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Form Approved OMB No. 0704-0188

...verage 1 hour per response, including the time for reviewing instructions, searching existing data sources, ... the collection of information. Send comments regarding this burden estimate or any other aspect of this ... Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson ... Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE: October 30, 1989

3. REPORT TYPE AND DATES COVERED: FINAL Report. 01 May 88 thru 30 sep 89

4. TITLE AND SUBTITLE: MASSIVELY-PARALLEL COMPUTATIONAL FLUID DYNAMICS

5. FUNDING NUMBERS: AFOSR-88-0212; 61102F 2304/A2

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8. PERFORMING ORGANIZATION REPORT NUMBER: AFOSR-TR- 90-0079

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES):
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
Building 410
Bolling AFB, DC 20332-6448

10. SPONSORING/MONITORING AGENCY REPORT NUMBER: AFOSR-88-0212

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT:
Approved for public release;
distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Algorithm development. Implementation of a 3-D Navier-Stokes implicit research code fro AFFDL was initiated. This required the parallel solution of block-tridiagonal systems and so was more challenging than the above explicit code. This is being continued in a new AFOSR grant. Connection Machine experiments. To keep abreast of SIMD architecture performance, a series of Fortran and C kerrels were studied on the Argonne Laboratory CM-2 during the summer of 1989. It was concluded that the available Fortran 8X implementation on the CM-2 was too inefficient to warrant continued study at that time. Keywords: Programming Languages, Computer programming, Computer architecture.

14. SUBJECT TERMS

15. NUMBER OF PAGES: 4

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

Final Technical Report

for Period 5-1-88 to 9-30-89

Grant AF-AFOSR-88-0212

MASSIVELY-PARALLEL COMPUTATIONAL FLUID DYNAMICS

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October 30, 1989

I. Progress Report

Goal

The research is intended to develop methodologies for specifying major machine design parameters for distributed parallel architectures useful in CFD. The effort has two major components.

(1) Gain algorithm experience in conversion of a suite of Air Force production and research CFD codes to a general format applicable to a variety of such commercial architectures.

(2) Relate critical code execution timing features to the machine parameters.

Progress (5/88-9/88)

(1) Algorithm development [2]. A full 3-D Navier-Stokes explicit production code from AFFDL was implemented on a 1024-node scalar NCUBE hypercube at SANDIA (Albuquerque).

(2) Distributed-memory architectures for CFD [1][3]. Timing models of this code were developed in terms of four critical design specifications - MFLOP execution rate, message startup and transfer times, and local memory size. These models were intended to permit a graphical specification of hardware tradeoffs to achieve given levels of parallelization efficiency.

Progress (10/88-9/89)

(1) Algorithm development. Implementation of a 3-D Navier-Stokes implicit research code from AFFDL was initiated. This required the parallel solution of block-tridiagonal systems and so was more challenging than the above explicit code. This is being continued in a new AFOSR grant.

(2) Connection Machine experiments. To keep abreast of SIMD architecture performance, a series of Fortran and C kernels were studied on the Argonne Laboratory CM-2 during the summer of 1989. It was concluded that the available Fortran 8X implementation on the CM-2 was too inefficient to warrant continued study at that time.

II. Coupling Activities

Air Force Flight Dynamics Laboratory

Several of the codes under study to illustrate the architectural modeling process were obtained from Dr. Joseph Shang, director of the Computational Aerodynamics Group at AFFDL. Five visits were made to his laboratory to plan the coordination of our research efforts. A four-processor NCUBE massively-parallel algorithm preparation workstation was loaned to his group to assist in these joint efforts.

Near the end of the grant period, it was decided during a visit that a moderately-parallel message-passing network of workstations would be of immediate interest to Dr. Shang's group; further, it appeared that the above-mentioned parallelized CFD code would be directly applicable to such an architecture. Work is continuing on this research under new AFOSR-sponsored funding.

III. Publications

[1] Wu, E.S., D.A. Calahan, and R.A. Wesley, "Performance Analysis and Projections for a Massively-Parallel Navier-Stokes Implementation," Proc. Fourth Conference on Hypercube Concurrent Computers and Applications, Monterey, CA, March, 1989.

[2] Wesley, R.A., E.S. Wu, and D.A. Calahan, "A Massively-Parallel Navier-Stokes Implementation," Proc. AIAA Computational Fluid Dynamics Conference, Buffalo, NY, June, 1989.

[3] Calahan, D.A., "Specification of a Fluids MIMD Distributed-Memory Architecture," Proc. Parallel CFD Conference, Los Angeles, CA, May, 1989.