

Research Experience for Undergraduates – Emerging Issues in Computer Networking

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ABSTRACT

The “REU site: research experiences for undergraduates (REU) – emerging issues in computer networking” at Columbus State University (CSU) is a NSF funded program which provides an opportunity for eight undergraduates, primarily underrepresented minority and women students, to conduct research in emerging issues in computer networking. Each participating student will receive 10 weeks stipend to do research in the summers of 2004 and 2005 at CSU. The program also features independent study courses offered in each spring semester to prepare students ready for the research projects. Seven faculty will serve as research mentors for the participating undergraduates. The program targets students who have completed their sophomore or junior year of study from CSU and smaller, primarily undergraduate institutions with limited research resources in the southeast area. Emphasis is placed on the recruitment of minority and women students. The REU program at CSU will provide the opportunity for undergraduate students to gain useful research experience in the exciting area of emerging issues in computer networking. In addition, the REU program will empower the students with general research methods, specific skills and techniques in this area, and presentation and writing skills.

Keywords: Research experiences for undergraduates (REU), computer networking, research projects.

1. INTRODUCTION

The “Research experiences for undergraduates (REU) – emerging issues in computer networking” is a national science foundation (NSF) funded

research program¹[1] at Columbus State University (CSU) [2]. The objective of the REU program at CSU is to provide an opportunity for eight undergraduates, primarily underrepresented minority and women students, to conduct research in emerging issues in computer networking [3]. Each student will receive 10 weeks stipend to do research in the summers of 2004 and 2005 at CSU. Dr. Yang, Dr. Bhagyavati and Dr. Kurkovsky will be responsible for coordinating all aspects of the program. Together with four additional faculty, they will serve as research mentors for the participating undergraduates.

The program targets students who have completed their sophomore or junior year of study, have already taken a computer networks course, and have significant knowledge of at least one high level programming language. We expect to recruit four students from smaller, primarily undergraduate institutions with limited research resources in the southeast area. Emphasis is placed on the recruitment of minority and women students.

The intellectual merits of the REU program at CSU are as follows. First, the program will provide the opportunity for undergraduate students to gain useful research experience in the exciting area of emerging issues in computer networking. Second, the program will empower the students with general research methods, specific skills and techniques in this area, and presentation and writing skills.

The REU program at CSU will also produce broader impacts. First, the program will bring useful resources that the research community can use and develop further. Research results gained from these projects will be valuable for further research on these topics. Second, the program will also bring useful educational resources. The participating faculty are interested in and teach courses in

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computer networks, wireless communications, and network security. The experience from this program will be carried into the course work in the form of projects. Third, this program will encourage undergraduate students to continue their graduate study and dedicate a career to computer science research. Fourth, the program will attract and increase the participation of underrepresented groups in higher education.

In the paper, we will describe the REU program at CSU in detail. The rest of the paper is organized as follows. Section 2 gives an overview of the program. Section 3 describes student activities. Section 4 is focused on research environment. Section 5 describes the student recruitment and selection plan. Section 6 is focused on project evaluation and assessment. Section 7 summarizes the paper.

2. OVERVIEW OF THE PROGRAM

The objective of the REU program at CSU is to provide an opportunity for eight undergraduates, primarily underrepresented minority and women students, to conduct research in emerging issues in computer networking. Research topics include switch scheduling, QoS in networking, wireless applications, network security, grid computing, and web services. Our goal is to offer each dedicated student an intensive and meaningful research experience that will encourage them to continue their graduate study and dedicate a career to computer science research.

Intellectual Focus

The intellectual focus of the proposed program is to expose undergraduate students to the exciting research area of emerging issues in computer networking. The program will empower the students with general research methods, specific skills and techniques in this area, and presentation and writing skills. Research topics include switch scheduling, QoS in networking, wireless applications, network security, grid computing, and web services. This focus was selected because it is an active research area with a wealth of applications and it represents the research interests of the participating faculty. The wealth of existing and potential applications of the selected focus will greatly motivate and attract targeted undergraduate students. The match between the faculty's research interests and the selected focus of this program provides a natural setting for students to get involved in ongoing research projects,

and an opportunity to follow up on this research and continue to contribute to this area after completion of their REU participation.

Organizational Structure

Dr. Yang, Dr. Bhagyavati and Dr. Kurkovsky will be responsible for coordinating all aspects of the program. Dr. Yang is responsible for the planning, coordination, and execution of all tasks. Besides the overall organization of the REU site, Dr. Yang will closely supervise the academic aspect of the program. In detail, Dr. Yang will be responsible for the preparation of projects, management of student applications and the selection process, matching mentors and students, organization of faculty and student research seminars, and field trips.

Dr. Kurkovsky will be responsible for the logistics of the REU site, including establishment of a REU website, publicity of call for participation (mails and emails to targeted schools and departments), mailing of program package to participants, and management of student financial allocations, room, boarding, and meals.

Dr. Bhagyavati will be in charge of the assessment and evaluation of the REU site and student tracking, including assessment of mid-term student report, assessment of final report and formal oral presentation, collection of evaluation feedback, sending tracking requests and collection of feedback.

In addition, each of them will teach one independent study course (for one to three hours of credit) in the spring semester and mentor at least one student in the summer semester. One graduate assistant will be hired for helping the web development and administrative tasks.

Program Schedule

We expect to start the first REU site on emerging issues in computer networking in Summer 2004. Each spring semester is dedicated to project preparation, including student selection and independent study courses. Each summer semester is dedicated to project development. Each fall semester is dedicated to the evaluation of the project outcomes and preparing reports on this REU initiative to be disseminated throughout the academic and professional community. A detailed timetable has been devised [3].

The CS department of CSU [4] is committed to support the REU site. The CS department will reserve one lab for the REU site. CSU will provide support for the summer participants including room-and-board, and the use of all student facilities on

campus, such as library, student union, recreational centers, the student health center, and bookstore.

3. PROGRAM ACTIVITIES

Organization of the Activities

The theme for the program is to expose the students to a wide range of problems in this area and empower the students with general research methods, specific skills and techniques in this area, and presentation and writing skills. The REU program will have two phases: independent study in each spring semester and research in each summer semester.

To better prepare students for the research projects, an independent study course (for one to three credit hours) on each research topic will be open for students in the second half of each spring semester. The independent study course is dedicated to literature research and project preparation. In this course, the mentor will assign related background materials and research papers for students to read, and students will report their readings and discuss their findings with their mentors. After the course, the students will be able to choose the research projects that best suit their interests. In addition, such a course can be applied to the student's degree program.

In the summer semester, students will work for 10 weeks on their research projects under the guidance of their mentors. The students will conduct research in a variety of environments: closely with a faculty member, with other students (in a team), and independently. The students are required to meet with their mentors at least twice a week, attend faculty and students research seminars, and communicate research results through presentations and written reports. Research reports will be disseminated through the project website. Joint research activities with students in the REU site at Auburn University and University of Alabama – Tuscaloosa will also be arranged [5].

We strongly encourage students to submit their reports to professional conferences. The project team with the best project report will be provided the travel allowance to attend a domestic conference to gain a broader experience about research as a significant part of the profession. We also encourage students to be enrolled in professional societies, such as Institute of Electrical and Electronic Engineers (IEEE) [6], Association of Computing

Machinery (ACM) [7], and Society of Women Engineers (SWE) [8].

Examples of Projects

In each spring semester, the investigators and participating mentors will devise up-to-date research projects related to the focus area of this initiative. In the following, we list some sample research projects [3].

- 1) Development of DiffServ supporting scheduling algorithms for high-speed switches/routers. This project will explore and develop DiffServ supporting scheduling algorithms with low implementation complexity for input-queuing (IQ) switches. This project will proceed in the following steps: (1) study DiffServ architecture, (2) investigate existing QoS supporting scheduling algorithms for IQ switches; (3) develop new DiffServ supporting scheduling algorithms and analyze their implementation complexity; (4) simulate the proposed algorithms and compare them with existing ones. Students participating in this project will be required to have programming experience in C/C++.
- 2) Development of efficient scheduling algorithms for multi-stage switches/routers. This project will explore and develop efficient scheduling algorithms with low implementation complexity for multi-stage switches/routers. In this project, the students need to (1) study multi-stage switch/router architectures, (2) investigate existing scheduling algorithms for multi-stage switches/routers; (3) develop new scheduling algorithms and analyze their implementation complexity; (4) simulate the proposed algorithms and compare them with existing ones. Students participating in this project will be required to have programming experience in C/C++.
- 3) Developing wireless applications. In this project, students will program applications designed to be executed on mobile devices such as cellular telephones and personal digital assistants. Applications will need to be robust and execute with the limited resources available on these mobile devices. As the first step, feasible applications are determined. The next step is to determine the best tool for implementing the application. Finally, the application is developed and tested. Prior knowledge of computer networking is assumed. Knowledge of languages such as hypertext markup language (HTML) or wireless markup language (WML) is preferred, but not required.

- 4) Automated vulnerability scanning. A vulnerability scan is a powerful tool in assessing the vulnerabilities of a computer on a network. Using widely available tools such as nessus, students participating in this project will attempt to periodically scan a computer when it is connected to a network. Students will first analyze the weaknesses inherent in current scanning tools, such as lack of automation. Then they will design and develop a client-server based vulnerability scan service that is automated. Students are required to have programming knowledge in any object-oriented language. Linux knowledge is preferred, but not required.
- 5) ISP anomaly detection for home users. Similar to a credit card company watching for suspect transactions, we consider an anomaly detection system for home users. In this project, students will develop a mechanism which allows an ISP to evaluate consumer usage patterns and identify deviations from these patterns to detect possible hostile activity. These basic patterns should include layer 4 information, direction of traffic flows, and time of day usage patterns. Students are required to have programming knowledge in any object-oriented language.
- 6) Mobile devices and grid computing. Students participating in this project will study the basics of grid architecture implemented in IBM Globus Project and its possible applications for grid computing. The project will be conducted in the following steps: (1) study the basics of grid architecture; (2) study potential applications of grid computing for mobile and embedded devices; (3) for a chosen application, design the necessary infrastructure for bridging it to Globus. Students participating in this project will be expected to have programming experience in C/C++ and/or Java.
- 7) Implementation of XML web services. Students participating in this project will study the architecture of extensive markup language (XML) Web Services, research issues of interoperability among Web Services based on different platforms, and implement applications using Web Services. In particular, students will investigate how Web Services are implemented in Microsoft .NET Framework and in Java. Students will be offered a variety of application projects, which can be implemented using Web Services.

4. RESEARCH ENVIRONMENT

The CS department at CSU is committed to support the REU program. The CS department offers a variety of degree programs including a Master degree program in Applied Computer Science, a Bachelor degree program in Computer Systems or Applied Computer Science, an Associate in Computer Science, a Minor in Computer Science, and a Certificate in Data Processing [4]. In May 2003, the CS department moved in the state-of-the-art Center of Commerce and Technology (CCT) building which has three general computer laboratories. In addition, the department has four well-equipped labs exclusively for CS students, including the Wireless Applications, Research and Project (WARP) lab, and the Security and Assurance of Information Lab (SAIL) [4]. The department will reserve one lab for the program usage. CSU will provide library access to each student.

Currently, the CS department has twelve full-time faculty members. Their research areas include computer networks, wireless communications, information security, software engineering, etc. Seven of them have agreed to serve as research mentors for the REU program. The three in-charge faculty have research experience in the proposed field, organization skills, and advising experience for undergraduates, which will greatly help the success of the REU site.

5. STUDENT RECRUITMENT AND SELECTION

We aim our recruiting effort at CSU and 2 and 4-year undergraduate institutions in the southeast area, with the emphasis on underrepresented minority and women students. An interactive web site is set up to serve as the focal point for the project [3]. It will provide information on the REU program at CSU, research projects, application and evaluation forms, and CSU in general. Hardcopy and email announcements will be sent to all Computer Science, Information Technology, and other closely related departments in the targeting 2 and 4-year undergraduate institutions. Individual phone calls will be made to department chairs/heads and faculty members of institutions with close relationship to encourage their students to apply. The three in-charge faculty will be responsible for answering any question that faculty or applicants may have concerning the program.

The project website will provide information about the application and selection process. The requirements for application include

- US citizen or permanent resident
- Has completed sophomore or junior year of study in computer science, information technology, computer engineering, software engineering, or a closely related field
- GPA 3.0 or above
- Programming knowledge in C, C++, or Java

In addition, we will clearly state that the objective of encouraging minorities, women, and students from 2 or 4-year undergraduate institutions. Each application should include

- Application form (on the web)
- College transcript(s)
- One page statement of research interest
- 2 letters of recommendation from faculty who have worked with the applicant

After the closing date of applications, all applicants will be checked for meeting eligibility requirements. All eligible applications will be ranked according to the following criteria.

- Academic performance
- Recommendations
- Matching of research interest with the project
- Underrepresented status (women, minorities, and neighboring undergraduate institutions)

The application review committee consists of three in-charge faculty. Each committee member will first make an independent ranking of the eligible applications. Then the committee will conduct a meeting to build ranking consensus and ensure that students from neighboring undergraduate institutions must be at least 50% and minority and women students are adequately represented.

Up to twelve eligible applicants will be selected and enrolled in independent study courses opened in the second half of the spring semester. The selected students will be given 2 weeks to accept or reject the offer. Alternates will then be notified when positions become available. After the independent study courses, eight outstanding applicants will be selected to continue their research projects in the summer semester.

Each participating student will receive \$3000 stipend to support their research at CSU. They will also receive \$2000 living allowance and \$400 travel allowance. CSU will provide on-campus house to accommodate participating students. Two field trips will also be planned to expose students the real working environment. To provide casual

communication environment among students and faculty, social activities will be arranged throughout the program in the department or local attractions.

6. PROJECT EVALUATION AND REPORTING

Our evaluation plan includes two aspects: technical program and project experience. The technical program evaluation will focus on the scholarly progress of the students; while the project experience evaluation will focus on all other associated activities.

Technical Program Evaluation

We will keep student portfolios which consist of their project deliverables, such as reading reports in the independent study course, analysis and design documents, reports, and records of the following activities:

- 1) Weekly-meetings: Students have at least two meetings per week with their mentors. During the meeting, students are expected to report their progress and discuss problems encountered during the program.
- 2) Weekly student status report: Students need to turn in a one-page report per week to their mentors. The report should describe their accomplishment in the past week and the goals for the next week and progress in the overall project.
- 3) Oral mid-semester report: An informal meeting is scheduled for all students and faculty mentors in the 6th week. Students should address all subjects learned, progress toward the overall research goals, and a refined plan to reach the goals.
- 4) Final report and formal oral presentation: Each student is required to write a final report describing their research results. All participants will receive copies of all the reports. On the Friday of the last week, each student/team will hold a seminar to present their research results. Seminars are open to public.

Student portfolios are monitored and evaluated by mentors. In the middle and end of the summer semester, these portfolios will be analyzed and assessed by the three in-charge faculty. Feedback will be returned to the students and mentors. We will select the project team with the best project report to receive the travel allowance to a domestic professional meeting.

Project Experience Evaluation

The REU program should benefit students and faculty. We consider devising two types of forms, one for the students and one for the faculty members, to evaluate the overall experience.

Student form includes the following items: application and selection, independent study course, housing and local arrangement, research project, research environment, faculty interactions, student interactions, workload and schedule, overall value of the program, comments and suggestions.

Faculty form includes student quality and composition, interaction with students, research quality, overall value of the program, and comments and suggestions.

Publications and Reports

We strongly encourage students to work with their mentors and submit their reports to a regional or national professional conference. Participating in a conference will be a valuable experience for an undergraduate student to meet and communicate with researchers in the field.

We will also consider putting student reports on the project website for disseminating their research results. This is also a valuable tool to recruit future applicants. In addition, the three in-charge faculty will write an annual report summarizing the project. The contents will include recruitment and selection results, summary for schedule and activities, student reports, and evaluation summary.

As educators, we care about the future of our students. We will send status requests to former participants and post their latest status of the former program participants on the project website. This information is useful for identifying career patterns for the participants and attracting future participants.

7. SUMMARY

In this paper, we describe the NSF funded research program, “REU site: research experiences for undergraduates (REU) – emerging issues in computer networking” at Columbus State University (CSU). The objective of the REU program is to provide an opportunity for eight undergraduates, primarily underrepresented minority and women students, to conduct research in emerging issues in computer networking. Each student will receive 10 weeks stipend to do research in the summers of 2004 and 2005 at CSU. Seven faculty will serve as research mentors for the participating undergraduates. The program targets students who

have completed their sophomore or junior year of study from CSU and smaller, primarily undergraduate institutions with limited research resources in the southeast area with emphasis put on minority and women students. The REU program at CSU will provide the opportunity for undergraduate students to gain useful research experience in the exciting area of emerging issues in computer networking as well as empower the students with general research methods, specific skills and techniques in this area, and presentation and writing skills. The REU program at CSU will also produce broader impacts to the research and education community.

8. REFERENCES

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