HIGH-LEVEL PARALLEL PROGRAMMING TOOLS
FOR FINITE ELEMENT ANALYSIS

FINAL REPORT

OCTOBER 17, 1994

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Institute for Computational Mathematics
Kent State University
Kent, OH 44242

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13. ABSTRACT *(Maximum 200 words)*

Automatic generation of sequential and parallel programs can bring the power of modern computers to more engineers and scientists. The project investigated *parallel code generation* and *automatic derivation of parallel finite element routines.* Software packages GENCRAY, a code translator producing Cray Fortran, and PIER, a finite element code derivation system, have been constructed as research tools.

14. SUBJECT TERMS
Automatic code generation, parallel computing, finite element method, interfacing symbolic and numeric computations.

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6. AUTHORS OF REPORT: Paul S. Wang

Statement of the Problem Studied

Improved operating environments and powerful parallel programming tools are vital to realizing the full potential of modern parallel processors. Under this project, we studied the automatic generation of parallel programs in the important application area of finite element analysis (FEA). A software system is built to derive the required formulas and procedures through symbolic computation. These formulas and parallel procedures are then fabricated, through a *code generator* into parallel code to run on a given parallel processor.

The project involves two related areas:

1. Parallel code generation – A portable code generator written in C (Lex/Yacc) to produce parallel code for the Warp, Encore/Sequent computers, that can be used from any symbolic computation system.

2. Automatic derivation of parallel finite element routines – A Common Lisp based package for the automatic mapping of finite element computations on the Warp, Encore/Sequent parallel processors and for deriving parallel procedures to be translated by the code generator into routines readily executed on the target machine.

Summary of the Most Important Results

Good progress has been made towards the overall goal of automating the generation of sequential and parallel codes for finite element analysis and in making the code generation software system easier to use. The free-standing code translator GENCRAY has been completed and a paper appeared in ACM/TOMS. The implementation and testing of the PIER software system, with special emphasis on text-book style input handling has been accomplished. Dr. Naveen Sharma finished his Ph.D. in this area.

List of All Publications and Technical Reports

1. Paul S. Wang, "Symbolic Computation and Parallel Software," Proceedings, First International Conference of the Austrian Center for Parallel Computation, September 30 - October 2, 1991, Springer-Verlag Lecture Notes in Computer Science, *Parallel Computation*, Vol. 591, pp. 316-337.

2. Sanjiva Weerawarana and Paul S Wang, "A Portable Code Generator for CRAY FORTRAN," ACM TOMS, September 1992, pp. 241-255.

3. Paul S. Wang, "Parallel Univariate p-adic Lifting on Shared-Memory Multiprocessors," Proceedings, ISSAC'92, July 27-29, Berkeley, California, 1992, pp. 168-176.

4. Sharma, N., *Automating FEA Programming*, Automating Software Design, AAAI Workshop, San Jose, July 1992.

5. Sharma, N., *Synthesis of Parallel Mathematical Modeling Programs*, IMACS International Symposium on Mathematical Modeling and Scientific Computing, December 7-12, 1992, Bangalore, India.

6. Sharma, N., *Synthesis of Sequential and Parallel Programs for Finite Element Analysis*, Technical Report ICM-9212-44, Institute for Computational Mathematics, Department of Mathematics and Computer Science, Kent State University, Kent, OH.

7. N. Sharma and P. S. Wang, "Automated Synthesis of FEA Programs," Extended Abstract, Third International Conference on Expert Systems for Numerical Analysis, Published as CSD-TR-93-028, Department of Computer Science, Purdue University, West Lafayette, IN 47906 (1993).

8. N. Sharma and P. S. Wang, "Automated Synthesis of Parallel FEA Code," Proceedings, Eleventh Army Conference on Applied Mathematics and Computing, Pittsburgh, June 8-10, 1993.

9. N. Sharma and P. S. Wang, "The PIER Parallel FEA Program Generator," Proceedings of the Thirteenth Annual ASME International Computers in Engineering Conference and Exposition, pp. 295-306, August 8-12, San Diego, CA, August 1993.

Scientific Personnel

Project personnel include Simon Gray, Naveen Sharma, Paul S. Wang (P.I.), and Syuzanna Zakharova.

Dr. Sharma finished his Ph.D. in the Fall of 1992. He left Kent to work for industry (Xerox Research, Rochester, N.Y.) The other graduates students are still making progress in their Ph.D. degree programs.