Provost’s Learning Innovations Grant for Faculty  
Special Request for Proposal  
Course Development  
2009-2010  

Project Title:  
Including Real Networking Hardware  
in the  
Modeling and Simulation (M&S) Environment.  

Applicant(s):  

<table>
<thead>
<tr>
<th>Name</th>
<th>Tae (Tom) Oh</th>
<th>Telephone</th>
<th>475-7642</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dept.</td>
<td>Networking, Security and System Administrations</td>
<td>College</td>
<td>GCCIS</td>
</tr>
</tbody>
</table>
Including Real Networking Hardware in the Modeling and Simulation (M&S) Environment.

1. Title and summary of proposed project.

Since the last decade, modeling and simulation (M&S) has become the evaluation method of choice for many areas of computer networking research. When upgrading an existing network, a common approach is to create a network model with upgrades using a network simulator tool and measure the performance of the upgraded network as compared to the existing network. The performance results are used to make critical design upgrade decisions. In some cases, modeling and simulation is used to create and revise components of the router as such as routing protocols, queuing methods, and transport protocols and then measure the performance of the new methodology as compared to the existing methods. Therefore, modeling and simulation provides a cost effective solution before building a prototype.

Most M&S tools use discrete event simulation (DES). DES has a list of stored pending events and those events are processed in order with some events triggering future events. For example, when the packet arrives at the node, this event of packet arrival triggers event of at the arriving node.

Recently, the industry has been cutting the cost of research and development (R&D) effort by utilizing modeling and simulation in a unique way. Along with using the network simulator for proving a new concept, the industry began to use M&S tools to test real hardware devices called “hardware-in-the-loop (HITL).” This is accomplished by providing an interface to the live hardware device. This extends the scope of M&S functionality by enabling technology testing and training. The prototype hardware or software application can interact with numerous virtual devices within the model, potentially avoiding the need for an expensive test lab.

Using this next generation M&S method, the users can:

- Perform developmental, interoperability, scalability, and conformance testing of prototype the hardware and software applications.
- Create a virtual training facility for devices or applications interfacing directly with simulated network infrastructure containing numerous simulated devices.
- Study the behavior of prototype applications by deploying them on a simulated network topology.
- Analyze the performance of a new protocol deployed in a simulated network environment by injecting real network traffic.

Currently, our curriculum has courses that utilize M&S tools. They allow students to more easily learn the theoretical concepts by not only following the modeling instructions but also by offering the latest and most in-depth modeling techniques. For example, HITL-technique is not taught in the courses. Updated M&S labs are needed to offer students modeling knowledge in order to provide an edge to stay ahead and marketable in today’s competitive job market.

This proposal seeks support for developing a M&S project that will provide students with theoretical, practical and research experience with HITL technique. The goal is to stimulate an interest in new M&S techniques and provide out-of-box thinking to solve problems. The project will be unique as the professors will be closely involved and guide students in performing HITL testing and performance evaluations of the real networking hardwares/devices. The students will be encouraged to publish their results in a technical conference or a workshop. This new M&S technique addresses President Destler’s goal for innovation - “Looking at ways in which our curricula could be modified to encourage innovation and creativity and perhaps offer each student an opportunity to exercise his or her creative side before graduation.”
2. Targeted learners or population (include cluster, departments, year level, number of learners impacted).

- The primary candidates for this project will be the 4th and 5th year Undergraduate and graduate students who are pursuing Computer Engineering, Networking, IT, Computer Science and Telecom Engineering Technology from the Kate Gleason College of Engineering, B. Thomas Golisano College of Computing and Information Sciences and the College of Applied Science and Technology.
- Any undergraduate and graduate students who have a strong background in networking can undertake this project with consent from the instructor.
- This project offers a good foundation of M&S skills for students who are wishing to pursue a doctorate in the area of networking and computer engineering as this modeling technique promotes creative thinking.
- In general, this project offers many benefits to undergraduate and graduate students who would like to learn and gain experience in the latest network modeling techniques.

3. The number of students who will be affected.

It is planned to offer this project in our current course twice per year with a class size of 25 students. The total number of students impacted by this course will be approximately 50.

4. Present a rationale for your project, as it relates to the area you have chosen.

Possible opportunities include:

- Creating a community-based learning component for an existing course

Before joining RIT, I had worked with Rockwell Collins, a defense contractor, in M&S organization for the past five years. The company is very interested in hiring graduates with M&S backgrounds especially with HITL skills since company need to invest so much resource to training their engineers. Also, other companies such as network equipment manufacturers, network service providers, and defense organizations have been using the M&S tools with HITL technique recently to perform following cases:

- Test, validate, and demonstrate prototypes.
  - Model testbed
    - Understand how software applications perform in your simulation infrastructure such as Mobile ad hoc network (MANET), satellite networks, cellular networks, Wireless Local Area Networks (WLAN).
    - Verify equipment interoperability as prototype device communicates with simulated legacy devices.
  - Hardware testbed
    - Test equipment scalability and behavior by injecting it with simulated data and control traffic.
- Create a virtual training facility for devices interfacing directly with simulated network infrastructure.

Using my support from Rockwell and possibly other companies, the students should be able to perform a projects related to those cases and hopefully, the co-op opportunities arise because of the collaboration effort with the company/ies. This new technique will enriches the student learning by applying theoretical knowledge in real device as well as virtual modeling environment and observing the experiment results in both real and virtual forms. With the guidance from an instructor and Rockwell Collin’s modeling experts, the students can learn the process of model from defense industry perspective as well. The collaboration with Rockwell Collins from this project will greatly increase the interest in RIT and as an industry partner.
• Developing project-based experiences that will engage students from multiple disciplines

This project involves students from engineering, networking and telecommunication engineering technology. This M&S technique should attract students from multiple disciplines especially doing research such as testing a new prototype hardware, protocol, and/or software in a large network scenario. It's too expensive to create a large network with real hardware but it's quite easy in M&S environment. For example, students from computer or electrical engineering could create a new networking prototype device. The computer science students can actually create a program to run in the prototype as well as creating a large network in a modeling and simulation environment. Networking, Security and System Administrations (NSSA) student can work on the interface between the prototype and the M&S tool. With a joint effort,

• Team with a faculty member in another discipline to design and deliver a course

This project can include in a new or existing courses in following disciplines.

- Computer Engineering from Kate Gleason College of Engineering
  The author can team with a computer engineering faculty to implement newly designed protocol in the hardware and study the performance of the new protocol in a M&S environment. For example, the student can design and modify the existing encryption protocol in the hardware using FPGA and observe the performance of the protocol in a M&S environment.

- Computer Science, Information Technology and NSSA from B. Thomas Golisano College of Computing and Information Sciences
  The students can connect different types of routers to the virtual modeling world and observe performance different between the routers. The students should have easier time of understanding of different protocols by observing the packet exchanges between the hardware and the simulator tool.

- Telecom Engineering Technology from the College of Applied Science and Technology
  The real voice switches or telecom devices can provide interface to virtual M&S effort. The author can team with telecom professor to evaluate the new telecom devices/prototypes. For example, the behavior and interoperability of the device can be studied in a large network scenario with different virtual devices.

5. Anticipated impact on teaching and/or learning.

To best of my knowledge, the several departments from the Golisano College of Computing and Information Sciences and the College of Applied Sciences and technology utilizes network M&S tool like Optimum Network (OPNET) in their labs and courses to enhance the student’s learning experience. However, many students do not have good understanding of the purpose of using M&S. The existing labs just consist of set of instructions to get the graph results by following the simple instructions. The students do not know why they are configuring the network and the nodes in such a way.

The student can have easier understanding of networking technology by using hand-on approach on both real hardware and network simulator tool. However, the learning curve to do this project could be little steep but the students will have good background in networking and M&S concept. Also, RIT has strong career motivated students and it’s our responsibilities to offer up to date project experiences. The hand-on experiences from the project promote student’s modeling interest and benefits.

The author’s plan is to present real world simulation problems and prepare them with required knowledge via lectures to utilize the M&S efficiently as possible to solve their problems. In class, the students are form into multiple groups to work on the selected problems. Main goal for students to learn the new modeling technique with instructor’s guidance and write a technical papers to publish in conferences and workshop.

This project will enhance M&S experience for students as well as motivate out-of-box thinking for
students. GCCSIS in RIT promote learning by doing concepts and the M&S lab component need to be updated to meet the RIT’s requirements.

In addition, the proposed project could lead to creating a innovative course while providing challenging but enjoyable learning environment. Also, the author expects to continue to develop HITL project to encourage and inspire students to get involve in research in modeling and simulation.

6. How will your project impact student success (i.e., retention, innovation, in society)?

Our current course utilizes the basic features of OPNET M&S tool although the tool has many useful simulation techniques and features. Implementing this project not only provides hands-on experience on both network hardware and the simulation tool but students can actually apply what they learn in the classroom to the projects in industry. This is a latest innovation technique for M&S, and only handful of graduates in US will have this type of experience. Our students who did this project will be very attractive to hiring companies. This will eventually improve our retention rates.

Last year at OPNETWORK 2008 conference, OPNET demonstrated HITL in one of the sessions and the new simulation technique attracted so many attentions from the existing and potential OPNET customers. It was a unique experience for many audiences to observe the demonstration of including a real router or switches in the virtual environment. Just like their customers, there are strong interests from current students and faculty in this technique from RIT. The demonstration could be used as outreach and recruitment efforts to attract many potential RIT students from surrounding high schools and community colleges.

7. How you will measure the course impact, and what could you will share about your project in a faculty forum.

I will measure the impact based on following list.

First, the students and I will submit an article about implementing HITL project into existing or new course to the conference. The article will include implementing process for HITL as well as feedback from students and colleagues.

The second measure will from the student feedback about this project. I am very interested in their interest level and learning effect. I will also collect student’s ideas and suggestions to improve the projects. I will closely monitor the progress of the projects through classroom discussion as well as discussion boards.

The third measure will be from other RIT faculty and other universities. Several faculties from Penn State University and James Madison University would like to include in their course work and the author will collect the feedback from them. If this project is funded, the project materials including the feedback results will be disseminated through out the conferences and workshops.

8. Provide a timetable of the development of the course.

Summer 2008
- Develop project content including the instructions and possible topics.
- Arrangements will be made for conferences/workshops presentations

Fall 2009
- Setup a lab
  1. Find used routers and switches
  2. Setup a modeling and simulation environment (OPNET is preferred tool).
  3. Test Ethernet interfaces between the hardware (router or switches) and OPNET tool.
- Offer the project in a networking course.
  Professor will help students to submit the papers.

Winter 2009
- Offer the project in a networking course
  Professor will help students to submit the papers.

Spring 2009
- Offer the project in a networking course
  Professor will help students to submit the papers.

Proposed budget: $5000