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ABSTRACT

In 1992, the National Research Council recommended that the computer science and engineering community should enrich its talent pool by reaching out to women and minorities, both underrepresented in the field. This paper describes four such outreach programs sponsored by the National Science Foundation's Center for Research on Parallel Computation (CRPC) at California Institute of Technology in 1994. One was a minority youth awareness program, a 2-day on-campus event for over 100 visiting Los Angeles County high school students. Its purpose was to expose young scholars to real-world uses of computers, demystifying them and previewing the challenges and rewards of computer-related careers. A summary of activities is provided. Also listed are: the 20 presentations given at the second program, a 5-day workshop for minority high school teachers; the third program consisting of a talk at the annual workshop of the Association of Departments of Computer Information Science and Engineering at Minority Institutions (ADMI), which focused on programming tools, operating systems, and the Internet; and descriptions of summer research projects in concurrent algorithm development, done by eight undergraduate women. (BEW)

Caltech CRPC Outreach Programs for Minorities and Women

by Adam Rifkin

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paper

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Introduction

In late 1992, the National Research Council issued a full report addressing the future of computing [Cou92]. Among the recommendations espoused by the Council is the following (page 154): "The academic CS&E community must reach out to women and to minorities that are underrepresented in the field (particularly as incoming undergraduates) to broaden and enrich the talent pool." In 1994, the National Science Foundation's Center for Research on Parallel Computation (CRPC, a consortium of six universities) at the California Institute of Technology (Caltech) sponsored many programs [TR93]. These activities collectively aimed to reach out to women and minorities at different levels of the educational pipeline (high school students and teachers, and undergraduate students and teachers). These outreach programs were developed to encourage female and minority students to pursue advanced studies and research in high performance computing. This document describes four outreach efforts designed and administered by Caltech CRPC scientists and students:

1. Minority youth awareness program.
2. Minority teachers education workshop.
3. A talk at the ADMI conference.
4. Undergraduate summer research program. Each of these endeavors was well-received by its participants, and some can be emulated at other institutions. Caltech's CRPC site plans to continue these programs annually.

Minority Youth Awareness Program

More than one hundred Los Angeles County high school students visited Caltech on March 21 and 22, 1994, for a computer awareness program. The two-day event, dubbed "Computers: The Machines, Science, People, and Careers!" [Mul94], was designed to encourage minority teenagers to consider computing careers, by exposing them both to the science and technology of computational science and engineering. This year marked the second time the program was conducted at Caltech. Sessions focused on the history and evolution of computers, current computer applications, and the futures in computer science. Participating students traveled to different sites on the Caltech campus for seminars, workshops, and video presentations. In addition, they were able to see and to report to each other about more than two dozen on-site applications of computer technology and computational sciences. By exposing young scholars to real-world uses of computers, professors sought to support the following program objectives:

1. Inspire curiosity about computers by showing them to be fun and exciting.
2. Demystify computer science through face-to-face interaction with professionals.
3. Preview the challenges and rewards of a computer-related career.
4. Develop participant confidence that they could succeed in such a career.

The event was organized by James Muldavin, with the aid of Caltech CRPC Administrative Assistant JoAnn Boyd [Boy94]. Support was provided by the CRPC, with cooperation from Mathematics, Engineering, and Science Achievement (MESA).

Summary of Activities

The minority youth awareness program spanned two days, as summarized in tables 1 and 2.

Overview, Day One	
Time	Activity
7:30 am	Arrival: Breakfast
8:30 am	Video/ Discussion: PBS's *The Machine That Changed the World*
9:45 am	Opening: Overview and welcome
10:00 am	Icebreaker: Familiarize participants with topics
10:40 am	Keynote: Dr. William Lester, U.C. Berkeley Chemistry
11:30 am	Interaction: Hands-on Using computers
12:15 pm	Lunch: Sandwiches and discussions
1:15 pm	Community: On-site visits to Caltech labs (astronomy, seismology, geology, physics, civil engineering, planetary science, math)
3:35 pm	Interaction: Student reports on on-site visits
4:00 pm	Leave: Send-off messages

Table 1. Minority youth awareness workshop, day one.

Overview, Day Two	
Time	Activity
7:30am	Arrival: Breakfast
8:30 am	Video/ Discussion: PBS's *The Machine That Changed the World*
9:30 am	Q&A Session: Students invited to field questions
10:00 am	Interaction: Parallel processing workshop
11:00 am	Community: On-site visits to Caltech labs (satellite, photography, aeronautics, climate modeling, graphics, biotech, economics)
12:35 pm	Lunch: Pizzas and discussions
1:15 pm	Interaction: Student reports on on-site visits
1:45 pm	Keynote: Career opportunities, by Al Paiz of JPL
2:15 pm	Round-Robin: Educational and career opportunity presentations
3:30 pm	Evaluation: Students share thoughts and ideas
4:00 pm	Leave: Send-off messages

Table 2. Minority youth awareness workshop, day two.

In the next section, as an example of the caliber of the on-site visits, we discuss one of the activities in which the students participated: a parallel processing workshop.

Parallel Processing Workshop

The centerpiece of this workshop was Dr. K. Mani Chandy's hands-on introduction to parallel and sequential computing. He guided the students through an archetypal case study of sorting students, introducing them to software engineering, good algorithm design, and the tradeoffs between alternative solutions. This particular program struck a balance between teaching a few key concepts: keeping students' interest, and simplicity of execution, as elaborated upon in [Rif94]. Our intention was to encourage the students to learn more about parallel computing in the future, and to convince them that computer science is fun. We also wanted them to think critically about issues involved in program design. We therefore set a goal to convey the following points:

1. Computer science concepts are not difficult.
2. Computers operate by following a specific set of rules.
3. More than one set of rules (algorithms) can be designed to solve a problem.
4. Good algorithm design is important for obtaining correct and efficient solutions.
5. Parallel operations are sometimes a natural way of thinking, and can have more efficient performance than sequential operations.

We used the task of sorting a list of numbers to convey our points; allowing each student to "be a number" in the list would provide interactivity. After Dr. Chandy's tutorials, several graduate students helped small groups of students tackle the problem of sorting numbers by themselves. Leaders walked the groups through three different solutions by assigning each a value and "role-playing" the algorithms:

1. Bubblesort to illustrate a sequential solution.
2. Even-Odd Transposition to illustrate a natural parallel version of Bubblesort.

3. Parallel radix sort as an alternative parallel solution for comparison.

The 50-minute workshop took the following format:

1. Students were given a short handout the previous day to familiarize themselves with the flavor of the workshop.
2. The workshop began with a 20-minute talk, briefly discussing computer science, good algorithm design, and parallel programming. The talk also described the problem of sorting a list of numbers, and the three algorithms we were going to explore. Audience participation was encouraged, and the underlying emphasis of the talk was that computer science is challenging, and often fun.
3. We then brought the students outside and divided them into nine groups of approximately the same size. Each group was led by a student volunteer from Caltech.
4. Three 10-minute exercises were performed by the group, one for each of the three algorithms discussed, led by instructions given by workshop leader Mani Chandy. Coordination was handled by the group leaders.
5. These exercises culminated in a sorting race, in which all the groups attempted to sort themselves faster than their peers.
6. The workshop closed with some discussion, and students completed a short evaluation form.

The results [Rif94] indicated that students had learned about many of the issues involved in parallel computation.

Minority Teachers Education Workshop Whereas the Minority Youth Awareness Program focused on enthusing minority teenagers with the prospects of studying and working in computing areas and applications, the Minority Teachers Education Workshop focused on helping their teachers to encourage the students with such prospects. High school teachers from various Los Angeles and Pasadena minority districts were invited to participate in the week-long sixth annual Minorities Teachers Computational Sciences and Graphics Awareness Program at Caltech, held June 20-24, 1994. JoAnn Boyd once again did a fantastic job of organizing the lineup of activities [Boy94].

Overview, Day One	
Richard Tapia	Contemporary Issues in Education (3 hours)
Michael Holst	Protein Modeling Equations (1 hour)
Paulett Liewer	Solar Wind Modeling (1 hour)
John Salmon	Particle Physics Simulations (1 hour)
Overview, Day Two	
Adam Rifkin	Electronic Textbooks for Teaching (3 hours)
Michael Garcia	Jet Propulsion Laboratory Tour (3 hours)
Overview, Day Three	
Kimberly Douglas	Hands-on with the Internet (1 hour)
Michael Harrington	Molecular Biotechnology (1 hour)
Jerry Solomon	Protein Folding Computational Methods (1 hour)
Roy Williams	Tour of Parallel Supercomputers (1 hour)
Al Barr	Computer Graphics Research (2 hours)
Overview, Day Four	
Jerry Landry	GALCIT 10-ft Wind Tunnel Tour (1 hour)
Bahram Valiferdowsi	GALCIT T5 Free-Piston Shock Tunnel (1 hour)
Tony Leonard	Computational Fluid Dynamics (1 hour)
Carl Kesselman	Parallel Computing and Object Oriented Programming (2 hours)
Adam Rifkin	Should All Education Herein Be Video Games? (1 hour)
Overview, Day Five	
Michael Holst	Numerical Simulation of Black Holes (1 hour)
Charles Plott	Economics and Poly Sci Experimental Methods (2 hours)
Dave Wald	Southern California Earthquakes (1.5 hours)
Eric Van de Velde	Panel Discussion (1 hour)

Table 3. Summary of the minority high school teachers workshop.

Discussion topics highlighted interdisciplinary applications of computer graphics, biotechnology, and concurrent computing systems. Exposing teachers to the cutting edge of computational science helps them influence their students in turn, by providing concrete experience with the academic and employment opportunities in the field.

The program was not designed to teach advanced biology or computational science to the participants, nor did it enable them to teach those disciplines. Rather, it taught them about the progress and opportunities in these evolving fields. This improved their ability to motivate and counsel their students, since advice and stimulation from a special teacher is a major factor in opening up to many minority students the fascinating careers available in science and technology. In addition to the discussion sessions, the teachers toured the Caltech Concurrent Supercomputing Facilities, the Jet Propulsion Laboratory, and other advanced Caltech laboratories.

Participating teachers were offered a $500 honorarium by the CRPC for the five day, thirty hour program. This activity

was part of the Minorities Programs of two NSF Science and Technology Centers at Caltech: the CRPC, and the Center for Graphics and Scientific Visualization. Scientists from both of these centers, as well as other faculty, staff, and students of Caltech, participated in the Awareness program. Table 3 describes activities during the five days of the workshop.

ADMI Presentation and Discussion

The CRPC sends speakers out to regional conferences on minority undergraduate education to complement its local efforts at the various sites. The Association of Departments of Computer Information Science and Engineering at Minority Institutions (ADMI) had its annual workshop July 22-24, 1994, at Spelman College in Atlanta, Georgia. The CRPC sent Adam Rifkin to talk about its concurrent programming tools. Other ADMI 94 talks covered the following subject matter (as listed in table 4): the Linux operating system, languages, network starters, PC-DOS tools, numerical packages, NCSA software, Internet, World Wide Web, scalable computing for HPC, and applications.

Presenter	Session Overview
Jesse C. Lewis	Keynote Address
Byron Jeff	Linux Operating System (3 hours)
Andrea Lawrence	Languages (1 hour)
Jerome Bennett	Network Starters (1 hour)
Ben Martin	GNU, PC-DOS, Numerical Packages (1 hour)
Robert Panoff	Hands-on with the World-Wide Web (3 hours)
Pamela Deveaux	Diversity Programs and Educational Initiatives (2 hours)
Forbes Lewis	Programs at the NSF (1 hour)
Adam Rifkin	Parallel Processing Tools (2 hours)
Anna Frederick	Scalable Computing for HPC (2 hours)
E.C. Ogbuobiri	HPC Applications (1 hour)
Robert Poole	Training and Infrastructure Requirements for HPC (1 hour)
Sandra DeLoatch	Training and Infrastructure Requirements for HPC (1 hour)

Table 4. Summary of the ADMI workshop.

The theme of the workshop was "A Quality Computer Science Program on a Shoestring Budget"; the speakers presented quality, inexpensive software that will execute on inexpensive machines. CRPC research projects are ideal in that they represent cutting-edge work available for free from the working groups. These projects enable people to experiment in high-performance computing at a relatively low cost; for example, softlib provides a centralized system for distributing software and other materials developed at CRPC collaborating institutions.

The CRPC talk disseminated information the CRPC's ongoing research, and how the attendees could get free software currently being developed by the CRPC's research groups [TR93]. This software included MPI, P4, Fortran D and the D System, Maisie, Fortran M, CC++, PCN, xNetlib, and eText. We also discussed the softlib and netlib repositories, the CRPC World-Wide Web page, and other Internet resources; table 5 lists some of the sites mentioned. In addition, participants were treated to videos including the LA smog simulation developed by Donald Dabdub and John Seinfeld at Caltech, a CC++ thread visualization graphics demonstration by James Patton of Caltech using a tool called PABLO developed by Dan Reed at the University of Illinois, and the CRPC high school minority youth program.

CRPC Resource	World-Wide Web Location
Home Page	http://softlib.cs.rice.edu/CRPC.html
ARPACK	http://www.netlib.org/
Benchmark Suite for HPF and Fortran D	gopher://softlib.rice.edu/
CC++ Language	http://www.compbio.caltech.edu/ccpp/
eText	http://www.etext.caltech.edu/
Fortran D Language	gopher://softlib.rice.edu/
Fortran M Language	http://www.mcs.anl.gov/
Ian Foster's book on parallel programming	http://www.mcs.anl.gov/dbpp/
F77D Compiler	gopher://softlib.rice.edu/
F90D Compiler	gopher://softlib.rice.edu/
HeNCE	http://www.netlib.org/
HPF Specification	gopher://softlib.rice.edu/
LAPACK	http://www.netlib.org/
Maisie	ftp://ftp.cs.ucla.edu/pub/
MPI Specifications	http://www.mcs.anl.gov/
PCN	gopher://softlib.rice.edu/
P4	http://www.mcs.anl.gov/
PVM	http://www.netlib.org/
ParaScope	gopher://softlib.rice.edu/
ParkBench	http://www.netlib.org/
PDS	gopher://softlib.rice.edu/
Softlib	gopher://softlib.rice.edu/

Table 5. Excerpt from the CRPC World-Wide Web sites distributed at ADMI.

We also provided information about some of the outreach programs in which the CRPC is involved. It was interesting to hear mixed reviews of praise for the CRPC for going out of its way to attract minority and female students, and criticism of the fact that, for example, a lot of the students that we attracted to Caltech for our summer program were what they deemed "well to do"; that is, these are already highly motivated students at top colleges, and our outreach programs should try to reach students at "second-tier" schools as well. No consensus was formed about how to be all-inclusive, but most participants agreed that the CRPC's programs represented a good step in the right direction.

In all, the CRPC talk lasted two hours, and an additional ninety minutes were spent after the talk discussing issues that had been raised. The response was overwhelmingly positive. Discussion accompanied ADMI 94, and frustration about the underlying attitudes that prevent minority students from pursuing higher education was vented.

Undergraduate Summer Research Program

Each year the CRPC sponsors a number of female and minority undergraduates to spend a summer doing research with Caltech scientists. In 1994, eight Women in Summer Parallel Research (WSPRs) conducted original research in concurrent algorithm development.

Female third and fourth year undergraduates were invited to apply to this small, intensive, personalized program in applied computation at Caltech. Eight women out of eighty applicants were chosen to participate in the program, which was managed by JoAnn Boyd, Herb Keller, Dan Meiron, Mani Chandy, and Caltech students Peter Hofstee, Svetlana Kryukova, Rajit Manohar, Berna Massingill, Adam Rifkin, Paul Sivilotti, and John Thornley. The program has succeeded in previous years as a minorities summer research program; this year, the WSPR's produced several excellent papers detailing their research [Boy94]

The undergraduates worked closely with Caltech groups (other undergraduates, graduate students, staff, post docs, and faculty) on exciting research dealing with computation and its applications. Students worked with their groups, using parallel supercomputers and networks of workstations to develop parallel algorithms helpful in the sciences and technology. Students learned about application areas of interest to them, learned to develop programs for parallel computers, and then used the computers to solve a problem in their area of interest. Research areas available to pursue included applied mathematics, astronomy, biology, chemistry, computer science, economics, and physics. Students were given genuine opportunities to conduct research on significant problems with experts in their fields, using the advanced equipment of the CRPC.

Students were given a minimal load of instruction about parallel languages, using Unix, the World-Wide Web, LaTeX, and HTML. The women created World-Wide Web home pages, collected centrally at the URL site http://www.ama.caltech.edu/~joann/crpc/sugp94.html. Meanwhile, students participated in their research from the beginning, including a weekly meeting in which everyone discussed their current research and bounced ideas around. Most of the students exhibited a degree of maturity that allowed them to seek out fellow researchers, establish research goals for themselves, and implement their goals. The students came from diverse backgrounds, with varying degrees of expertise in computing. Students received a stipend of $1500 per month, a reasonable travel allowance, and lodging on the Caltech campus.

The eight students in the program worked on a variety of projects, although many of them worked on aspects of the ongoing Archetypes project [Cha94] at Caltech. We provide a summary in table 6. For those readers interested in the technical

details of the projects, research summaries follow.

Researcher	Project
Amy Biermann	Parallelizing Othello Algorithms
Tzu-Yi Chen	Parallel Mesh Archetype Applications
Mauria Finley	Parallelizing Checkers Algorithms
Claudette Martz	Distributing Objects in OS/2
Anita Mareno	Parallel Mesh Archetype Applications
Yolanda Palomo	Parallelizing Dynamic Programming Algorithms
Alissa Pritchard	Parallelizing Branch-and-Bound Algorithms
Linda Stewart	Parallel Message Passing

Table 6. Summary of the WSPR projects.

Amy Biermann, Bryn Mawr

This project explored the design, implementation and performance of the minimax algorithm with alpha-beta cutoffs in both the sequential and parallel domains for the game Othello. Optimizations for both the parallel and sequential versions were investigated. It was found that the parallel algorithm can achieve a 50% speedup over the sequential version on 4 processors, with promise for much more, though this research did not investigate performance using general numbers of processors. Experience with parallelization suggests that there will be an optimal number of processors for the game to achieve a good balance between communication overhead and load balance. This may be difficult to analyze because the optimal number of processors may vary with the size of the tree to be searched. All of the improvements to the code focused on the time performance of the game.

Tzu-Yi Chen, MIT

This work implemented the pseudocode for several iterative methods presented in Templates for the Solution of Linear Systems by Jack Dongarra, et. al, using an existing mesh archetype to achieve parallelism. This project focused in part on exploring the potential usefulness of archetypes which hide inter-processor communication from the user. Use of the mesh archetype simplified the parallelization of the sequential pseudocode; in particular, the time spent learning how to use the archetype was small compared to the time that would have been needed to learn message passing in Fortran-M, to implement the communication structure needed, and to debug the parallel code. In addition, good scaling was seen for up to four processors. With more than four, the time needed for communication between processors began to overwhelm the time used for computation. However, to ensure that archetypes will be used, detailed documentation is necessary, to make clear when it is appropriate to use a certain archetype, and to make using the archetype intuitive. This project also implemented iterative methods in an easy-to-use fashion, making them suitable for students in solving assorted discretized partial differential equations. By using an idea termed "intuitive stencils", the implementation chosen simplifies the connections between the physical problems posed by certain elliptic partial differential equations, the storage of the diagonally sparse matrices created by the discretization of these equations through finite difference analyses, and the iterative methods used to solve them. In short, this work explored the usability of archetypes by using the mesh archetype to implement a program presenting iterative solvers in a simple and usable fashion.

Mauria Finley, Stanford

This research looked at two parallel implementations of minimax with alpha-beta cutoffs for the game checkers. A centralized algorithm was designed to provide three-fold speedup for a small number of processors. This implementation was then compared to a decentralized algorithm designed to scale to a larger number of processors. The work investigated the problems of granularity, latency, and load balancing, common to all parallel algorithms. Parallelizing minimax with alpha-beta pruning included a challenging problem: to exploit the parallelism without increasing the size of the search (which would counteract the gains of alpha-beta pruning).

Claudette Martz, MIT

This work used OS/2's multitasking and CORBA-compliant distributed objects (DSOM) to obtain performance speedup. The aim of such work was to facilitate the porting of code to a PC platform. OS/2 provides a broad range of synchronization and communication mechanisms, and further support for additional paradigms might be needed. With support for parallel blocks, atomic functions, and synchronization variables, for example, a large collection of CC++ code could have been trivially ported to OS/2. With support for explicit message passing, ported channels, and process creation, Fortran M style programs would be easily translated to run on OS/2. With the increasing popularity of PC's as parallel platforms, such an exploration of the costs/benefits involved in running these applications, typically targeted for networks of workstations or mpp architectures, might have been interesting. We examined OS/2 as is, with no modifications or additions to the fundamental programming paradigm, to determine the ease with which parallel applications can be developed from correct sequential ones. Debugging was found to be a huge problem in the parallel domain.

Anita Mareno, Wellesley

A template is a skeleton of a parallel program that can be re-used with various parallel applications programs that share common features of communication and computation. This work provided the documentation and the code for a 1-dimensional template that characterizes mesh computations, which can then be incorporated into the archetypes methodology for scientific computation.

Yolanda Palomo, UCLA

This work investigated sequential and parallel implementations of algorithms developed using the dynamic programming archetype. Using C and the NX library, solutions to the all-points shortest-path and zero-one knapsack problems were written.

Alissa Pritcard, UC Berkeley

This research project involved creating a template for branch-and-bound tree search algorithms that would enable the user to be concerned with the branching and bounding functions and not with the upkeep of data structures. The template allows the user to run a developed program in either the sequential or parallel domain, without changing the branching and bounding functions that the user provides. The parallel implementation was written using the NX library package, which provides a message-passing interface that can be used to write parallel programs for multicomputer systems, such as the Intel Touchstone Delta Supercomputer, and for networks of workstations. An application of the template, the 0-1 Knapsack Problem, was written to demonstrate the use of the template, and performance timings showed the superior performance of the parallel implementation.

Linda Stewart, Mississippi State

This work explored message-passing paradigms on multicomputers. Several programs were developed, and issues involved in the writing and debugging of parallel programs were explored. The primary focus of this project was the nearest neighbor problem, which involved finding the closest pair of points, given a set of N points in a plane. A sequential and parallel solution to the problem was developed and tested. The sequential version was written in C, whereas the parallel version was implemented using NXLib. The student plans to continue future research on this project at her home institution.

Summary

The 1994 outreach efforts initiated by the CRPC at Caltech have sought to encourage women and minority students at many echelons of education, and their teachers and mentors, to pursue computer science studies and careers. These efforts have been well-received and the CRPC intends to build upon them in future years. We plan on follow-up studies in a year or two to determine the effects of the programs on their participants.

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