



Parallelization of the Fluid Dynamics Equations on Unstructured Grids  
Christopher W. S. Bruner  
Naval Air Warfare Center, Patuxent River, MD

COMPUTER RESOURCE: Intel Paragon, Wright-Patterson Air Force Base (WPAFB)

RESEARCH OBJECTIVE: To investigate the parallelization properties of different time-integration algorithms for Computational Fluid Dynamics (CFD) on unstructured grids, i.e., to compare the scalability of several commonly-used algorithms on distributed-memory parallel processors.

METHODOLOGY: The author is developing a parallel Euler solver, PUE3D, on the Intel Paragon at WPAFB. This machine is a distributed-memory machine based on the Intel i860 processor. Several different implicit and one explicit algorithm have been implemented, and encouraging preliminary results have been obtained for the Symmetric Successive Over-relaxation (SSOR) algorithm. This research effort is being funded through the Office of Naval Research (ONR) Independent Laboratory In-house Research (ILIR) program, which does not cover computer charges; therefore, the availability of the DoD HPC SRC makes this research possible.

RESULTS: Only preliminary results are available. The code has just been extended to higher-order spatial accuracy. Using SSOR, however, an efficiency of 79% was obtained when using 32 processors on a test case with a 2-dimensional geometry. The 3-dimensional case run thus far compares well with established codes, but timings are currently unavailable.

SIGNIFICANCE: The significance of the research is the extension of the knowledge base in parallelizable algorithms. Currently, almost all implicit parallel unstructured codes implement the Generalized Minimum Residual (GMRES) algorithm, while explicit codes almost invariably implement m-stage Jameson-style Runge-Kutta. No systematic comparison of different algorithms has been performed. The capability to calculate the flowfield about a complete aircraft, both quickly and accurately, is essential to future warfighting in that different aircraft/store combinations, new appendages on aircraft, changes in airloads, or any other change in geometry or conditions can be analyzed before a flight test in time to impact that test. Production codes using the results of this research would be excellent tools for the commercial aircraft designer.

DTIC  
ELECTE  
SEP 02 1994  
S G D

Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	<i>per [signature]</i>
By _____	
Distribution / DTIC QUALITY INSPECTED 1	
Availability Codes	
Dist	Avail and/or Special
A-1	

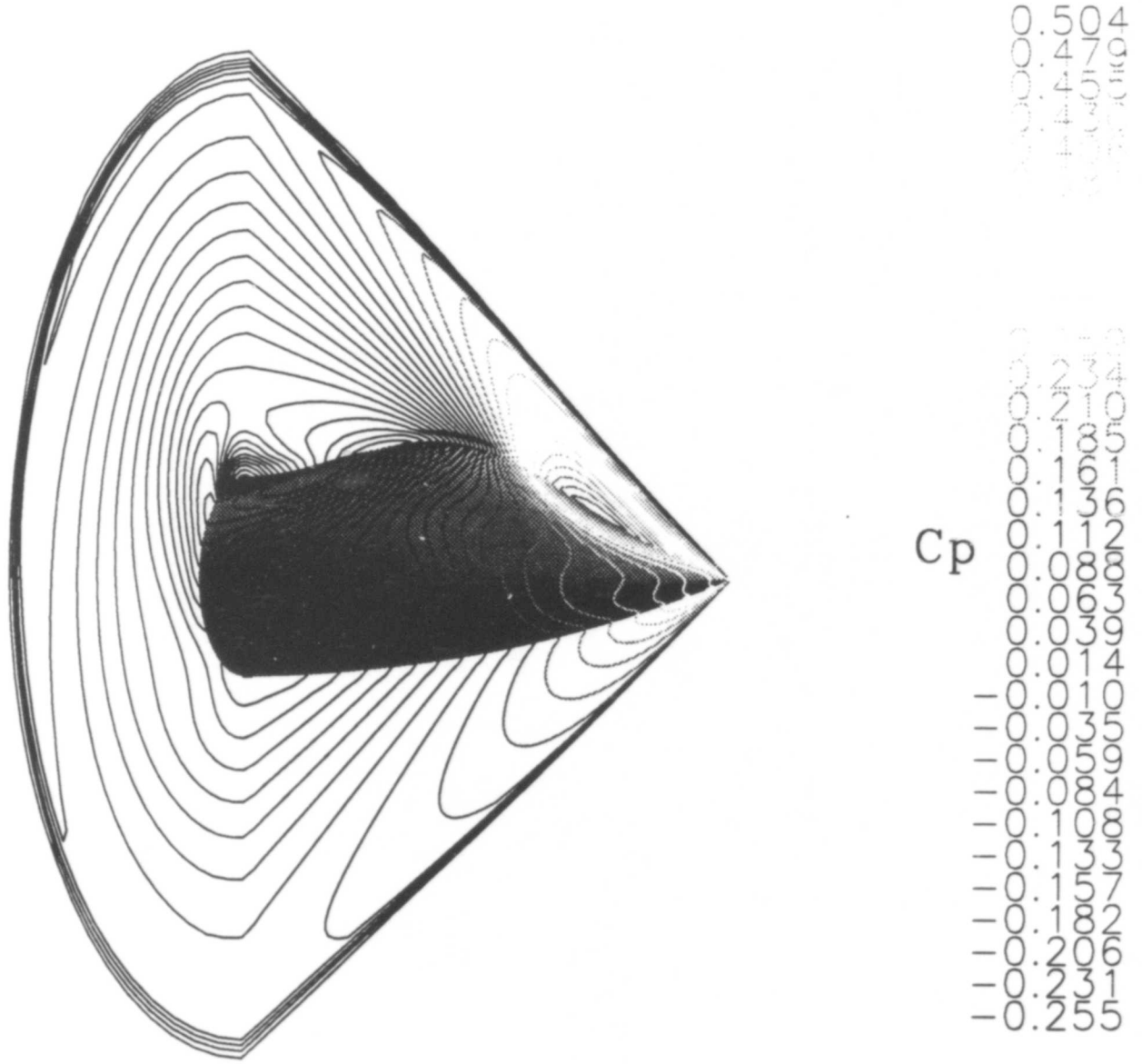
94-28634



498

94 9 01 2 1 3





Thu, 9 Jun 94 16:46:02 EDT

From digests@ida.org Thu Jun 9 16:58:26 1994

From: DoD HPC Mod Office@ida.org, Leland Williams@ida.org

To: IDA-hpc-approval@ida.org

Subject: Success Stories

Date: Thu, 9 Jun 94 16:46:02 EDT

1. Thank you for an overwhelming and prompt response to my 3 May and 10 May requests for success stories. It has been decided that, instead of including a small selection of success stories in the forthcoming HPC Mod Plan Update, we will publish a much larger set in a separate Appendix. And, we want some syntactic and editorial uniformity. Hence, we have engaged a technical editor and support staff at NRL, and we are asking you to re-submit selectively and in specific format.

2. Each account approval authority (there are 33, not counting alternates at some lab sites) should select not more than five (5) success stories to best illustrate HPC contributions to DoD mission success at your lab/center. Consider that we want to illustrate both basic and applied research, both DoD lab/center researchers and supporting academic contractors, and both warfighting and dual use projects. Contributions must be unclassified and account approval authorities must so certify. It is expected that all five success stories (if submitted) from each lab/center will be published, but the DoD HPC Mod Office reserves the right to make final publication choices.

3. Each contribution must be prepared as follows:

Exactly one page including required graphic.

Page size - 8-1/2 x 11 in.

Margins - left - 1-1/4 in.; top, right - 1 in., bottom - 1-1/2 in.

Type size - 12 point

Spacing - single space for text; 1-1/2 space between headings

Title box - consists of three lines of information: Title - limited to one line; Author(s) - list all authors as they prefer (e.g., J. G. Jones or John G. Jones); and Affiliation - name and city location only (e.g., Naval Research Laboratory, Washington, DC; do not include any lab sub-division).

Specific headings must be addressed in following order. Headings are placed flush left, followed by a colon; text is run in following the colon:

COMPUTER RESOURCE: - name the computer and the DoD site.

RESEARCH OBJECTIVE: - what and why (hardware, algorithm, scalability, scalable efficiency, critical element, etc.)?

RESULTS: - to research objective and to computational science, if any; include reference to any one publication wherein the HPC grant is credited (if more than one, choose one to reference and indicate "1 of N").

SIGNIFICANCE: - to warfighting and to dual use, if any.

Color graphic - each submission must contain a color (only) graphic; black and white graphics are not acceptable. Submit hard copy only; size limited to 8 x 10 in. Author does not need to scale graphic to fit text; this can be done by the editor if necessary, but author must ensure that graphic will be intelligible when scaled to fit on the single page. Clearly indicate top and bottom of graphic. Provide first-generation copy; do not make prints of computer-generated output; do not provide negatives. Be sure that all data information is clearly defined, not

smudged. Send graphic in plastic "elevator;" carefully note author name(s) on back of graphic in light blue pencil.

All graphics must have captions; these are placed under the figures in final layout. Make them as brief as possible, preferably no longer than three lines. Try to avoid repeating caption in text.

Define all acronyms and abbreviations the first time they are used.

4. For each contribution, provide a point of contact who will be available for editorial questions and final review. Availability is critical; once the process of publishing this appendix has begun, we will be processing more than 100 submissions in three weeks. We need immediate access for questions and final approval. Please provide: name, e-mail address, fax and telephone numbers, and mailing address.

5. E-mail ascii text (only ascii) to: long28nrlfsl.nrl.navy.mil (Maureen Long, Technical Information Division, NRL, tel 202-767-2782).

Simultaneously send graphics and single-page hard-copy text [priority mail, Federal Express...] to:

Maureen Long  
Code 5231, Bldg 222, Room 253  
Naval Research Laboratory  
Washington, DC 20375-5333

The hard-copy must have an attached certification from your lab/center security officer such as:

"This material is unclassified; it does not contain militarily critical, technology related material; and it is releasable to the general public."

Contributions must be received by COB 24 June 1994 for publication about five weeks later.

6. Let me just remind you that, when the program achieves stable state, success stories will be an almost automatic by-product of the annual report promised by each researcher and his/her account approval authority upon execution of the account application form:

Report. It is agreed that an unclassified short annual report will be submitted to the Shared Resource Center, covering research objective, computational methodology, and results (significance to warfighting capability, importance of particular computer architecture, etc.). The report will include reference to any publications per item 4. The report will be submitted via my service/agency approval authority.

7. SRC site managers are copied for information and coordination, but we want to channel selection and forwarding through the account approval authorities.

Thanks, Leland

Success Stories

Thu, 16 Jun 94 17:15:12 EDT

From [djcasts@ida.org](mailto:djcasts@ida.org) Thu Jun 16 17:23:43 1994  
 From: DoD HPC Modernization Office@ida.org, Leland Williams@ida.org  
 To: [IDA-hpc-approval@ida.org](mailto:IDA-hpc-approval@ida.org)  
 Subject: Success Stories -- new info for submissions  
 Date: Thu, 16 Jun 94 17:15:12 EDT

1. Thanks to all for good response to ref (a), i.e., no one has threatened to hang me yet! But, let me answer for all a few questions that have come in:
  - a. Please let us have an additional week? Granted; deadline is a. COB Friday 1 July.
  - b. What type font to use? We don't care. The only purpose for the hard-copy text is to ensure that you know that the 12 point text and graphic will fit on one page with required margins and spacing. NRL editors will use your ascii text to do some style and format editing for uniformity and clarity; and they will choose the type font.
  - c. 5 contributions per account approval authority? This will not be a firm limit. If you need 6 or 7 to tell story from your lab, do it. By same token, I don't really expect as many as 5 from certain smaller labs. If you can tell your lab's story with 1 or 2 or 3, stop there. Bottom line, I am depending on the account approval authorities to ensure that what you send is quality and good for your lab and for DoD. And remember, it is the quality of the research that counts; keep the HPC in perspective as an enabling tool. DO NOT SEND ANYTHING THAT SMACKS OF NELOPS COMPETITION AMONG X HPCs. The DoD Mod Office continues to reserve right to make final publication choices, but I want you to make that job easy.
  - d. Computer site involvement? NRAD wants to be sure that Major Andrew's target identification program (Wright Lab) is included. It absolutely should be and NRAD and Wright Lab should negotiate to ensure it is. Since it is a Wright Lab project, it should be submitted by Wright Lab. ALL SUBMISSIONS ARE TO COME FROM THE ACCOUNT APPROVAL AUTHORITY REPRESENTING THE LAB RESPONSIBLE FOR THE RESEARCH. SITE MANAGERS WHOSE HPC WAS USED SHOULD NEGOTIATE TO ENSURE INCLUSION OF THE GOOD STUFF THEY KNOW ABOUT.
  - e. What success stories submitted on previous call? This question came from MPECC. I cannot answer it in general because the 2.5 " of success stories are not sorted by either home lab or computer site. However, Peg, I can tell you about one that had been selected for the small section of success stories, before that plan was scrapped in favor of publishing many stories in a separate book -- "A Portable Parallel Smooth Particle Hydrocode" by Smith and Baker, PL/WSCD. They cite the MPECC SP-1 W-P Paragon, ABPCRC CN-5, and several workstations.
  - f. Someone called Maureen to ask for a model. If you want same, Maureen can fax a copy to you.

2. Choose a primary identification for each submission from the following DoD Computational Technology list -- so indicate in your email submission and by sticky note on hard-copy; no need to embed in text:

- (1) Computational Structural Mechanics (CSM)
- (2) Computational Fluid Dynamics (CFD)
- (3) Computational Chemistry and Materials Science (CCM)
- (4) Computational Electromagnetics and Acoustics (CEA)

- (5) Climate/Ocean/Weather Modeling (CWO)
- (6) Signal/Image Processing (SIP)
- (7) Forces Modeling and Simulation/CAI (FMS)
- (8) Environmental Quality Modeling (EQM)
- (9) Computational Electronics and Nanoelectronics (CEN)

3. The Service/Agency Principals would like to see your success stories. They want to ensure proper coverage in each respective service. So, please email ascii and fax hard-copy to them same time you send it to the NRL editor. PLEASE DO \*NOT\* EMAIL TO ME. IT WILL JUST CLUTTER MY EMAIL; MAUREEN LONG WILL PASS TO ME WHEN APPROPRIATE. These people are:

Army Harold Breaux  
 ARL  
 AFG, MD 21005  
 Tel 410-278-6259  
 FAX 410-278-5077  
 email harold@bri.mil

Navy Beta Wald  
 ONR  
 800 N. Quincy Street  
 Arlington, VA 22217-5000  
 Tel 703-696-0157  
 Fax 703-696-2611  
 email ewald@cmsun.nrl.navy.mil

AF Charles Holland  
 AFOSR  
 Bolling AFB  
 Washington, DC  
 Tel 202-767-5025  
 Fax 202-404-7496  
 email holland@afosr.af.mil

DNA Gene Stokes  
 DNA/IRMA  
 6801 Telegraph Road  
 Alexandria, VA 22310  
 Tel 703-325-6414  
 Fax 703-325-1323  
 email gstokes@lanl.gov

Thanks, Leland

Success Stories -- new info for submissions