Department of Computer Science

School of Sciences

Universidad de Buenos Aires

Argentina

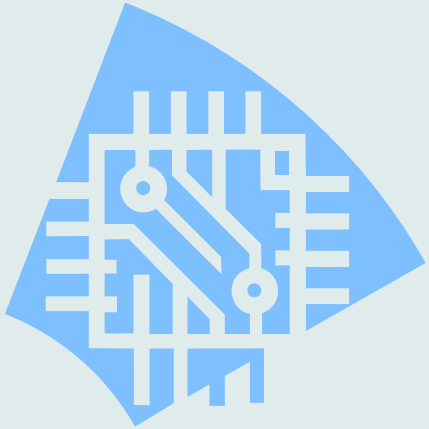
About Us

- Largest computer science department in the country.
- 150 total staff, 33 professors (19 full time).
- Our students rated 10th in ACM Programming Contest 2002, above all other North & South American teams.
- Most Computer Science international publications from Argentina come from our Department.

Itanium Equipment

Hardware

Processors: 2x Intel Itanium 2
Clock frequency: 1.5 GHz
Cache: 6MB L3
System bus bandwidth: 6.4 GB/s.
Memory: 2 GB DDR, 8.5 GB/sec bandwidth



Software

Operating System: Debian Linux Version 3.1r1 (Sarge)
Compiler: Intel C++ Compiler for Itanium-based applications Version 9.1.042 (20060707)
Math Libraries:

- Intel Math Kernel Library 9.0
- HP MLIB 9.2

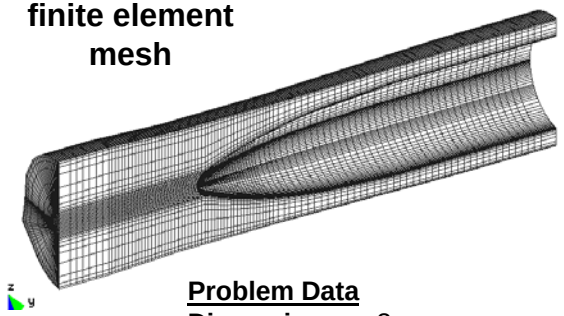
Current work

The problem of **solving very large systems** of linear algebraic equations appears in many real world applications.

The following problems arising from the use of the Finite Elements Method are being solved by SIDERCA, a company belonging to the TENARIS group, a worldwide manufacturer of seamless steel tubes for several industries.

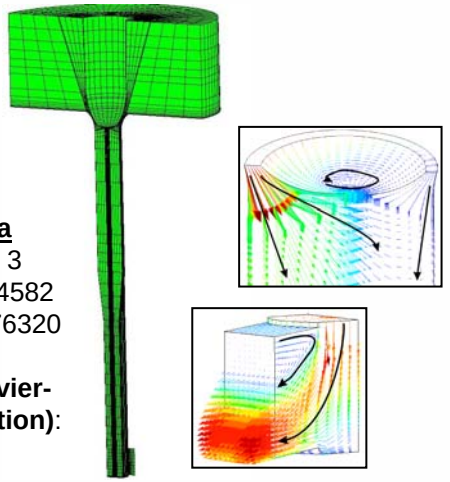
Finite element simulation of the Mannesmann piercing process

View of the finite element mesh



Problem Data
Dimensions : 3
Nodes: 109148
Elements: 100950
Number of unknowns 322894

Finite element modeling of control flow devices in steel industry



Problem Data
Dimensions: 3
Nodes: 84582
Elements: 76320
Degrees of freedom (Navier-Stokes equation): 235565

AcCim

Beyond certain sizes, direct methods can not be applied to solve these problems and iterative methods are employed.

In the last years we have developed a **new category of fast, intrinsicaly parallel iterative methods.**

Publications

"New Optimized and Accelerated PAM Methods for Solving Large Non-Symmetric Systems", H. Scolnik, N.Echebest, M.T.Guardarucci, M.C. Vacchino.in the book: Inherently Parallel Algorithms in Feasibility and Optimization and their Applications, D.Butnariu, Y. Censor and S. Reich (Editors), Studies in Computational Mathematics 8, 2001 Elsevier Science, Amsterdam, pp 457-471,2001

"A Class of Optimized Row Projection Methods for Solving Large Non-Symmetric Linear Systems", H.Scolnik, N.Echebest, M.T.Guardarucci, M.C.Vacchino, Applied Numerical Mathematics 41, 4, pp.499-513, 2002, Elsevier Science.

"Acceleration Scheme for Parallel Projected Aggregation Methods for Solving Large Linear Systems", H.Scolnik, N.Echebest, M.T.Guardarucci, M.C.Vacchino. Annals of Operations Research. Volume 117, 2002, Baltzer Science Publishers.

"An acceleration scheme for solving convex feasibility problems using incomplete projection algorithms", N. Echebest, M. T. Guardarucci, H. D. Scolnik, M. C. Vacchino , Numerical Algorithms., 35, pp.331-350, 2004

"Incomplete Oblique Projections Algorithms for Solving Large Inconsistent Linear Systems", H.Scolnik, N.Echebest, M.T.Guardarucci, Mathematical Programming, 2007.

Test Results with AcCim

We tested the AcCim solver with the six difficult problems from computational mechanics, proposed by Bramley and Sameh in [1].

These problems have sparse, non-symmetric matrices with 13824 rows and columns, and 93312 non-zero values.

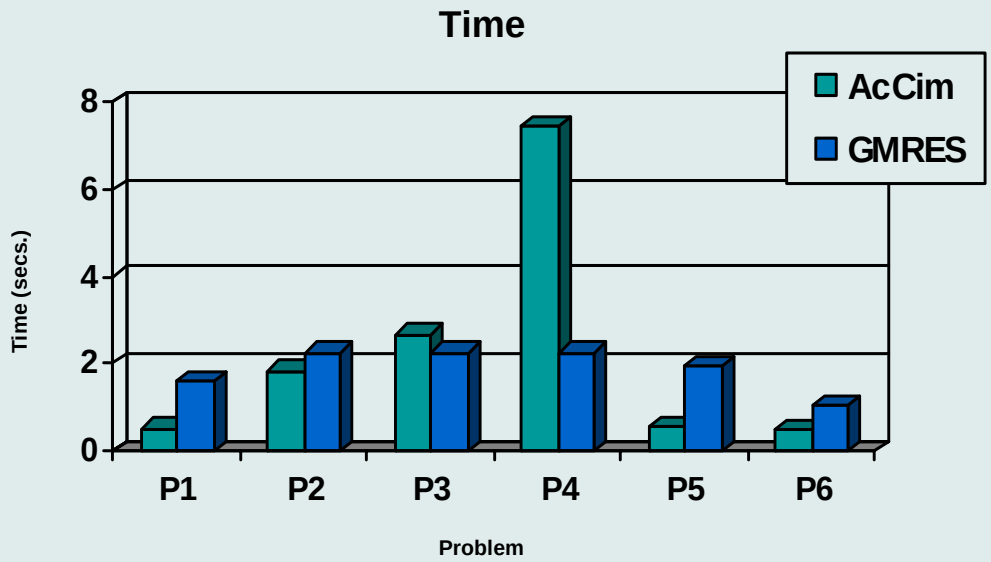
	P1	P2	P3	P4	P5	P6
Estimated *k*(A)	9	57	40000	4786	36	77

The following results were obtained running the AcCim solver on an Itanium 2 machine.

	P1	P2	P3	P4	P5	P6
Residual	9.68178e-08	1.95547e-05	0.000153996	6.11926e-06	2.52025e-06	5.73289e-06
$\|X^* - X_k\|$	2.76788e-07	5.73204e-05	0.00563879	5.90394e-05	9.06588e-06	8.0397e-06
Time (secs)	0.521184	1.84366	2.67326	7.45664	0.564128	0.466528

[1] R. Bramley and A. Sameh. Row projection methods for large nonsymmetric linear systems, SIAM J. Sci. Statist. Comput. 13 (1992) 168-193

Comparison with GMRES(*)



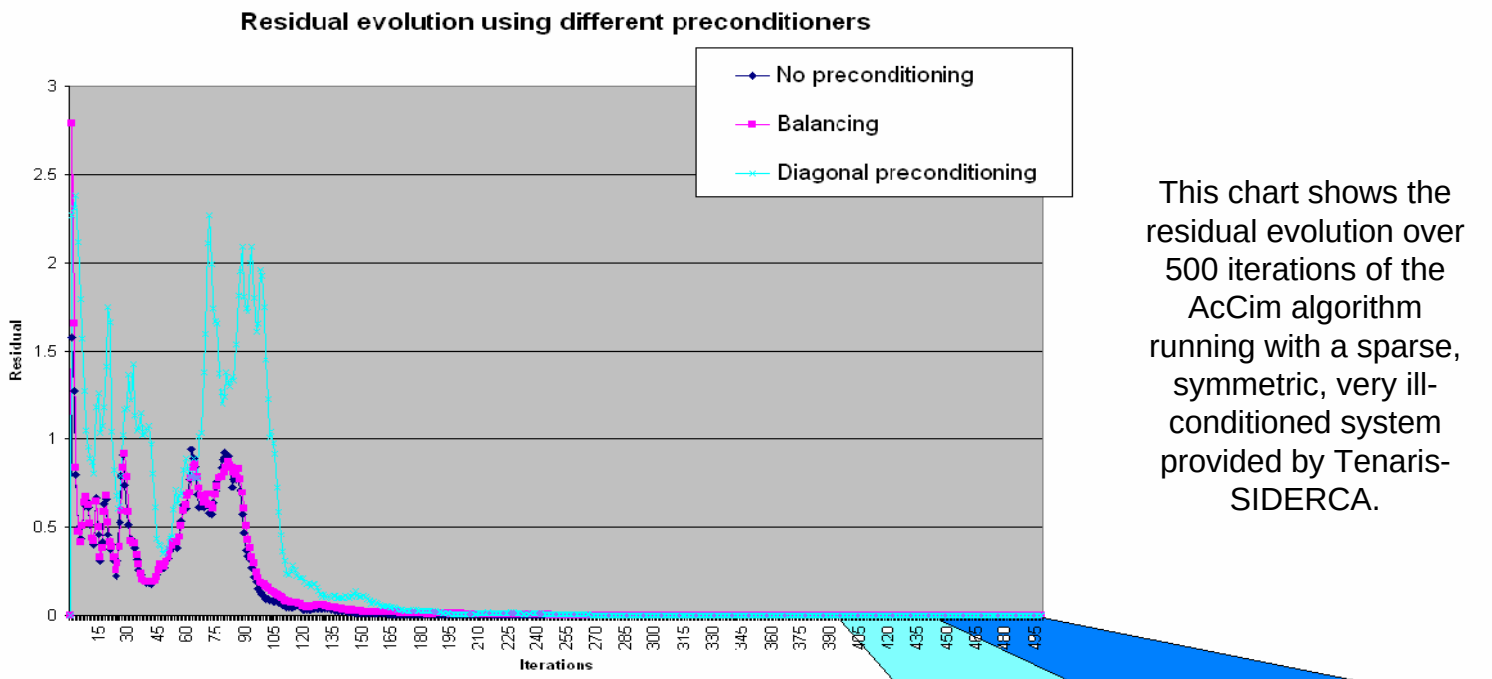
Precision (Final residual)

	P1	P2	P3	P4	P5	P6
AcCim	9.68178e-08	1.95547e-05	0.000153996	6.11926e-06	2.52025e-06	5.73289e-06
GMRES	2.16674e-006	0.0506362	0.0474483	108.796	0.000333852	0.000246743

(*) Open source version downloaded from http://people.scs.fsu.edu/~burkardt/cpp_src/mgmres/mgmres.html.

Preconditioners

We used different preconditioners for very ill-conditioned matrices, but none of them improved the results.



This chart shows the residual evolution over 500 iterations of the AcCim algorithm running with a sparse, symmetric, very ill-conditioned system provided by Tenaris-SIDERCA.

Problem size: 13345x13345

Number of non-zero values: 474966

Future Work

Our solver is very good with general and ill-conditioned matrices, but still presents some problems with some almost singular ill-conditioned matrices.

In order to find a solution for this problem, we are moving along two lines of work:

- Implementation of a block-splitting algorithm. Although this is a time consuming solution, it can be reused for several systems having the same matrix.
- Development of a new kind of preconditioners.