

Cover Page

Provost's Learning Innovations Grant for Faculty (Full Proposal) 2005-2006

Proposals, plus the signed budget page, should be hand-delivered by Monday, March 14, 2005. Applicants should provide the original plus 11 copies for committee members, as well as email all to Susan DeWoody at skdetc@rit.edu, Location: 1530 Wallace (5).

Project Title:

Improve Students' Learning in Pervasive Computing From Both Science and Engineering Perspective

Track #2 Adaptation & Implementation

Applicant(s):

Name: **Dr. Fei Hu**
Department: **Computer Engineering**
Email: **fxheec@rit.edu**

Telephone: 475-5139
College: **College of Engineering**

Name **Dr. Ankur Teredesai**
Department: **Computer Science**
Email: **amt@cs.rit.edu**

Telephone: 475-6181
College : **College of Science**

Name: **Dr. Marcin Lukowiak**
Department: **Computer Engineering**
Email: **mxleec@rit.edu**

Telephone: 475-2808
College: **College of Engineering**

(A&I) Improve Students' Learning in Pervasive Computing From Both Science and Engineering Perspective

Preface: Last year we submitted the PLIG proposal titled as “Enhance Multi-Disciplinary Undergraduate Wireless & Mobile System Learning With Experimental Bluetooth & Sensor Kits”. It was selected for funding by PLIG Review Committee. Due to the 2004 PLGI budget limitation, the Provost's Office suggested us to decompose our project into two phases as follows:

- (1) Phase 1 (awarded in 2004 PLIG): It was a “Proof-of-concept” project. This phase has generated the following promising outcomes: Two new courses (called “Advanced Networking (wireless security)” and “Distributed Data Management”, respectively) have been successfully developed by the three PIs. Moreover, six team-based wireless labs have been created and assigned to the students taking the course “Wireless Networks” (offered in Summer 2004, CE/KGCOE).
- (2) Phase 2 (i.e. proposed by this document): We are moving to Adaptation and Implementation (A&I) phase. We will apply benchmark institutions' Pervasive Computing course materials to RIT's Computer Engineering (CE) and Computer Science (CS) networking curriculum. So far three schools (Rutgers University, Cornell University, and University of Illinois) have agreed to provide relevant educational resources and evaluation comments for this proposed project.

1. Project Description

*“On the development of information computing, the clearest part of my vision is that of nomadic computing and smart spaces. Nomadic computing refers to the technology that enables end users who travel from place to place to gain access to Internet services in a transparent fashion, no matter where they travel. The next step will enable us to move out from the netherworld of cyberspace to the physical world of smart spaces. Our environment will come alive with technology, through actuators, sensors and communication. Intelligent software agents are deployed across the network to mine data, act on that data, and carry out tasks dynamically and adaptively. The Internet will essentially be a **pervasive** global nervous system!”*¹ -

By Dr. Leonard Kleinrock, a renowned computing scientist, the Inventor of Internet Technology, currently a professor of Computer Science at University of California Los Angeles.

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.

Unfortunately, most universities have only “graduate-level” *Pervasive Computing* courses, which may not be suitable for “undergraduate” learning. Known as a leader in applied undergraduate curricula, Rochester Institute of Technology (RIT) is currently undertaking an effort to enhance the *pervasive computing* skills of our *undergraduate* students in two programs, i.e. Computer Engineering (in College of Engineering) and Computer Science (in College of Science).

This A&I project seeks to enhance RIT computing skills by adaptation and implementation (A&I) of some of the exemplary Pervasive Computing lab environments at Benchmark Universities. We substantially investigated the design principle, facilities and performance of a dozen of wireless labs at other universities and decided to select the following three schools as our benchmark institutions: Wireless Network LAB (WINLAB) at Rutgers University, Wireless Networking Lab (WNL) at Cornell University, and Mobile NETwork (MONET) Group at University of Illinois. The primary reason is as follows: they have contemporary pervasive computing lab resources and their lab/course materials are most suitable to our undergraduate program.

The concrete adaptation contents including both lecture materials and lab projects. Specifically, we will adapt the sample teaching materials from the benchmark schools to our CE/CS undergraduate courses/labs and develop the following education resources:

¹ James F. Kurose, Keith W. Ross, “Computer Networking, A top-down approach featuring the Internet,” Pp 74-75, ISBN: 0-201-97699-4, publisher: Addison-Wesley, 2003.

- (1) **New 4-credit Course: “Pervasive Computing: Wireless Communications,”** This course will focus on wireless communication issues include radio propagation, wireless digital modulation, antenna system, channel coding, multiple access techniques (including the impact of multiple antennas), cellular system design, and ad-hoc wireless networking. Lectures will be based on required reading from technical journal articles, textbook sections, or supplemental handouts.
- (2) **New Seminar Course: “Data Mining in Wireless Sensor Networks,”** The constraints of sensor networks that are of special relevance to *data mining* can be tentatively divided into the following categories: energy, computational, memory, communication, and time-related constraints. This seminar course focuses on data mining algorithms, which address one or more of these constraints.
- (3) **Pervasive Computing lab materials:** We will make an innovative extension of the benchmark labs to develop a series of new laboratory hardware/software materials on pervasive computing. We attempt to prepare our undergraduate students for careers in *pervasive computing*. Our final goal is to provide an integrated wireless-plus-wired networking platform, including current *pervasive computing* platforms such as *Wireless LAN*, *Personal Area Networks* (based on Bluetooth technology), and *Wireless Micro-sensor Networks*.

2. Adaptation & Implementation Strategy

We have a strong motivation and need to be innovative during our **adaptation** of the benchmark institutions’ course/lab materials, due to the following reasons:

- (1) Our project is an extension of their wireless labs. New materials are needed to cover all the three components of Pervasive Computing (nomadic computing, smart spaces and data management);
- (2) We need to meet the requirements of CE & CS majors (from both engineering and science perspective);
- (3) RIT uses the quarter system instead of the semester system. A key adaptation issue is the difference between RIT’s 10-week quarters and the benchmark institutions’ 15-week semesters. From a simple point of view, two semesters equals three quarters. From the pedagogical viewpoint, however, such a partitioning is not reasonable. Part of our adaptation of the exemplary materials will be creating several 10-week courses, each providing a well-defined, cohesive set of educational outcomes.

Instead of simply using the existing materials in benchmark schools, we will make the following groundbreaking implementations based on *Pervasive Computing* requirements:

(1) Extend their wireless lab concepts to a complete *pervasive computing* environment. Most existing wireless labs only focus on the first component of *pervasive computing*, i.e., *nomadic computing* through wireless / mobile networks. We will develop materials on two new components in pervasive computing systems: *Smart Spaces* (through Sensor Networks) and *Distributed Data Management in mobile platforms*.

(2) Perform significant revisions of materials specific to **graduate** teaching, adapting them to the capability and applicability of our upper-level **undergraduate** students.

(3) Add important topics revolving around “*pervasive computing security*”, such as WLAN security and sensor network security, thus adapting to the career requirements of wireless industries.

3. 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) *Wireless Communications*; (2) Seminar on data mining in sensor networks.

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 section.

4. 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.

5. 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., Mobile Networks, ad hoc Sensor Networks and wireless data management. Additionally, the latest *wireless ad hoc 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 Pervasive Computing 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 CE/CS courses.

6. Project evaluation and results dissemination

There will be three distinct external/internal inputs to the evaluation of this project:

- (1) **Adaptation universities:** i.e., the mentor faculty at the benchmark schools. We will send them our developed materials and ask them to freely comment on the following aspects in our materials:
 - Is the course/lab material appropriate and relevant to the profession?
 - Is the material being presented in a logical and cohesive way?
 - Is the time and emphasis that is being placed on each topic appropriate?
 - Are the experiments/projects/lab equipment appropriate to accomplish the aforementioned two project objectives (see *Introduction* section)?
- (2) **Students who will be taking the courses.** We will use surveys and tests 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 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 our students’ work performance in the field of pervasive computing.
- (3) **Communication/Computer Society members whose expertise is pervasive computing:** The PI is currently the Associate Director of Rochester SigmaXi Chapter and also a local IEEE Communication Society officer. Each year there are a few meetings providing opportunities for exchanging education experiences on how to improve undergraduate computing learning. The PIs will ask two to three *pervasive computing* experts from the local IEEE / Sigmaxi Chapters to evaluate our outcomes.

Dissemination: The report of this project will be composed of three parts: (1) Pervasive Computing lab materials; (2) Course materials for *Wireless Communications*; and (3) Course materials for Data Mining in Sensor networks. 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 Pervasive Computing education. We also do not have *wireless network* track even though it is so important. 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 pervasive computing systems.

c. How this project is relevant to other faculty: The course materials will be available to any faculty who are interested in pervasive computing. It will also 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

| Tasks | 2005 | | | | | | | 2006 | | | | | |
|---|------|---|---|---|----|----|----|------|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 |
| Purchase/install lab items | | | | | | | | | | | | | |
| Develop “Pervasive Computing: wireless Communications” course materials | | | | | | | | | | | | | |
| Develop “Data Mining in sensor networks” course materials | | | | | | | | | | | | | |
| Develop class labs on wireless communications | | | | | | | | | | | | | |
| Offer courses to students in Summer’06 | | | | | | | | | | | | | |
| Project report preparation | | | | | | | | | | | | | |

Appendix: A&I Support Letter from UIUC

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Department of Computer Science
1304 West Springfield Avenue
Urbana, IL 61801 USA



Jennifer Hou, Associate Professor
telephone 217-265-6329
email jhou@cs.uiuc.edu

November 1, 2004

Computer Engineering Department
Rochester Institute of Technology
83 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Prof. Fei Hu,

It is my pleasure to write a support letter for your plan to build a Pervasive Computing Laboratory at RIT based on our successful pervasive computing lab establishment experiences.

With the decommissioning of the NSFnet Internet in 1995, the use of the Internet has transitioned from a research-only network to a network by which companies can profit. The Internet (and its wireless extension) has caused a major change in the way we bank, reserve airline tickets, file income tax, and access information. Clearly, this evolution of information technology will continue with the development of advanced networking and communications technologies playing a key role in the scalability, accessibility, and utility of next generation internets. With the massive changes that will occur in the networking infrastructure over the next decade, the universities with leadership in the networking curriculum have the opportunity to influence fundamental technological growth of general importance to the world's economic future. This, in turn, positions these institutions as future leaders in higher education. With this understanding, we have strengthened our networking curriculum in the past 2-3 years and provided in the Department of Computer Science the following networking, wireless & mobile computing lab projects/courses for both undergraduate and graduate students.

- CS 338: Communication Networks for Computers;
- CS 328: Distributed Systems;
- CS 397: Computer Networking Laboratory;
- ECE 371: Wireless Networks (Course Objectives: This is a senior-level course on wireless networking, with an emphasis on understanding the unique characteristics of such networks.)
- Other high-level, network-related courses: Additional network-related seminars and special topics courses in 2003-2004 include
 - ECE 467 Communication Network Analysis
 - CS 491 Advanced Topics in Computer Networking
 - CS 491 Selected Topics on Multimedia Communication
 - CS 497 Special Topics in Computer Networking Research
 - CS 497 Advanced Topics in Network Protocols, Architectures and Applications
 - CS 497 Mobile Computing and Communications

We are delighted to disseminate the above networking, wireless & mobile computing curriculum, along with lessons learned and experiences gained in the curriculum design process. The curriculum can be, in fact, used as "templates" to be duplicated at RIT, provided that adequate resources are available at RIT. Specifically, we will be able to provide assistance in the following ways:

1. We will provide you with access to our course materials including lectures notes, lab assignments, projects, and exams for the courses listed above;
2. We will answer questions you might have regarding our teaching materials and share our experience with systems lab building and administration;

3. You are welcome to visit our network systems lab and wireless lab to gain first-hand experience in setting up and administrating lab facilities;

4. We will help evaluate, and provide feedback to, the courses/labs that you and your colleagues develop. The following are our proposed course/lab evaluation plans for your project:

Course Evaluation:

- (2) Find whether the developed lecture materials are relevant to the pervasive computing profession or not. Especially, we hope that each lecture will focus on contemporary wireless & mobile networking issues instead of some technologies that are not used much today.
- (3) Ensure that the materials being presented are in a logical and cohesive way. Help adjust the teaching order of some materials if necessary.
- (4) Check the depth of wireless /mobile networking issues including CDMA, 3G wireless, OFDM, sensor networks, Wireless LAN, Ad hoc networks and distributed database. Make sure that each topic can be well understood by undergraduate students.

Lab Evaluation:

- (1) Evaluate lab design and help make the experiments/projects/lab equipment appropriate to accomplish your project objectives. Especially help make a good balance between engineering knowledge (such as hardware architecture) and science materials (such as application programming) since this project has a multi-discipline nature;
- (2) Evaluate the procedure of each class lab and help ensure the close connection between the lab assignments and the lecture materials;
- (3) Evaluate the depth of lab design and find out whether they are closely linked to practical pervasive computing platforms.

Please let us know if we can be of any further assistance.

Sincerely yours,



Jennifer Hou
Associate Professor