Research Experiences for Undergraduates in High Performance Computing and Communications

The Northeast Parallel Architectures Center (NPAC) at Syracuse University (SU), a proposed site for a summer Research Experiences for Undergraduates (REU) program, requests NSF support for twelve (12) REU participants per year for a three year period, 1995-1997. This program will involve research in high-performance computing and communications (HPCC), and will combine in a coherent way the resources available in the following divisions of Syracuse University: the Northeast Parallel Architectures Center (NPAC), the College of Engineering and Computer Science, the Department of Physics, and the Newhouse School of Public Communications.

The research stipends will be awarded to talented and motivated undergraduate students entering their junior and senior years. At least 8 of the 12 REU participants will be selected from external applicants attending other colleges and universities. A particular effort will be made to attract women, minorities and disabled students. The proposed REU project is a ten (10) week summer program. Syracuse University will make a major contribution to the project of approximately \$50,000 per year. We request \$75,600 in annual support from the National Science Foundation.

The proposed program will be a continuation of the successful REU program in computer science and computational physics run by NPAC over the past four years. During those years, the scope of NPAC activities has broadened from computer science and computational science to a range of activities concerned with the development and application of high-performance computing and communications, including applications in industry and education, and the study of high-speed network technologies and their use in areas such as interactive multimedia communications. Hence the current proposal is for a more general interdisciplinary program, with the common focus being high-performance computing and communications.

Sixteen full-time faculty members from NPAC and various academic departments at Syracuse University have expressed interest in supervising the REU participants. Most of these faculty have successfully supervised students during the past four years of the NPAC REU program. Projects proposed by the faculty members include research in the areas of parallel computing languages, software and algorithms, computational fluid dynamics, computational physics, optimization problems, computer graphics and virtual reality, parallel databases, natural language processing, high-speed networking and ATM technologies, development and application of multimedia technologies such as video-on-demand and the World Wide Web, and the use of HPCC for education.

Nature of Student Activities

Scope of the Program and Proposed Activities

This aim of this project is to create an interdisciplinary program of undergraduate research in high-performance computing and communications (HPCC). The project reflects NPAC's research interests in the development and application of parallel and distributed computing, and interdisciplinary study in the areas of computer science, computational science and engineering, and multimedia communications. NPAC and Syracuse University bring to this program a unique combination of world-class computational resources; strong support for, and experience with, interdisciplinary work; and a strong commitment to undergraduate and graduate teaching and research programs, including hosting an REU site program for the past 4 years.

The program will stress a breadth of interdisciplinary projects, however these need to be focussed in a coherent way. From our experiences so far with the REU program, we have found that this works well when the student projects are closely integrated with the many collaborative projects in HPCC technologies that NPAC has with the various academic departments at Syracuse, and this will be our strategy for the program. There will be a diverse mixture of projects in the use of HPCC for both computational science and engineering, and multimedia communications. The research projects in each of these areas will focus on either applications or computer science issues.

We aim to create a diverse group of student participants, in terms of academic major, home academic institution, computing experience, sex, and ethnic/racial background. We attempt to foster an environment where the students form a very close-knit group. This group atmosphere allows students to work together and help each other, with those students having more advanced computing skills helping those with a weaker computing background, and with students sharing ideas and insights from different disciplines.

Our philosophy is that the 10 week REU program should be a real-world research experience in miniature. This will enhance the participants' understanding of, and interest in, research and graduate studies. Students accepted to the program will be provided with information describing the research areas of the prospective faculty supervisors and possible research projects, as they would for graduate school. We start the program with background training in HPCC, and then the students make the final choice of their research project. The students prepare a research proposal and give a presentation of their proposed research, do supervised research work with their advisor, attend weekly seminars and informal group meetings, write a poster and paper on the results, and present their work at a workshop at the end of the program.

Training

The first week of the program provides intensive training in high-performance computing and communications. Some additional training sessions on technical writing, document preparation, and graphics and visualization are given in the following weeks. The training sessions are organized as a series of lectures in the mornings, with guided laboratory exercises on many of the topics given in afternoon hands-on lab sessions held in a facility with 20 IBM RS/6000 workstations. In addition, the evenings are devoted to more informal labs where background tutorials are given on topics such as Unix, text editing, and programming languages. In these labs, students are encouraged to work together; those with more computing experience share their expertise and help in bringing the other students up to a knowledge level that allows them to work effectively on their research project.

The topics for the training sessions in the 1994 program were:

Introduction to Parallel Computing

Numerical Methods

Data Parallel Programming in Fortran 90

Parallel Computer Architectures

Mosaic and the World Wide Web

Networking and Information Technologies

Message-passing Programming

High Performance Fortran

Scientific Visualization

Additional training sessions were given in the following weeks:

Writing a Research Proposal

The Latex publishing system

The AVS visualization system

Writing a Research Paper

The first week of training is very intensive, but we find that it is important to get the students started on projects as soon as possible. The other benefit of the week of intensive activities is that we build the sense of cameraderie and communication in the group.

The training lectures are provided primarily by NPAC staff. We also have a graduate assistant for the program who presents the evening lab sessions. The training in technical writing is provided by a member of the faculty in the Writing Program of the School of Arts and Sciences.

Research

During the selection process, we try to choose students whose interests and background appear to match well with available research projects. We recommend these projects to the appropriate students, however the students are free to choose from any of the available projects.

On the afternoon of the first day of the program, potential mentors briefly describe their research interests. This session is followed immediately by a social event, during which participants and faculty get to know one another and interact individually to ask questions and explore mutual interests. During the first 2 weeks of the program, time is allocated for students to talk to the research advisors about the various projects, with the final choices being made by the end of the second week.

The research advisors try to keep the scientific and computational scope of the research project simple, yet meaningful. A strong effort is made to provide challenging problems that are not beyond the participant's background and grasp, and for which useful results can be obtained within the 10 week summer program. Students participate in a research project under the supervision of one of the research advisors. Sustained personal guidance is given to the students by their supervisors to ensure that each of the participants feels confident to conduct their research project.

We also hold informal weekly research update meetings, in which students comment on their progress, discuss problems, and make suggestions. Administrative issues are also addressed. Students can also make effective use of an email alias provided for the group in seeking solutions to problems.

Students have unlimited access to NPAC's computing facilities for both their research projects and the training sessions. When the students arrive, they are given computer accounts for NPAC's facilities and also for the main campus computing center, so that all of Syracuse University's computer clusters are available for their use. In addition, we designate a number of workstations in the NPAC graduate student office areas for the shared use of the REU students. This area is adjacent to the NPAC senior staff offices and the NPAC library resources. This is helpful in integrating the students into the department, and getting them to interact with NPAC staff and graduate students.

Seminars

A weekly seminar on a range of relevant topics is given by faculty members from various disciplines. In past years, seminar topics have included chaotic systems, computational fluid dynamics, Monte Carlo simulation, computational geometry, genetic algorithms, neural networks, image processing, virtual computing environments, virtual reality, weather prediction, telemedicine, and industrial applications of HPCC.

One of the topics addressed concerns the ethical issues raised as communications increasingly becomes computer-generated and computer-mediated. The talk, by Prof. Joan Deppa of the Newhouse School of Public Communications, includes recent mass media examples as well as looking at issues that may arise with computing technology of the future.

Presentations

After the students have decided on their research project and had some time to become familiar with the work that is required, they write a short proposal and give a presentation on their proposed research for the summer.

In the last week of the program we organize a three-day workshop in which all the students give half-hour presentations on the work they have accomplished in the program. This is done as a combined presentation with students from the Mechanical and Aerospace Engineering REU program at Syracuse University. The research advisors provide assistance and advice in the preparation of the presentations. Research advisors, graduate students and other faculty members attend the workshop and give constructive feedback on the students' talks.

The students also create "electronic posters" presenting an overview of their work, which are accessible from the NPAC World Wide Web server.

Papers

During the last week of the program the students prepare a final report on their individual projects, with help from their research advisors. These papers are published in the *Journal of Undergraduate Research in High-Performance Computing*, which is made freely available as an NPAC technical report. Some of the papers may also be submitted to undergraduate research journals. Some research work may lead to papers being submitted for publication in appropriate technical journals, particularly if the student chooses to continue the work during the following academic year, for example as an honors project or senior thesis.

Apart from being provided with classes on technical writing, the students each have a one-on-one session where the writing instructor reviews their draft papers and suggests improvements in style and clarity.

Evaluation of the Program

A variety of information is collected to facilitate evaluation of the program. Evaluation forms are distributed to students at the at the end of the second week (after the training program) and at the end of the program. Participants are also asked to submit a final written evaluation in the form of a personal letter to Professor Fox. Faculty mentors also provide comments about the program. Additional items used in the evaluation of the program include the materials produced by the participants: their proposals, posters, presentations, and final reports.

As a result of this feedback, we believe we have been able to improve the program every year. The overall evaluations of the program by the students have been overwhelmingly positive.

Plans for Post Participation Activities

Students are encouraged to continue their research at their home institution during the academic year following their participation. Their computer accounts and access to NPAC facilities are continued for a year after the completion of the program, and longer if requested. Many of the students continue working in the area of their research project as a senior honors thesis at their home institution, with external students staying in touch with their REU advisors via electronic mail.

Faculty Supervisors

Prof. Geoffrey Fox is to serve as the director of the proposed REU project. He has served in a similar project at the California Institute of Technology between the years 1985-1990, and as director of the NPAC REU program for 1991-1994.

Prof. Nancy McCracken and Dr Paul Coddington will also be involved in the organization and running of the program. They have both been actively involved in co-ordination, administration, teaching, and research activities for the NPAC REU program over the past four years.

Sixteen faculty members from NPAC, the College of Engineering and Computer Science, the Department of Physics, and the Newhouse School of Public Communications will be available to devote the needed time and effort to guide and supervise the research efforts of the REU participants. Almost all of these faculty members have been involved in supervising undergraduate research in previous REU programs, and in some cases in undergradate research programs at other institutions. Biographical sketches outlining the academic and research backgrounds of some of the participating faculty members are appended to this proposal. Salaries for research advisors will not be included in the NSF budget request.

Suggested Research Projects

Faculty advisors have proposed a broad spectrum of possible undergraduate projects, including research in the areas of parallel computing languages, software and algorithms, computational fluid dynamics, computational physics, optimization problems, computer graphics and virtual reality, parallel databases, natural language processing, high-speed networking and ATM technologies, development and application of multimedia technologies such as video-on-demand and the World Wide Web, and the use of HPCC for education.

Based on our prior experience with past projects, the capabilities of the students, and the time constraints involved in a summer program, examples of possible undergraduate research projects are listed below. Some of these are continuations of projects from previous years, others are new projects.

High Performance Fortran Application Kernels

NPAC is one of the institutions leading the development of High Performance Fortran (HPF), a superset of Fortran 90 that is portable between any computer architecture. The student will work on a subset of a large project to create exemplar program kernels in High Performance Fortran for a wide range of applications, in order to test the suitability of the language and the performance of HPF compilers under development. The application area can be contingent on the student's background and interests. This project would provide good experience in writing parallel programs.

Interactive Multimedia Information Systems

This project will experiment with new forms of interactive multimedia in networked information systems with links to the Internet. The on-campus portion may involve video-on-demand, as well as system design and complex graphics. The work will be based on Orange Source, an on-line service created by Syracuse students which also serves as a test bed for advanced multimedia applications.

Optimization using Simulated Annealing and Tempering

Simulated annealing is a very powerful and general optimization technique. This project involves working on improving simulated annealing by using ideas from statistical mechanics, including a novel technique known as simulated tempering.

Testing Parallel Random Number Generators

Random number generators are widely used in computer simulation, but high quality generators with good randomness properties are hard to find, as are good tests for randomness. This is especially true for parallel computers, where the random numbers on different processors can be correlated. This project will develop a suite of programs for testing the randomness properties of parallel random number generators, including Monte Carlo and statistical tests.

Parallel Algorithms for Computational Physics Simulations

Students will work on the development of parallel programs and algorithms in an area of computational physics. Possible application areas include disordered systems in condensed matter physics, spin models of magnetism, numerical relativity, and random surface models of quantum gravity.

Natural Language Text Retrieval

The DR-LINK system provides intelligent text retrieval by using natural language processing to find linguistic characteristics of the query and use them in retrieving text. This approach requires more processing power than traditional methods based on word matching and high performance computing may help achieve good performance. A student working in this area would help port the text retrieval system to the IBM SP2 from its current workstation base or participate in ongoing research in detecting meaningful linguistic characteristics through natural language processing (or both).

Data Mining

Investigate methods for searching for data on a specific subject using the Internet, in particular new ideas such as intelligent agents or "knowbots". Also of interest are methods for caching parts of the World Wide Web to allow for fast searching and local retrieval.

The Living Textbook

The Living Textbook Project is a joint project between NPAC, the School of Education, NYNEX, and Columbia University to define how new communication technologies will enhance the quality of teaching and learning. Several pilot projects will design multimedia educational applications and tools appropriate for high-speed computing and communications networks. One possible student project is interfacing interactive simulations of various natural phenomena such as storms with interactive learning modules describing the phenomena. Another is working on Kid's Web, a World Wide Web digital library designed for schoolchildren.

ASKERIC - Access to Educational Resources Digital Library

AskERIC is a project at Syracuse University to provide educators with easy access to the national Educational Resources Information Clearinghouse (ERIC). ERIC is beginning the transition towards digitized information, and this project will look into the issues involved in storing educational materials in a digital library and accessing them across a network. These include document format, compression, database searching, the user interface, and what can be achieved with currently available hardware.

Computer-Aided Instruction Using Mosaic

Develop hypertext modules for computer-assisted instruction of an undergraduate class (such as calculus) using Mosaic.

Parallel Rendering Algorithms

Work on a parallel rendering program designed to produce real-time three dimensional graphics. One of the applications of this program is to combine and display digital elevation and satellite image data to construct realistic 3-D images of terrain in order to simulate an interactive flight over New York state or Mars.

Virtual Reality

Install and investigate available public domain VR packages and develop demonstrations using these systems.

Parallel Methods for Computational Fluid Dynamics

This project involves the evaluation of different solution schemes for computational fluid dynamics. The REU participant will modify an existing simulation program for supersonic mixing layers to evaluate effects of alternate approximation schemes.

Visualization of Unsteady Flows

The purpose of this project is to develop an environment for the visualization of unsteady fluid flow simulations. Input data will be obtained from existing codes. The REU participant will learn to use visualization software and prepare modules for visualizing instantaneous flow fields and animating sequences of images.

Video Database Browsing/Indexing

This involves the use of state-of-the-art speech recognition software to produce automatic indexing into a video database based on its audio content, with either text or audio keyword input from the user.

Parallel Graph Partitioning Algorithms

Optimization and performance evaluation of different parallel graph partitioning algorithms on the CM-5.

Application for the Virtual Computing Environment

A network of supercomputers and high-performance workstations appears to be a cost-effective approach to provide adequate computing resources for the Grand National Challenge problems. Such a collection of computers and supporting software environment is called a Virtual Computing Environment. This project will involve development of an application that can utilize dynamically the computing resources of different parallel computers available at NPAC.

The Research Environment

Syracuse University

Syracuse University is one of the largest private universities in the United States. It is located in the center of New York State, a short distance from some of the state's most spectacular scenic areas. Its twelve colleges provide more than 200 different programs of study that lead to degrees in arts and sciences, architecture, computer science, education, engineering, human development, information studies, management, nursing, public communications, social work and visual and performing arts.

Syracuse University has about 12,000 undergraduate students, 2,130 full time and 2,340 part time graduate students, and 900 full-time faculty. The activities at Syracuse University takes place in more than 324 buildings on its extended campus of 900 acres.

The Northeast Parallel Architectures Center

The Northeast Parallel Architectures Center (NPAC) will run the REU program and provide computing, administrative and technical support. NPAC was established in 1987 to foster research and training in high-performance computing technologies. NPAC is a member of the Center for Research in Parallel Computation (CRPC), an NSF Science and Technology Center. Professor Geoffrey C. Fox, a pioneer in the development and application of parallel-architecture computers, joined NPAC as its Director in 1990. Professor Fox has established an ambitious program that includes basic research, industrial applications, and educational opportunities for undergraduate and graduate students. As part of this initiative, NPAC has conducted a summer REU program annually since 1991.

NPAC has world-class facilities, with leading-edge high-performance computers and high-speed networking technologies. These include a 32 node Connection Machine model CM-5 with vector units, a 16 node IBM SP2 with a high-speed switch and 192 Mbytes of RAM and 9 Gbytes of disk per node, an 8 processor IBM RS/6000 cluster connected by an Allnode switch, a 64 node nCUBE2 with 200 Gbytes of associated disk accessed by a parallel I/O system, an 8 node DEC Alpha workstation cluster connected by a Gigaswitch FDDI network, a 16 node Intel iPSC860, two DECmpp 1200 massively parallel SIMD machines with 8K and 16K processors respectively, Sun and Silicon Graphics workstations with real-time digital video capability, Macintosh computers with multimedia capability and peripherals such as color scanners and an Apple QuickTake digital camera, and an SGI Challenge hosting a FORE ATM switch connected to NYNet, a prototype Gigabit optical fiber network connecting NPAC, Cornell University, and Rome Laboratory. NYNet will soon be extended to four high schools in the Syracuse school district.

As in previous years, NPAC's staff will provide a week of training in high-performance computing and communications, and particularly parallel computing, for the students at the start of the REU program. A workstation laboratory consisting of twenty IBM RS/6000 workstations is used for hands-on training and research for the program. These and other workstations at NPAC and Syracuse University are also available for research work.

The facilities at NPAC, which are valued at over $10 million, will be provided for the use of the REU students at no cost to this proposal. The students are invariably very excited to be allowed access to these world-class facilities, particularly since many of them are from small schools which do not have any high-performance computers.

NPAC is actively involved in a wide range of interdisciplinary collaborative research projects involving many departments at Syracuse University, including the School of Computer and Information Science (CIS), the Department of Electrical and Computer Engineering, the School of Information Studies, the Department of Physics, the Department of Mechanical and Aerospace Engineering, the Newhouse School of Public Communications, the School of Education, and the Center of Computer Applications and Software Engineering. These programs build on the experiences of NPAC's director, Geoffrey Fox, at Caltech, where he led the Caltech Concurrent Computation Program, which pioneered an interdisciplinary approach to high-performance computing with close coupling between physics, computer science and other scientific application areas.

The center and the faculty members involved also have a strong commitment to developing new educational programs in computational science. A group of such faculty, the Computational Science Faculty, have developed new courses and degree programs, which are administered in CIS. At the undergraduate level, a minor in computational science includes new courses in computational science, scientific programming and computational science projects. At the graduate level, students can take courses in computational science, applied math, computer science and an application project to get a Certificate in Computational Science or take the newly accredited Master's Degree in Computational Science.

School of Public Communications

The Newhouse School of Public Communications operates in one of the world's most complete centers for the study of mass communications. The two-building S.I. Newhouse Communications Center is fully equipped with computer facilities, photography laboratories, and television and audio studios and equipment. The Newhouse School is one of the most prestigious departments in its field, attracting outstanding students.

The Newhouse School has been involved in interactive telecommunications and multimedia since 1985. A group of its students founded Orange Source, which provides an on-line information service to students through the campus computer clusters and kiosks in the Schine Student Center and in some dormitories. Orange Source also serves as a test bed for new interactive multimedia applications.

Results from Prior NSF Support

For the past four years NPAC has hosted an REU Site program entitled "Undergraduate Research in Computer Science and Computational Physics", under two NSF grants: Grant No. CDA-9100833 ($35,720 for 1991) and Grant No. CDA-9200577 ($46,000 per year for 1992-94). This developed into a somewhat broader interdisciplinary program encompassing applications of high-performance computing in computational science and engineering. During this time the NPAC REU program hosted a total of 55 undergraduate students, with 30 faculty advisors from a number of different academic departments participating. A total of 44 students were supported by the NSF REU grants (8 in the first year, 12 in each of the three subsequent years), and 11 students were supported by other funding.

The students studied a variety of problems in computer science and computational science and engineering, using NPAC's computer facilities to study or develop software and to perform simulations. They wrote research papers which have been compiled and published in the *Journal of Undergraduate Research in High-Performance Computing*, Volumes 1 to 4. The journal is available from NPAC at no cost, either by requesting a hardcopy or downloading an electronic version of the journal (or the individual papers) from the NPAC World Wide Web or ftp servers. The papers and the accompanying seminar presentations of their work given by the students were were generally of a very high standard.

In previous years, the participants were asked to make a poster describing their project. These were prominently displayed at NPAC, as well as at meetings and conferences such as Supercomputing '93, which was attended by two of the 1993 NPAC REU students. For the 1994 program, each student made an "electronic poster" describing their work, using the hypermedia capabilities of the World Wide Web (WWW). These electronic hypertext posters can be accessed through the NPAC WWW server by anyone on the Internet with a Web browser such as NCSA Mosaic. The students also created their own "home pages", and we created a home page for the 1994 NPAC REU program with links to information on the program, the student home pages, project posters, abstracts and papers. The Web address or URL of the NPAC REU home page is `http://www.npac.syr.edu/REU/reu94/reuhomepage.html`

The goal of the REU program is to encourage students to undertake research careers in mathematics, science and engineering. Probably the best measure of the success of our program comes from the overwhelmingly positive evaluations of the students, who are invariably extremely grateful for the opportunity for research experience allowed by the REU program, and enthusiastic about continuing their studies after this experience. In many cases the students began the program not knowing what research entailed or whether they wanted to attend graduate school, and have become very excited by their research work and now hope to enter graduate school and pursue research careers. Those students who were already planning to attend grad school generally expressed the view that they had received valuable insight into how research was conducted, that had strengthened their desire to pursue this goal. Note that while the great majority of these students go on to attend graduate school, only a small number (around 10%) of them pursue their graduate studies at Syracuse. In this sense, the NPAC REU program is providing a service of broad national significance.

Here are just a few examples of comments made by NPAC REU students in their evaluation letters:

> "The opportunity to get involved in an actual research project...has helped me to solidify my desires to continue my education." (Michael Harry, 1992, now a graduate student in computer science working at NPAC)
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> "Before I was a member of the REU Program, I had planned on looking for a job after graduation. ...Another result of the REU program is an increased confidence in my academic ability. Because of the credentials the REU Program has given me, I have made graduate school a top priority and have decided to apply to the best applied math schools in the country, schools I never dreamed of attending but now consider within my reach." (Thomas Rose, 1992)
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> "...I came to this program with very little knowledge of computers and perhaps even a little fear of them. This summer I walk away with a lot of learning under my belt as well as a new

found confidence in computing. I have now decided that I want my career to center on the computer aspect of engineering." (Jennifer Rubbo, 1992, now a graduate student in Mechanical and Aerospace Engineering at Syracuse University)

"The students in the program worked in a microcosm of what I perceive to be the life of a researcher. This had two main effects. First of all, it gave us occupational training, i.e. we are that much closer to being professional scientists. ...Second, I believe that the REU helped many students shape their goals for their futures." (Thomas Willis, 1992, now a graduate student in mathematics at Syracuse University)

"My experience at Syracuse was incredible. The training sessions in parallel computing, the different talks and seminars presented, my project and the close interaction with my advisors have influenced my career path. ...Because of my experience at the Northeast Parallel Architectures Center, I [have] decided to attend graduate school and focus on parallel computational fluid dynamics." (Mario Campuzano, 1993, now a graduate student in Mechanical and Aerospace Engineering at Syracuse University)

"I found that this project and the extensive training program provided a firm and working foundation in parallel computing and the general skills needed in the realm of the scientist. This project solidified my interests in continuing towards more advanced degrees in the sciences." (Christopher Martin, 1993)

"...I will continue work on the research project at FSU during the coming year which will result in an honors thesis ...I am, moreover, quite determined to pursue a graduate degree in computational science." (Matthew Shore, 1993)

"When I started this REU, I had absolutely no research experience...The REU exposed me to research in the cutting edge of computer science, and has influenced me in my decision to pursue graduate studies in the future." (Pat Angeles, 1994)

"I think it is safe to say that it has greatly helped the careers and learning experience of everybody involved ..." (Jay Hui, 1994)

"I have learned a great deal, and the program has dramatically changed my life. I came the the program a 'shy' and 'dependent' individual, but after the program, I am more confident about myself and the decisions that I am about to make in the future. ...Before the program, I was undecided about graduate school. However I am very confident that I will be attending graduate school after my senior year." (Trang Tran, 1994)

"The people both in the program and running it were a great group. ...Thank you again for the opportunity that this summer has given me. I hope you will continue to provide college students with such opportunities for growth and learning." (Michelle Williams, 1994)

Some of the research performed by NPAC REU students has led to scientific publications, as listed below (the students are identified by asterisks). There are at least 7 additional journal papers based on REU research work in preparation.

1. T.J. Willis* and E.A. Bogucz, "Coupling Symbolic Processing with Parallel Numeric Computation," *Proceedings of the 6th SIAM Conference on Parallel Processing for Scientific Computing*, edited by R.F. Sincovec *et al.*, Society for Industrial and Applied Mathematics, Philadelphia, 1993, pp. 788-792.

2. Y.S. Han, C.R.P. Hartmann, and C.-C. Chen*, "Efficient Priority-First Search Maximum-Likelihood Soft-Decision Decoding of Linear Block Codes," *IEEE Transactions on Information Theory*, **39**, 1514 (1993).

3. Y.S. Han, C.R.P. Hartmann, and C.-C. Chen*, "Efficient Maximum-Likelihood Soft-Decision Decoding of Linear Block Codes Using Algorithm A*," *Proceedings of the 9th IEEE International Symposium on Information Theory*, San Antonio, 1993.

4. Y.S. Han, C.R.P. Hartmann, and C.-C. Chen*, "Efficient Maximum-Likelihood Soft-Decision Decoding of Linear Block Codes Using Algorithm A*," *Proceedings of the Sixth National Conference on Undergraduate Research*, Minneapolis, 1992.

5. D. Han, D.C. Melcher*, E.A. Schiff, and M. Silver, "Optical bias effects in electron-drift measurements and defect relaxation in a-Si:H," *Phys. Rev.* **B 48**, 8658 (1993).

6. E.A. Schiff, H.M. Branz, D. Han, D.C. Melcher*, and M. Silver, "Photocarrier drift and recombination in a-Si:H: The vital importance of defect relaxation," *J. Non-crystalline Solids*, **164-166**, 331 (1993).

7. T. Rose*, P. Coddington and E. Marinari, "Evaluation of Simulated Tempering for Optimization Problems", *Proceedings of the Seventh National Conference on Undergraduate Research*, Salt Lake City, 1993.

8. N. LaFontaine* and N. McCracken, "MIMD Implementation of Advanced Regional Prediction System", *Proceedings of the Seventh National Conference on Undergraduate Research*, Salt Lake City, 1993.

9. M. Harry*, D. Shiau and C. Hartmann, "An Efficient Parallel Implementation of SIMPLE", *Proceedings of the Seventh National Conference on Undergraduate Research*, Salt Lake City, 1993.

10. David G. Solt, Jr.*, "A Parallel Approach to Finding Maximum Planar Subgraphs," *Proceedings of the Sixth National Conference on Undergraduate Research*, Minneapolis, 1992.

Student Participants

Selection Procedure and Expected Profile of REU Participants

One of our goals in selecting participants for the REU program is to create a diverse group of students, in terms of academic major, home academic institution, computing experience, sex, and ethnic/racial background. Participants are specifically selected to represent a range of academic disciplines and prior computing experience, as is typical of cross-disciplinary research projects in high-performance computing and communications. Roughly half of the previous students in the program were majoring in computer science or computer engineering, while the rest included majors in physics, mathematics, engineering (mechanical, aerospace and bioengineering), visual arts, economics, and media communications.

We have found that students with more advanced computer science backgrounds will help others in learning about computing, while students with science and engineering backgrounds can help computer scientists learn about applications of HPCC. Students can exchange ideas and insight from different perspectives. The advantages of this approach are expressed in the following excerpt from an evaluation of the program written by one of the NPAC REU students:

> "One of the most unique aspects of the program was the ability to live and work with a group of students that seem brighter and more energetic than the typical student body at any university. For a mathematician, it's very valuable to discuss a mathematical problem, say, in terms of fluid dynamics with an engineer, and then to walk down the hall and discuss the concept in terms of quantum field theory with a physicist. Of course, when I sat down to write the code, I could peek over the cubicle divider and discuss the theory of parse-trees and hash tables with a computer scientist. Even if you disregard the project advisors, the NPAC REU qualifies, in my book, as a high-calibre think tank."

At least eight of the twelve participants supported by the NSF will be selected from academic institutions other than Syracuse University. We particularly target students from smaller schools who would otherwise not have access to high-performance computers, and are therefore extremely excited to be able to use the state-of-the-art facilities at NPAC. Also, some smaller schools do not have relevant graduate programs, so the students could otherwise not easily find out about research in their fields of interest.

On the basis of past experience we expect the greatest response from prospective participants in the Northeast region of the United States, so we target individual schools in this region. We have identified over one hundred appropriate institutions in this region. During the previous four years our program has attracted students from many diverse institutions in the Northeast, ranging from small schools such as Clarkson University, Eckerd College, St Bonaventure University, Bryn Mawr College, and St Michael's College, to larger universities including Boston University, Harvard, MIT, The Johns Hopkins University, University of Rochester, Rochester Institute of Technology, University of Pennsylvania, and SUNY Buffalo.

We also advertise the program nationally, which has resulted in the recruitment of students from Davidson College, Oberlin College, Auburn University, Rice University, Texas A&M, University of San Diego, University of Texas of the Permian Basin, University of Washington, University of San Francisco, University of Missouri, and Florida State University.

A special effort is made to select qualified women, minority and disabled participants. In our recruitment advertising, we strongly encourage applications from these groups. In the past three years of the NPAC REU program, we have had 13 women and 8 under-represented minority students out of a total of 44 participants. For example, in the most recent (1994) program, 5 of the 12 NSF REU students were women and 2 were from under-represented groups. We had received an acceptance from another minority student, but he was forced to withdraw at the last minute due to health problems. Two additional female students in the 1994 NPAC program were supported by the General Electric Foundation Faculty for the Future Program, a program for Syracuse University students that sponsors summer undergraduate research for minorities and women in the sciences and engineering, providing an excellent complement to the NSF REU program. NSF REU programs at Syracuse University have helped the university to be selected for this award from the General Electric Foundation. For the past three years the award has provided NPAC with two or three fellowships each year, and we expect this level of support to be continued in future years.

Recruitment Plan

The program is advertised in four ways. First, a poster, information packet, and application materials is mailed to engineering, computer science, and physics departments at 45 schools throughout the Northeast. Second, announcements of the program are posted electronically to relevant bulletin boards and news groups, and made available via the NPAC WWW server. Third, information is distributed at appropriate conferences and meetings. Fourth, information about the program is distributed widely within Syracuse University, with special efforts made to bring the program to the attention of women and members of under-represented groups through announcements in the classroom and by individual recruiting of well-qualified candidates by faculty members.

The advertising brochure includes information about the objectives of the program, as well as details such as the stipends, room and board, and duration of the program. A short description of the research areas pursued by the faculty supervisors involved, and some typical research projects, is included. Previous students have requested that they be given as much information as possible before the start of the program. We therefore plan to set up a WWW home page for the program before it has even begun, so students from across the country can access information about NPAC, the REU program, and the available research projects before they come to Syracuse.

Each applicant is asked to provide a curriculum vitae, two letters of recommendation, academic transcripts, and a short essay on why they wish to participate in the program. Students are selected by the project director and a panel of faculty members, taking into account the various goals stated above, and trying to achieve the best possible match between the students' interests and the available projects being offered. Preference is given to students entering their junior and senior years.

In the first year of our program, we received about 40 applications. The number of applicants has risen steadily in subsequent years, due to increased advertising and word-of-mouth, with past participants in the program recommending it to their fellow students. For the 1994 program we received about 100 applications, with 80 from external students, for only 12 positions. The quality of the 1994 applicants was extremely high, and the selection process correspondingly difficult. At least half of the applicants were outstanding, highly qualified students who were very enthusiastic about the program.