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FIELD	GROUP	SUB-GROUP	ADA, SOFTWARE ENGINEERING, MACSYMA, CAI, PARALLEL PROCESSING, LU FACTORIZATION, SOFTWARE REUSE, NETWORK ROUTING

19. ABSTRACT (Continue on reverse if necessary and identify by block number)
This grant covered work primarily based on the Ada Programming Language. Included are 1) research on LU Factorization algorithms in a parallel processing environment, 2) an Ada-based software reuse tool, 3) solving applied mathematics problems using Ada and MACSYMA, 4) Ada simulation of interactions of nodes in a network, 5) conducting a workshop in Ada and software engineering, 6) developing CAI tools to teach Ada and software engineering concepts, and 7) dissemination of research results.

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Research, Development, Training & Education
Using the Ada Programming Language

FINAL REPORT

July 16, 1989

Author: George C. Harrison, Ph.D.

United States Army Research Office

ARO PROPOSAL NUMBER: 25510-EL-H
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FORWARD

This research grant is titled Research, Development, Training & Education Using the Ada Programming Language and is hereafter called ReDTEA. The primary goal of this activity was to conduct research in the application and development of Ada, and in broader terms the objectives were as follows:

1. To develop numerical algorithms for parallel processing using the Ada language.

2. To develop new methodologies in reusing Ada software.

3. To solve select problems in applied mathematics using MACSYMA and Ada.

4. Simulate the interactions of nodes in a network using Ada.

5. To increase the cadre of educations available to provide Ada training by conducting Ada workshops for Norfolk State University faculty and staff.

6. To develop a series of in-class and individualized modules addressing Ada programming using computer assisted instruction.

7. To disseminate research results and CAI modules to other minority institutions through computer networking, workshops, and lecture series.

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OBJECTIVE 1.   To develop numerical algorithms for parallel
                processing using the Ada language.

Dr. Shantilal N. Shah studied LU Factorization algorithms in light
of simulating a new algorithm in a parallel processing environment
using Ada's tasking facilities to simulate this environment. His
abstract to a paper "Modification of LU Factorization Algorithm for
Parallel Processing Using Tasks Supported by Ada Language" (see
bibliography) follows:

        An Algorithm to factor a given non-singular matrix
    A into two Lower and Upper matrices is modified so that
    the Lower triangular matrix can be computed by one task
    and the Upper triangular matrix can be computed by a
    second task, with both tasks running in parallel."

Dr. Shah's work on simulating parallel algorithms is currently
being utilized and expanded in a NASA research grant.

OBJECTIVE 2.   To   develop   new   methodologies   in   reusing   Ada
                software.

Dr. George C. Harrison studied a automated code reuse system and
has virtually completed a working prototype system to aid in the
reuse and project integration of Ada source code. His abstract to
the paper "AdaL, An Automated Code Reuse System" (see bibliography)
follows:

> Under a United States Army grant we are developing a
> prototype software package to produce an automated Ada
> code reuse system supported by the language LIL to aid
> the Ada programmer/designer in choosing the appropriate
> Ada generic or ordinary package from a data base of
> reusable code and to automatically instantiate that code
> if it is generic. Our goal is to have reusable code
> chosen effectively WITHOUT actually examining Ada
> specification. By examining the semantics in the LIL
> files the programmer may choose the appropriate LIL file
> that corresponds to the specification and semantics
> needed in his or her Ada source.

Dr. Harrison has used and disseminated portions of this AdaL tool
to other researchers for their use. Appropriate designations in
source are given to the Army Research Office. Dr. Harrison plans
on extending this Ada reuse system, AdaL, into a more advanced CASE
(Computer Assisted Software Engineering) tool.

With student assistance Dr. Harrison has developed a comprehensive
Ada to VMS interface for VMS Screen Management Guidelines of the
VMS Run-time Library.

OBJECTIVE 3.   To solve select problems in applied mathematics using MACSYMA and Ada.

Dr. Sandra Deloatch because of other research and administrative commitments and because of a delay in obtaining the MACSYMA software has only completed preliminary work on this topic. However, other faculty in the Department of Mathematics and Computer Science, Drs. Philip McNeil and John Wiggs, are using MACSYMA, Ada and other software to expand their research and educational goals.

Dr. Deloatch (and the others) is following up her objectives and findings and the experiences of others in the department into other research funding sources.

OBJECTIVE 4.   To simulate the interactions of nodes in a network
                using Ada.

Dr. Mou-Liang Kung has completed this research and has issued an
extensive internal report "Simulation Testbed for Routing
Algorithms" (see bibliography) with the following abstract:

> There are recent efforts in designing simulation
> facility for testing routing algorithms, such as that by
> P. Bell and K. Jabbour who used IBM PC and compiled
> BASIC. We selected Ada language on a twin CPU VAX 8350
> to design and construct this testbed for routing
> algorithms. Our study showed that a simple experiment
> of 400 messages per hour of length 10,000 bits at all
> seven nodes in a network can take up to 9 CPU hours to
> conduct a one hour test run. When the random walk
> algorithm was used, the simulation ran for 2 CPU days.
> To yield all meaningful results, we must incorporate
> higher level protocols, the simulation time can become
> too time-consuming. Hence we believe that a parallel
> architecture combined with a parallel language such as
> Ada is more suitable to run large scale simulations of
> networking.

Dr. Kung is following up this work with proposals for funding for
an appropriate computational platform and software tools.

OBJECTIVE 5.   To increase the cadre of educators available to provide Ada training by conducting Ada workshops for Norfolk State University and Staff.

During the Summer of 1988 Dr. George Harrison conducted a two-week extensive workshop on Ada and Software Engineering. The following persons were the paid workshop participants:

Dr. Richard O'Daniel, Associate Professor, Department of Management, School of Business

Dr. WIlliam Spriggs, Assistant Professor, Department of Management, School of Business

Mr. Charles Taylor, Associate Professor, Physics Program, Department of Chemistry, Physics, and Engineering, School or Health Related Professions, and Natural Sciences (HRPNS)

Dr. Charlesworth Martin, Associate Professor, Engineering Program, Department of Chemistry, Physics, and Engineering, HRPNS

Dr. Andrew Hargrove, Professor, Engineering Program, Department of Chemistry, Physics, and Engineering, HRPNS

Dr. John Wiggs, Associate Professor, Mathematics Program, Department of Mathematics and Computer Science, HRPNS

Mr. Mustaq Khan, Instructor, Mathematics Program, Department of Mathematics and Computer Science, HRPNS

Ms. Jacquelyn Long, Assistant Professor, Computer Science Program, Department of Mathematics and Computer Science, HRPNS

Ms. Deborah Chen, Instructor, Computer Science Program, Department of Mathematics and Computer Science, HRPNS

Mr. Paul Hsiung, Instructor, Computer Science Program, Department of Mathematics and Computer Science, HRPNS

Ms May Tsai Hou, Instructor, Computer Science Program, Department of Mathematics and Computer Science, HRPNS

Mr. Mark Manes, Systems Manager, Academic Computing Unit

Unpaid participants:

Dr. Mou-Liang Kung, Associate Professor, Computer Science Program, Department of Mathematics and Computer Science, HRPNS

Ms. Esther Lumsdon, CAI Assistant/Programmer, ReDTEA Project, Department of Mathematics and Computer Science, HRPNS

The workshop was one of the best successes of the entire project. No fewer than six of the participants are using their expertise in Ada and software engineering in permanent and temporary DoD positions, DoD contracts, and other research.

OBJECTIVE 6.   To develop a series of in-class and individualized modules addressing Ada programming using computer assisted instruction.

Ms. Esther Lumsdon was hired as CAI Assistant/Programmer from May 1988 through mid April 1989. She and Dr. George Harrison developed and maintained several class-assisted CAI modules. The primary source for the software purchased was ADA-TUTR, a shareware product from Dr. John Herro of Computer Innovations Technology. The use of this product was so successful that much of the work on direct class-assisted CAI products were postponed. Ms. Lumsdon, however, was assigned and completed a LRM (Ada Language Reference Manual) on-line reader. This software uses the LRM text files from the Army Simtel 20 Ada Repository. It can isolate chapters, sections, and paragraphs; view them; print them; etc. This software was written in Ada for VAX/VMS and for the PC using Meridian AdaVantage. It has been submitted to Simtel 20 for submission into the Ada Repository. Limited copies can be furnished upon request.

We have purchased three PC Ada compilers (Janus R&R, ALSYS, and Meridian) for educational use and the ADA-TUTR Customization Kit to revise Dr. John Herro ADA-TUTR to make compiler-dependent versions of that tutorial. Work is still in progress on this by Dr. George Harrison.

Dr. George Harrison is also working on CAI modules for graduate and continuing education courses in software engineering using the Software Engineering Institute's guidelines. This work is expected to continue under a National Science Foundation grant.

OBJECTIVE 7.   To disseminate research results and CAI modules to other minority institutions through computer networking, workshops, and lecture series.

The research in OBJECTIVES 1 and 2 have been presented at the Seventh Annual Conference on Ada Technology in March 1989. One of the primary foci of that conference is the dissemination of Ada and software engineer research at minority institutions. Copies of these papers had been deposited with Army Research Office as required, and appropriate credit was given ARO in them. The Herro ADA-TUTR and the LRM READER software is been made available to minority institutions and to anyone who asks for it up to the availability of our resources.

CONCLUSIONS

HISTORY OF PROJECT:

In February 1987 we were asked to present a proposal for approximately $400,000 to the United State Army for research and development initially in a consortium with two other Historically Black Universities (HBUs). Because we had Ada educators in the Department of Mathematics and Computer Science and because we felt that the potential for research and education in the Tidewater area of Virginia in Ada related topics was necessary, we drafted a proposal within the 24-hour deadline given us. The grant was to last one year.

In September 1987 we began our work on the grant which was based on a newly drafted proposal to last 18 months until February 28, 1989. Because we had not completed some of our goals nor spent significant portions we were granted an extension to May 31, 1989.

PROJECT ACTIVITIES:

We found that since there was a large time interval in the submission of the initial proposal and the granting of the proposal some researchers were already committed to other projects. Due to lack of budgeting for a full-time position we were also unable to hire a part-time secretary as a part of our project. Paperwork and other hindrances prevented us from hiring a programmer until May of 1988.

We perhaps over-estimated our timing on parts of the project. We were unable to complete all the CAI work we had planned; although completion is near and has been greatly extended and broadened to include more work on continuing education and graduate curricula.

The work on MACSYMA and Ada is still in progress; however, we were able to include Mr. Jonathan Graham, Instructor of Computer Science to take the Summer 88 place of Dr. Sandra Deloatch, who had a previous commitment on a different DoD grant. His summer work on "Using Ada tasking to simulate theoretical operating systems concepts in multiprocess environments" is not completed yet but is in progress and is being tied to his research toward his Ph.D. in Computer Science at the College of William and Mary.

The successes, however, far outweigh our expectations. The purchase through the grant of a VAX 8350 to complement our VAX 11/785 has allowed us to increase our computation research platform capabilities well beyond this ARO research grant. The Academic Computing Unit at the University is clustering these two computers, adding additional software and storage capabilities, placing the University on a national network (NSFNet), and developing CAI work.

Virtually none of this could have happened without the acquisition of the VAX 8350 from this grant.

We have been able to train approximately 20 faculty in software engineering principles and Ada, which in many cases have encouraged them to submit new research proposals. Many of them are doing research now that they would not have ordinarily done. Approximately, seven students have been hired to aid the researchers and to do independent work. Some are now being employed and using the knowledge, experience, and techniques received while working for the ReDTEA project. Approximately, forty students have taken Ada-related courses during the grant period. Some are now in the employ of DoD and its contractors using that language in software engineering environments.

The effects of the funding of research and training, the acquisition of hardware and software, the purchase of research materials, and the support of an excellent CAI Assistant/Programmer have had the above measurable and many unmeasurable positive effects on the overall computational research capabilities at this University. We are being solicited even more often to write proposals for both governmental and private grants in computational research; we are now considered a Historically Black Research University by some private research foundations; and we are beginning to attract better faculty.

Needless to say we appreciate the funding and feel that the entire University community has benefitted and will still benefit.

FUTURE DEVELOPMENTS:

Virtually, all the researchers and participants are continuing with the same or similar activities; some of these have already been supported by other funding organizations. New avenues of investigation and interests have also been generated directly and indirectly from this ARO grant. Some current areas of interest include

1. Using Ada has a program design language. There have been conversations with Army officials (TRADOC) dealing with an Ada-based design data base design and management.

2. Building a software engineering laboratory, establishing specialized graduate continuing education courses in this area, etc. Funding is being sought to accomplish both educational and research objectives in software engineering. We are beginning to establish a relationship with the Software Engineering Institute.

3. We have research contracts with NASA (Langley Research Center), plan to establish contracts with the Naval Surface Weapons Center, and have made proposals to the National Science Foundation.

In November, 1988 we asked for an extension on this grant (called ReDTEA II - ARO Proposal No. 26808-EL) to

1. Extend our Ada Education and Training,

2. Extend the AdaL prototype to other computational platforms,

3. Establish additional Ada and Software Engineering Workshops,

4. Continue with the work of investigating the modifying algorithms to a parallel processing environment using Ada's tasks as a simulation tool,

5. Study fault tolerance and distributed systems in an Ada-controlled environment,

6. The development and application of a basic fuzzy-set, fuzzy-graph package in Ada, and

7. Further enhancements of the Academic Computing Unit.

Since November, some of these items have already been funded, but the proposal is still outstanding at ARO.

BIBLIOGRAPHY

Shah, Shantilal N.   "Modification of LU Factorization Algorithm for Parallel Processing Using Tasks Supported by Ada Language" <u>Proceedings of the Seventh Annual Conference on Ada Technology</u>, March 1989.

Harrison, George C. "AdaL, An Automated Code Reuse System" <u>Proceedings of the Seventh Annual Conference on Ada Technology</u>, March 1989.

Kung, Mou-Liang   "Simulation Testbed for Routing Algorithms" Department of Computer Science, Norfolk State University, internal document (February 1989).

SOFTWARE:

Lumsdon, Esther   "Ada Language Reference Manual Reader (March 1989)" Available upon request subject to availability of resources. Submitted to Simtel 20 Ada Repository.

Herro, Dr. John   "ADA-TUTR" Shareware Ada language tutorial. Purchased and customized by ReDTEA personnel. Available upon request subject to availability of resources.

Harrison, George C. "ADAL" Ada reusability software prototype. Available upon request subject to availability of resources. Currently being upgraded to work in an integrated environment.

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     Deborah Chen
     Paul Hsiung
     May Tsai Hou
     Mark Manes

Undergraduate Student Assistants   DUTIES

Bryan Jervey	Initiate the development of an interface between VMS SMG run-time library routines and VAX Ada
James Edwards	Examine the CPU timing differences between sequential and parallel (tasking) implementations of LU factorization algorithms

Theyartis Edwards	Assist the CAI Assistant/Programmer in certain file management activities necessary in the development of the LRM reader
Camille Deleveaux	Assist the CAI Assistant/Programmer in certain file management activities necessary in the development of the LRM reader
	Produce an Ada package to support exact floating point computations
Valerie Johnson	Use Ada as a design language to produce a software design for a prescription package to be used by the Mathematics Program
Lorina Dozier	Test the implementations of the ADA-TUTR package.