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SUBMITTED TO Supercomputing '91, Albuquerque Convention Center, November 18-22, 1991, Albuquerque, NM

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ABSTRACT

The national need for well trained scientists and engineers is more urgent today than ever before. Scientists who are trained in advanced computational techniques and have experience with multidisciplinary scientific collaboration are needed for both research and commercial applications if the United States is to maintain its productivity and technical edge in the world market. Many capable high school students, however, lose interest in pursuing scientific academic subjects or in considering science or engineering as a possible career.

An academic contest that progresses from a state-sponsored program to a national competition is a way of developing science and computing knowledge among high school students and teachers as well as instilling enthusiasm for science. This paper describes an academic-year long program for high school students in New Mexico. The unique features, method, and evaluation of the program are discussed.

INTRODUCTION

Since the launching of Sputnik by the USSR in the 1950s, the United States has realized the need for increased scientific knowledge at all educational levels to supply well trained scientists and engineers for research and industry. While science education has made significant progress, the nation today still has an urgent need for well trained scientists. If the U. S. is to maintain its productivity and technical edge, it must have scientists who are skilled in advanced computational techniques and experienced in multidisciplinary scientific collaboration.

To meet this need, a partnership of New Mexico businesses, universities, national laboratories and a state-wide, nonprofit electronics communication network joined with public and private high schools throughout the state to sponsor a computing and science competition. The competition known as the New Mexico High School Supercomputer Challenge was conceived in the summer of 1990 and conducted during the 1990-91 academic year.

The goals of the Challenge program include

- Expose a large number of students and teachers to computational subjects and experiences
- Increase the participants' level of interest in science and computing
- Promote careers in science and engineering
- Encourage students to compete academically and give them the experience and confidence to enter national competitions

• Utilize the science and computing expertise and resources available within the state for the benefit of high school teachers and students

The Challenge is a program that can be replicated in other states; it does not require a unique environment. A nationwide program of state competitions leading to the national level can provide in the scientific arena the excitement and widespread interest that is now primarily associated with athletic events.

This paper describes the unique features of the New Mexico program, tells how the program was conducted and administered, evaluates the results, and discusses future plans.

THE NEW MEXICO PROGRAM

The New Mexico High School Supercomputing Challenge is a competitive program in which teams of students devise scientific problems that can be solved with the supercomputers at Los Alamos National Laboratory. The Challenge gives teachers and students hands-on experience in defining problems, researching related scientific areas, formulating algorithms, writing computer programs, drawing conclusions from their research, and reporting the results. Participants vie for monetary prizes for student team members and computing equipment for their schools.

From this state competition, exceptional students can go on to compete in national programs, such as the SuperQuest sponsored by Cornell University, the National Science Foundation, and IBM Corporation or the National High School Supercomputing Honors Program sponsored by Lawrence Livermore National Laboratory. Guidelines for the Challenge were designed to be compatible with those of SuperQuest. The advanced New Mexico teams are encouraged to enter the SuperQuest Competition, and individuals can apply for admission to the Livermore program.

Like the national programs, the Challenge enables students to discover the excitement of science and encourages them to consider careers in science and engineering. It exposes both students and teachers to computational subjects, gives them hands-on experience in solving a scientific problem on a supercomputer, and provides the opportunity to work with professional scientists from many disciplines.

The Challenge was initiated by Sigfried Hecker, director of Los Alamos National Laboratory, and New Mexico Technet, a nonprofit, statewide communications network. Technet was established in 1985 and links national laboratories, universities, state and federal government offices, and some private industries. The Challenge is an effective way of using state-wide scientific and computational expertise, in collaboration with education communities, to generate interest among students, parents, and teachers.

FEATURES OF THE NEW MEXICO PROGRAM

The New Mexico High School Supercomputing Challenge has a number of features that make it especially effective. It offers participation on a non-selective basis, draws members from a wide range of students and teachers (235 students on 65 teams sponsored by 55 teachers at 40 schools during the initial Challenge), makes available a variety of computer architectures, and provides ongoing support to the participants. These unique features enable the Challenge to touch the lives of large numbers of students.

• Participation on a Non-selective Basis

The Challenge is open to students enrolled at any New Mexico high school (grades 9 through 12). It reaches students from schools where computing equipment and computing courses are not available as well as those schools who have equipment and advanced level computing courses. Because the Challenge is open to all students on a non selective basis, the emphasis is on achievement or competition at the teams' own levels. There is a wide breadth of knowledge among the students – from experienced video and

computer programming whizkids to students who do not know any programming language.

The program also reaches students who are historically under represented in scientific fields. In the initial program in 1990-91, women represented 20% of the students and 35% of the teachers, and three teams were all women. Many Hispanic students and students from several other ethnic groups participated, and students from the New Mexico School for the Visually Handicapped entered the contest.

- Availability of a Variety of Computer Architectures

Students are provided computer time on CRAY Y-MP/264, Connection Machine CM-2, Convex, IBM 3090-300E, and VAX computers. Students can take advantage of the different architectures in finding solutions to their problems.

- On-going Support.

Throughout the Challenge, support is provided at many different levels—initial training and computer documentation, equipment loans, communications and computing troubleshooting and consulting, and scientific coaching.

Point of Contact
Participants have a point of contact at Los Alamos National Laboratory who acts as an ombudsman. These contacts talk with the teachers, take requests for equipment and documentation, and answer questions or find someone who can give the answer. The contacts send out frequent newsletters to keep in touch with the participants and relieve the feeling of isolation experienced by those who live in remote rural areas.

From their frequent communication with teachers, coaches, and students, the contacts can also alert the program administrators to situations that the teams are encountering, so that the administrators can handle difficulties before they become serious problems.

Equipment
Because many schools do not have adequate equipment to access the supercomputers, LANL loans terminals and modems to those schools. An equipment expert contacts each school to ascertain what is needed, finds the appropriate equipment, ships it to the school, and remains in touch to be sure that everything is functioning properly.

In 1990 ____ pieces of equipment were provided to ____% of the participating schools.

Consulting
Personnel in the Consulting Office at LANL are available to answer questions and solve programming problems. Because most of the students must use long-distance telephone service to call Los Alamos, they have learned to use the online communication utilities (primarily the talk and mail utilities) to ask for help.

Technical Coach
Each team is assigned a technical coach from either academia or a scientific laboratory. The coach is someone familiar with supercomputing and software development and is an expert in the scientific area for the project. These people help the teams design their project to run on a supercomputer at Los Alamos National Laboratory, suggest additional or alternate approaches to the topic, answer questions, and encourage the participants when the project becomes difficult.

OBJECTIVES

The overriding objective of the New Mexico High School Supercomputing Challenge is to instill enthusiasm for science. When students are interested in science at the high school level, they are more likely to seek careers in the areas of science and engineering. Additional objectives include:

- Develop science and computing knowledge at the high school level. Students and teachers are exposed to computational subjects and experiences that they might otherwise not have. New Mexico has many small, remote school districts that lack computing equipment and offer no computing courses. Information is given to the teachers suggesting ways to enhance the science, math, and computing curriculum.

- Take advantage of the science and computing expertise and resources in New Mexico for the benefit of high school teachers and students. Los Alamos National Laboratory is the largest supercomputing facility in the world. The Challenge gives the Laboratory and other research centers in the state the opportunity to use their expertise and resources to benefit New Mexico and the nation.

- Prepare students for national competitions. The Challenge increases the level of interest in competitive academics among high school teachers and students. This program gives them the confidence and technical background needed to enter national competitions.

- Develop programs that can be replicated and may serves as models for other educational communities. Holding supercomputing competitions throughout the nations could be a positive step toward raising the level of academic achievement in high school students

ADMINISTRATION AND ORGANIZATION

The Challenge is administered by a board of advisors consisting of representatives from the sponsoring organizations (Technet, national laboratories, universities, and businesses). The board oversees the general operation of the Challenge and raises funds to support it. The day-to-day functions of the program are carried out by personnel from Los Alamos National Laboratory, Technet, and the University of New Mexico.

The Challenge is organized into six phases, which occur in sequence throughout the academic year.

Phase 1: Call for participation

The Challenge begins with a call for participation for teams to do computational science projects using high-performance computers. The schools organize their teams and submit entry forms listing the participants and describing, in general terms, the scientific area and project they plan to work on.

Phase 2: Introductory Workshop

Students and teachers attend a two-day Fall workshop where they are introduced to computational science and taught basic computing on the supercomputers at Los Alamos National Laboratory. The workshop includes a hands-on laboratory where students and teachers are able to sign on to the Los Alamos supercomputer. They are given a brief tutorial about the UNICOS operating system and the computer commands they will need to do their work. Each student is given a password for signing on to the system and instructed in the importance of network security, which is monitored by the Laboratory's security personnel.

Phase 3: Initial preparatory work

Students return to their schools to begin tackling their problem. Many students must also learn a programming language. With guidance from their technical coach, they set up the problem and gather data needed to solve their problem. At the end of this phase, students write an abstract of 200 words or less

describing the team's project and report their progress.

Phase 4: Computing

Students, with the help of their technical coaches, define an algorithm to solve their problem. They then write a computer program in Fortran or C to run on one of the Los Alamos supercomputers. They are able to complete this phase by using software, such as debuggers, to get their code running. Many of the teams display their results with graphics output.

Phase 5: Final Report

Students complete their project by writing a final report. Because of the diverse computing background of students entering the competition, two categories of reports are acceptable.

Category 1 reports are for teams who made progress in learning to work on a computer but were not able to make significant progress on their problem. Their report includes what they have learned about their project and what they have learned about supercomputers, programming, and communications on the supercomputers. These teams can continue working on their problem in the state competition during the next school year.

Category 2 reports are for teams who completed their project or made significant progress with it. Their report includes an executive summary, statement of the problem being investigated, description of the method of solution, results of the investigation, conclusions drawn from the analysis, and supporting evidence. These teams can further define their projects and submit them to the national competitions in the next year.

About one month before the deadline for submitting the final report, the teams can indicate in which category they will submit their report. Those who are unsure about the status of their project can submit reports in both categories.

Phase 6: Judging and Awards

The judging is done by a group of scientific and computing experts. This group is in place at the beginning of the Challenge and is kept informed of the directions and support given to the teams. They judge only the projects in Category 2 and visit these teams in their schools to talk with the students about the projects.

The projects are judged according to the following criteria:

Scientific content	30 points
Effectiveness of approach	30 points
Creativity	30 points
Clarity	10 points
Total	100 points

At the culmination of the competition, all teams attend a one-day awards ceremony and science tour. Each member of a team that submits a report in either of the categories receives an award for project completion.

Awards for the 1990-1991 competition included: first place awards of a $1,000 savings bond for each student on the team and computer equipment for the school; second place awards of a $500 savings bond for each student on the team and computer equipment for the school.

In addition, three scholarships are awarded, one to each of University of New Mexico, New Mexico State

University, and New Mexico Institute of Mining and Technology. This is a separate competition where individual students write a report describing their involvement and leadership in the project.

EVALUATION AND PRELIMINARY RESULTS

Information collected for evaluation includes the number of participants at beginning and end, noting the involvement of historically under-represented groups in science; the quality of each project relative to the computing background of the team; and feedback of teachers, students, parents, coaches, judges, and staff. Workshops are evaluated through feedback of participants, including teachers, students, speakers, and staff.

At the completion of the first Challenge, we expect the following results:

- Some teams will be able to enter the national competitions during the next school year.

- Teams will complete computational projects appropriate for the level of knowledge of the students. Horizons of teachers and students will expand beyond that of their own communities.

- High School science and computing curriculum will change because knowledge of teachers and students in these fields will increase and computing will be integrated into more educational offerings in science and mathematics, and perhaps even in nontechnical subject areas.

- Schools, teachers and students will participate on a continuing basis. Younger students will develop more sophisticated knowledge and projects each year, and there will be an increase in the interdisciplinary nature of the projects.

- This program can be replicated in other regions for other communities. It does not depend on a unique local environment.

FUTURE PLANS

The New Mexico High School Supercomputer Challenge will be offered as a yearly competition. It will feed into the national competitions. The sponsors will continue to evaluate results and improve and adapt the competition to meet the needs of the participants and encourage a high level of academic excellence. Wide spread participation especially among schools in disadvantaged areas will be promoted.

Additional training in the use of supercomputers will be provided for teachers with the following educational programs:

- a six-week summer institute in computational science for teachers
- four regional one-day in-service workshops for teachers

New Mexico Technet will continue to enhance the communications network so the students at their high schools can have direct network access, instead of limited telephone access.

COMPARISON WITH OTHER PROGRAMS

Other programs at both the state and national level have both similarities and differences to the Challenge. Like the New Mexico program, the Alabama state program is non-selective and serves both average and exceptional high school students, but its community of involved schools and students is somewhat smaller and only the Cray supercomputer architecture is available. Other competitions, such as the SuperQuest national competition, the National High School Supercomputing Honors Program, and the North Carolina

state competition, are selective, serve the exceptional high school students and give students access to only a single high-performance computer architecture.

CONTRIBUTIONS OF SPONSORING ORGANIZATIONS

The Challenge is sponsored by a partnership of businesses, universities, national laboratories, a nonprofit communications corporation, and public and private schools throughout the state. Technet, KMBA radio, and the Albuquerque Chamber of Commerce provided funds for food and lodging for the workshop, awards, and publicity. University of New Mexico, New Mexico State University, and New Mexico Institute of Mining and Technology supplied personnel for administration, teacher support, and coaches and judges, and they also provided presidential scholarships for outstanding individuals in the competition. Los Alamos National Laboratory contributed personnel as coaches and judges, teacher and student support, speakers, and computer consultants; network connections and high performance computing resources; computer documentation about local computing resource and access to a library of videotapes and other instructional materials; and computing equipment for schools and workshops. Sandia National Laboratories and Phillips Laboratory (Air Force Weapons Laboratory) provided funds and personnel as coaches. The participating schools provided funding for some travel expenses, time for students and teachers to participate, school phone lines, and classroom equipment.

CONCLUSION

The New Mexico Supercomputing Challenge is an effective way of encouraging students to discover the excitement of science and computing. The enthusiasm and self confidence generated by academic success can provide the impetus to pursue a career in science and computing.

The Challenge serves as a model that can be enhanced and adapted by other states. A nationwide program of state competitions leading to the national level will increase the level of interest and the number of students participating in scientific and computing endeavors and lead to higher levels of academic achievement.

Without the influx of significant science and computing expertise and resources into high school educational communities, high school teachers cannot by themselves help teams enter these competitions. The Challenge uses scientific and computational expertise, in collaboration with education communities, to make a difference in high school and mathematics education.

By combining science and computing with a high school activity of high visibility and excitement, students, parents, and teachers are attracted and will learn more about advanced computation and the multidisciplinary approach to scientific problems.