Industrial Advisory Boards* (IAB) who have specialized in *Pervasive Computing* systems. In the beginning of 2003 we contacted some IAB members on our plan to establish a Wireless Lab that is very close to our current *Pervasive Computing* development concept, and they fully endorsed our idea as a valid concentration area that would enhance curriculum options in both CE/CS programs. We will discuss the status of this project in the following 2005 IAB meetings to receive feedback on our more fully developed concepts. (2) **Students** who will be taking the courses. We will use surveys and tests (to be administered at the beginning and end of each course) to evaluate the student learning outcomes. The attitudinal survey will measure the students’ interest in *Pervasive Computing* and their self-assessment of achievement of the course outcomes. We will longitudinally track students taking multiple courses developed by this project to determine if their qualifications and interest increase after taking additional courses. In addition, we will keep track of Co-op and full-time employment data to examine students’ work performance.

The report of this projects will be composed of three parts: (1) All wireless lab materials; (2) Course materials for *Wireless Security*; and (3) Course materials for *Distributed Data Management*. The findings of the project will be presented in two departments’ faculty meetings. Dissemination of this project will also be pursued through other appropriate channels such as the *Journal of Engineering Education*, ASEE forums or educational conferences.

7. **Rationale**

a. **This project is not part of regular college business:**

In the current CE/CS curriculum, we do not have regular requirements and materials for wireless system education. We also do not have wireless network track even through it is so important. Usually students can learn this field only when they get to the Graduate or BS/MS program. Therefore the proposed *Pervasive Computing* education is an innovative concept.

b. **Its relevance to required college and/or department competencies:**

We feel that it is our obligation to improve the quality of the courses delivered in the two departments (CE & CS), especially by making them more accessible and attractive for students. The main goal of this project is to help the students to gain practical knowledge in wireless & mobile systems.
c. **How this project is relevant to other faculty:**
   The equipment and lab materials will be available to any faculty in any course they teach. We also believe that it will be used in some faculty research projects that will require development and hardware implementing of new wireless protocols and remote data acquisition systems.

d. **Relevant credentials, experience of involved faculty:**
   *Dr. Fei Hu* is currently an assistant professor in the Computer Engineering Department at RIT. His research strengths are *Pervasive Computing* including wireless ad hoc sensor networks, 3G wireless & mobile networks and network security. He completed over ten large projects on high-performance networks when he was a Senior Networking Engineer in Shanghai Networking Lab and Lucent Inc.

   *Dr. Ankur M. Teredesai* is an assistant professor in the Department of Computer Science at RIT since August 2002. His research interests are Data Management in *Pervasive Computing* environments, Data Mining Algorithms, and Pattern Recognition. Before joining RIT, he worked at the data management and exploration group at Microsoft Research and the pervasive computing group at IBM T.J. Watson Research Center.

   *Dr. Marcin Lukowiak* is a visiting assistant professor in the Computer Engineering Department at RIT. His research interests are concentrated in the area of multidisciplinary projects that require modeling and hardware implementations of signal processing and data acquisition systems. In particular, he has been focused in two following fields: Electronic Design Automation and Development of switched-current (SI) technique.

e. **How this innovation is in our discipline(s):**
   The concept of *Pervasive Computing* education proposed in this project fits both disciplines (Computer Engineering and Computer Science) very well, which can be seen from its main features as follows: (1) It includes a human-friendly middleware framework and other important *Computer Science* education topics such as *Sensor Database Management* and *Data Mining in Distributed Environment*; (2) Computer Engineering students will be interested in the following materials to be developed in this project: integration of typical pervasive networks including *Personal Area Networks (PAN)* based on Bluetooth protocol stack and *Wireless Sensor Networks (WSN)*. (3) Wireless Security issues in pervasive environments will be emphasized for both majors (CE & CS).

8. **Timetable**

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<thead>
<tr>
<th>Tasks</th>
<th>2004</th>
<th>2005</th>
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<tbody>
<tr>
<td>Purchase/install lab items</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Develop “wireless network security” course materials</td>
<td>8</td>
<td>9</td>
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<tr>
<td>Develop “distributed data management” course materials</td>
<td>10</td>
<td>11</td>
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<tr>
<td>Develop class labs on wireless networks</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Offer courses to students in Summer</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Project report preparation; write ASEE conference papers</td>
<td>4</td>
<td>5</td>
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