

CAPTtools Project: Evaluation and Application of the Computer Aided Parallelisation Tools

Richard Luczak
Rice University

David O'Neal
The University of Illinois

Michael White
Ohio Aerospace Institute

Outline

- CAPTools project history
- CAPTools overview
- Applications & status
- Summary

Project History

- Jan 98 - Government sponsored visit from Prof. Mark Cross, Director of Research at the University of Greenwich, London, UK
- Aug 98 - collaborative evaluation of CAPTools defined and proposed
- Oct 98 - PET funding for tech support and travel approved; internal workshop at ASC by UG

Project History (cont.)

- Dec 98 - collaboration between UG and NASA Ames incorporated into ASC project through use of OpenMP code generation directives
- Apr 99 - integrated (MPI/OpenMP) beta release provided to ASC
- Jun 99 - internal workshop at ASC by UG

What is CAPTools?

A software environment to transform Fortran codes from scalar to parallel form with message passing or OpenMP directives in interactive semi-automatic way

Main Components

- State-of-the-art interprocedural dependence analysis techniques
- In depth analysis using symbolic algebra methods
- User supplied knowledge to assist parallelization
- GUI interactive front end
- Automatic user directed array partitioning
- Automatic parallel code generation
- Portable scalable code

Input codes to CAPTools

- Standard Fortran 77 (Fortran 90 in development)
- Multiple program files
- Include statements
- External references must be resolved prior to loading
- Conditional compilation directives should be preprocessed

Applications

- R-Jet (AFRL Air Vehicle Directorate) - a hybrid high-order compact finite-difference/spectral method for simulating vortex dynamics and breakdown in turbulent jets.
- N-Body (Rice University) - a 3D n-body model with constraints.
- PFEM (Carnegie Mellon University) - finite element code for solving highly nonlinear boundary value problems in 2 dimensions.

Applications (cont.)

- Chimera (Wright State University) - high-frequency Navier-Stokes model to study aeroelastic effects.
- ARC (University of Pittsburgh) - models electrothermal effects in large electric ovens used to reduce pure aluminum out of bauxite ore.
- ADM (AFRL Materials Directorate) - a fracture mechanics code to simulate crack propagation in composite materials.

Status

Appl	Geom	Subr	F77 in	OMP out	MPI out	OMP validat	MPI validat
R-Jet	3D	63	7655		19284		1, 4
N-Body	3D	2	195	207	376	1-6	1-6
PFEM	2D	16	2073	1934	3371	1-8, 16 32, 64	1-8, 16
Chimera	3D	76	9964		11993		1-8, 16
ARC	2D	28	2027	1881	2451	1-4	1-3
ADM	2D	78	12679				

PFEM timings (sec) for a 128x128 case

	1 PE	2 PEs	4 PEs	8 PEs	16 PEs
Serial	45.6				
Cray	47.1	27.6	17.6	11.4	8.4
OMP	48.4	26.9	14.9	10.2	4.4
MPI	75.0	50.2	31.0	16.2	12.2

Benefits

- Speedy parallelization of Fortran codes
- Generic parallel code (not restricted to any one parallel system)
- Parallel code is recognizable to the user:
 -) the code can be maintained as the single version
 -) the code can be optimized, e.g. TRIB routine in ARC code
- The parallel code is scalable (not restricted to any fixed number of processors)

Summary

- CAPTools is able to generate OpenMP and MPI source codes that compile, run, and produce correct results on an SGI Origin 2000
- Although we regard CAPTools as a research-level application we can recommend deployment in a limited sense (restricted access for pioneer users)

`http://captools.gre.ac.uk`

`luczakr@asc.hpc.mil`