Field problems (heat transfer, elasticity) in three-dimensional domains

Th. Apel A. Meyer M. Theß

TU Chemnitz-Zwickau

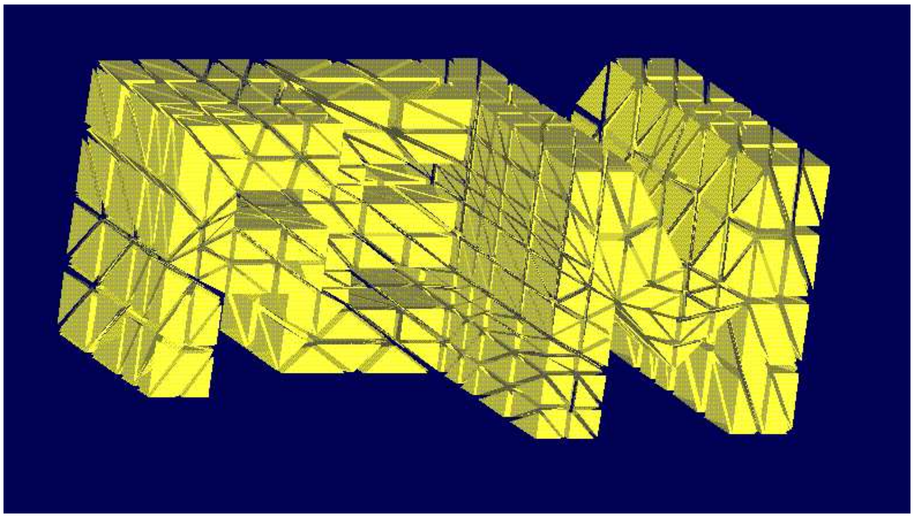
Keywords: finite element method, conjugate gradient method, preconditioning

Our research group is developping a parallel finite element code with the following features:

problems: Poisson equation and Lamé system over three-dimensional domains;

finite elements: linear and quadratic tetrahedra (cuboidal elements are in progress);

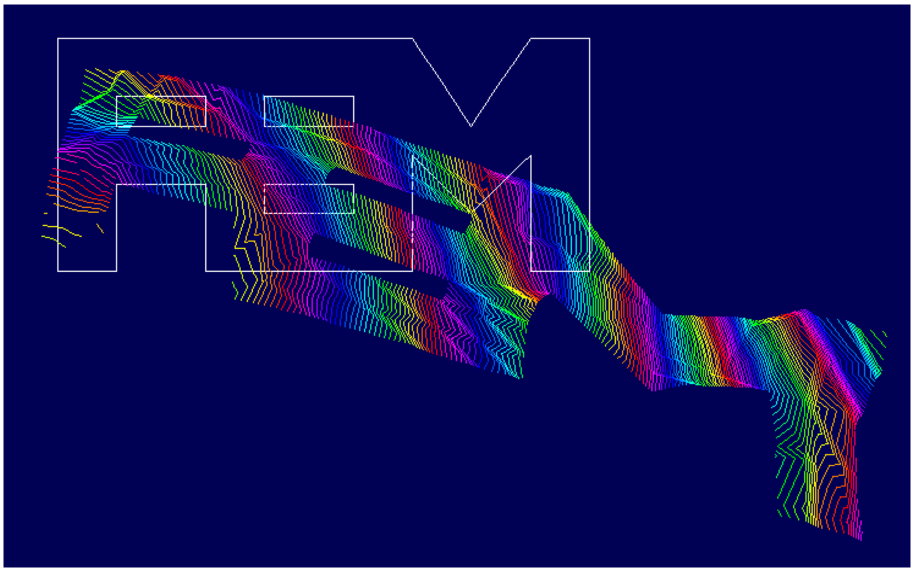
mesh generation: special programs for restricted classes of domains, hierarchical mesh refinement;



solver: conjugate gradient method with Yserentant and BPX preconditioning (multigrid methods in progress);

communication: efficient routines for adequate data structure, see [1];

postprocessing: calculation of error norms, visualization using GRAPE [3].



The quality of our algorithms is demonstrated by the following example: Our test example is to solve

$$\begin{aligned} -\Delta u &= 0 \quad \text{in } \Omega = (0,2)^3, \\ u &= xy \quad \text{on } \partial\Omega, \end{aligned}$$

via the finite element method with linear shape functions on tetrahedral meshes. We generated a coarse meshes with 192 elements and refined it uniformly until the memory was exhausted. In the following table we show the times for solving the corresponding system of equations on different numbers of processors:

level	number of nodes	number of iterations	time [s]		
			8 proc.	32 proc.	128 proc.
0	65	7	0.04	0.09	0.16
1	369	22	0.22	0.39	0.95
2	2 465	38	0.57	0.80	1.87
3	17 985	58	2.10	1.70	3.87
4	137 345	87	17.16	6.87	10.01
5	1 073 409	128	–	–	38.45

References

[1] Th. Apel, G. Haase, A. Meyer, and M. Pester. Parallel solution of finite element equation systems: efficient inter-processor communication. Preprint SPC95_5, TU Chemnitz-Zwickau, 1995. `HREF="file://www.tu-chemnitz.de/pub/Local/mathematik/SPC/spc95_5.ps.Z"`

[2] Th. Apel, G. Haase, A. Meyer, and M. Pester. Numerical comparison of two communication algorithms. Technical report, 1995. `HREF="file://www.tu-chemnitz.de/pub/Local/mathematik/Apel/ahmpnote.ps.Z"`

[3] A. Wierse and M. Rumpf. GRAPE – Eine objektorientierte Visualisierungs- und Numerikplattform. *Informatik Forsch. Entw.*, 7:145–151, 1992.

Contact address

Contact:	Dr. Thomas Apel
Institution:	Technische Universität Chemnitz-Zwickau
	Fakultät für Mathematik
Mail:	D-09107 Chemnitz
Phone:	+49-371-531 2146
Fax:	+49-371-531 2657
Email:	apel@mathematik.tu-chemnitz.de
WWW:	http://www.tu-chemnitz.de/~tap/apel.html