Provost’s Learning Innovations Grant for Faculty
Request for Full Proposal
2005-2006

Please hand-deliver your completed grant proposal (4 pages, plus attachments),
the original plus 15 copies, to:
Susan DeWoody, 1530 Wallace (5)
by 4:30 p.m.
Monday, March 14, 2005.
No hand written proposals will be accepted.
Notification of awards will be made by Friday, April 8, 2005.

Project Title:
Multi-disciplinary Training on Wireless Ad Hoc & Sensor Networks via
Integrated Hardware/Software Experiments

Track #1 Proof-of-concept

Applicant(s):

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<tr>
<th>Name</th>
<th>Telephone</th>
<th>Dept.</th>
<th>College</th>
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<tbody>
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<td>Dr. Xiaojun (Matt) Cao</td>
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<td>GCCIS</td>
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Multi-disciplinary Training on Wireless Ad Hoc & Sensor Networks via Integrated Hardware/Software Experiments

(Proof-of-concept)

1. Project Summary

Recently, MIT's Magazine of Innovation - Technology Review has identified ten emerging areas of technology that the editors and a body of technology experts believe will soon have a profound impact on the economy and how we live and work. In the January/February 2003 issue, Wireless Ad hoc and Sensor Networks (WASNs), which are defined as the wireless interconnections of large amount of sensors and mobile actuators to detect/respond to important events in some scenarios (such as fires, chemical pollution, building intrusion, earthquakes, and so on), have been identified as one of “the ten emerging technologies that will deeply change the world”. As a matter of fact, Wireless Ad hoc and Sensor Networking (WASN) technologies are having huge effects on many civilian/military applications, including homeland security, data communications, transportation systems, health care, environmental monitoring, and so on. Since “9.11”, the U.S. government has invested heavily in the national establishment of WASN-based “homeland security” infrastructure. It was reported in the local media that Rochester would deploy ‘sensor networks’ to witness gunshots so that criminals can be timely captured.

Although WASN has received tremendous/increasing attentions from both academia and industry worldwide, unfortunately most US universities cannot provide necessary WASN educational resources in their computing programs. We must confess that currently, our undergraduate/graduate students in all computing programs including Information Technology, Computer Engineering, Computer Science, and Software Engineering, have very little understanding of WASN hardware/software design principle other than elementary networking knowledge. Known as a leader in applied undergraduate curricula, RIT needs to build a pioneering training program in this field. This proof-of-concept project will be carried out by three PIs from two colleges at RIT, i.e. Golisano College of Computing & Information Sciences (GCCIS) and Kate Gleason College of Engineering (KGCOE). It will arm our students with the latest technologies by introducing sensor networking hardware/software design principle and related wireless communication technologies to our IT/CE curricula. After the training of WASN platforms, our students will be able to better satisfy the requirements of the wireless industry and obtain better co-op and other career experiences.

In this proof-of-concept project, we propose to improve the multi-disciplinary learning across two programs (i.e. Information Technologies and Computer Engineering) through the development of comprehensive lab and teaching materials on WASN-related technologies. Thus our students can learn not only the “applied technologies” in WASN platforms but also the “engineering design” principles. In this project, we will coherently organize the materials into a 10-week course that will cover the following topics: WASN architecture /algorithms / protocols, hardware components, OS support, wireless security, and practical WASN applications. Students will learn how to program and communicate with TinyOS, which is a prominent application development environment for sensor systems consisting of motes from Crossbow Inc.

Through this course and relevant lab projects, students will gain hands-on experience through real-world programming assignments on sensor hardware and be able to implement algorithms

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3 TinyOS: operating system for sensor networks, see: http://www.tinyos.net
involved in WASN systems as well as debugging the system.

2. **Targeted population**

The primary audience for this multi-disciplinary project will be the 4th/5th-year Undergraduates and 1st-year Graduate students in two departments at RIT, i.e. Information Technology (IT) Department in GCCIS, and Computer Engineering (CE) Department in KGCOE. The project will propose an innovative learning experience and training approach that take advantages of both the strong training program on “applied networking” technologies in IT department and the contemporary “wireless engineering” educational resource in CE department to provide IT / CE students a comprehensive understanding of the design principle of WASNs. Since there is no such opportunity from other departments, students from other departments such as Computer Science (CS) and Electrical Engineering (EE) may also take the course to be developed in this project. It is anticipated that the students who take this course will also be able to develop their own senior projects or theses topics related to wireless sensor networks.

In addition, as a new PhD program in Computer & Information Sciences is going to be established in GCCIS in the near future, the materials to be developed in this project can also be used to provide a solid knowledge foundation and research background for some future GCCIS PhD students who are interested in sensor network research.

3. **The number of students who will be affected:**

Currently IT department has over 1,500 students and CE department has over 500. It is anticipated that annually 2–3 sections of classes (each section with around 30 students) will be offered for students from IT/CE and other departments after the lecture/lab materials are developed in this project. In addition, it is estimated that about 5–10 senior students per year who are interested in ad hoc & sensor networks will develop their senior or capstone projects/thesis based on the contents they learn from this new course.

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

The expected innovations and impact of the proposed projects on teaching/learning lie in several aspects as follows:

1. **Enhance the multi-discipline training.**

   Currently, at RIT, we observe that the IT students have interest and experiences in the application/implementation of technologies and theories, but they lack in knowledge/understanding of the physical layer and hardware issues. On the other hand, the CE students own thorough knowledge of the physical layer issues, but they are not confident how to apply them into real-life applications. However, in today’s industries, people are required to have cross-disciplinary knowledge and thus to be able to work in harmony with people from different fields. Hence, in this project, we propose an innovative learning experience that enables IT and CE students to collaborate and learn from each other. Three professors from IT and CE departments will collaborate and focus on different parts of the entire course based on their own research/teaching expertise.

2. **Improve students’ integrated hardware/software learning.**

   Effective software tools and sensor hardware combined with interactive team assignments will provide a chance for students to actively learn the different issues in an integrated WASN system. The interactive teaching through hardware/software and lectures/labs should result in a more effective way of communicating and instructing, as well as improved students’ knowledge retention and assimilation.

3. **Meet the contemporary wireless industrial requirements.**
In addition, as the topics of the proposed project are closely bounded with the advancing of current industry technologies, the proposal activities will provide good chance to collaborate with local industries by designing some course assignments with practical industry projects, which in turn greatly enhance our teaching at RIT.

5. Impact on student success and retention at RIT

Wireless communication and related topics such as ad hoc networks, sensor networks, and wireless security have gained the attention of industry, academia and the press. Currently more students would like to pursue the study of advanced networking.

This project will give students the opportunity to learn one of the most important and hot technical fields today, i.e. wireless ad hoc & sensor networking. The materials developed from this project will enable students to further touch the fast-growing technologies. In this way, students learn more updated theories and technologies (and expect to be more successful after graduation). The connection between lab materials and devices from students’ real-life (such as PDA, cell phone, laptop) will motivate students to explore more in IT/CE courses. This will also help students to buildup more confidence and enjoy an advantage in the marketplace. Students involved in the coursework will receive constant attention and feedback while their abilities grow and develop as they advance through their classes, which in turn motivate students to retain and succeed.

Once this project is successfully carried out, RIT will become one of the few universities that have a set of effective education materials that allow students to adapt to the Wireless Ad-hoc & Sensor Networking career requirements. Our relationships with various companies including Cisco, AFRL, and Critical Technologies Inc. should help us get feedback about the educational process from industries and provide co-op opportunities for our students, which in turn improves scholastics, student success and retention at RIT.

6. Project evaluation and results dissemination

To verify the students’ learning efficiency in this proof-of-concept project, we will adopt the following evaluation approaches: (1) Students who take the course: We will track students learning process and utilize surveys/tests to monitor the learning outcomes. Moreover, we will create different sensor hardware settings and assign realistic application scenarios to the students in each lab/exam to test their capability of extending classroom knowledge to industrial design. (2) WASN experts: We will invite other wireless networking faculty members and local wireless company people to examine the student lab/project results and to provide the feedback from both educational efficiency and career benefits points of view. (3) Industrial Advisory Boards (IAB): Each year we have an IAB meeting held in our department. The developed course materials and projects will be presented to them for comments and feedbacks.

7. Rationale

In the current IT/CE curriculum, we do not have regular requirements and materials for wireless sensor system education. We also do not have wireless sensor networking track even through it is a very important component of a networking education and ensure that our students remain the top in the industry. Hence, this project is not part of regular college business. However, we believe that it is our obligation to improve the quality of the courses offerings, update materials, fill gaps, and bring about the best possible environment or experience for our students. As wireless ad hoc & sensor networking is one of the most promising technologies in the industries and academia, this project will assure us to stand in the frontier of wireless education and is crucial to the continued success of our program.
The concept of multi-discipline education in wireless ad hoc & sensor networking from this proposed project fits both disciplines (Information Technology and Computer Engineering) very well. As indicated before, this project will provide IT and CE students experience to collaborate and learn from each other. Based on this project, the innovative teaching/learning process will be an integration of hardware & software, theories & technologies, and academia & industries. This grant will be used to support the extra time and efforts of the faculty and students who will develop materials and environment for such innovative teaching/learning process outlined in this document. Some activities, such as building labs or writing course materials, the creation of WASNs environment, control of the tools, design of the activities/analysis and the evaluation, will require extensive research, survey and preparation to ensure that all students benefit from this project, which is well above normal course development.

Due to its multi-disciplinary nature, this project will be conducted by the three PIs from IT and CE departments: The PI, Dr. Xiaojun Cao, is from IT /GCCIS: He has worked in the field of Wireless Communications for several years and has been closely tracing the cutting-edge wireless networking technologies. He will lead the progress of the entire material development. The other two PIs have strong background in the field of Ad hoc Networks and Sensor Networks. The three PIs’ academic backgrounds comprehensively cover the three technologies aspect of WASNs: (1) Wireless Communications, (2) Sensor Networks, and (3) Ad hoc Networks. In addition, the three PIs are bounded tight with the industry research, which will facilitate the design of industry-oriented labs/projects for the course.

The materials and devices from this project will be available to any faculty in RIT. In IT department, a number of faculty members are interested in wireless. The materials can also be adopted in faculty research projects that require development and hardware implementation of new wireless ad hoc & sensor protocols as well as remote data acquisition systems. The materials will also present a basis for other faculties to explore potential thesis/project topics with their students. As the faculty from IT/CE department own solid experience in networking education, our dissemination plan will make it straightforward for other faculty to pickup useful experience from this innovative project.

8. Timetable

This project will be carried out based on the following timeline. It starts this summer and ends next spring. The project report will be submitted in Summer 2006. The new course will be offered in Fall 2006 for both IT and CE students.

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<th>Summer 04-05</th>
<th>Fall 05-06</th>
<th>Winter 05-06</th>
<th>Spring 05-06</th>
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<td>Prepare ad hoc sensor network equipment; Setup hardware platform; Design the simply experiments.</td>
<td>Lecture materials development: detail 10-week teaching plan; all homework and tests;</td>
<td>Lab material development: Develop 5~7 sensor network labs; Each lab should have clear goal and operation procedure.</td>
<td>Comprehensive course evaluation: the matching between lectures and labs; Test all labs; Project report editing.</td>
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