Fraunhofer SCAI

SAMG: A linear solver collection boosting performance in Computational Engineering

SAMG: Efficient and versatile

The task of solving sparse linear systems of equations is inherent in a vast class of application codes used in Computational Engineering. This task is, very often, **the** major runtime bottleneck, all the more when coping with the constantly growing complexity of simulation processes.

SAMG has repeatedly **provided feasibility breakthroughs for industrial clients.** Our customer Yokohama Rubber®, e.g., **reduced certain simulation times from a couple of months to a few days.**

The "magic" behind this success is a composite of properties, the fundamental one being the "Multi Grid" principle (the "MG" in SAMG). This principle has initially pioneered and still delivers **numerical scalability:** The run time and memory consumption increase linearly with the problem size. Non-multigrid/Multi Level solvers fail in this respect, in most cases drastically (see Fig. 1).

There are SAMG customers, e.g., VW, whose applications trigger this ideal behavior. There are others, however, whose models require research and adaptations of the SAMG ingredients. Available since 2001, one key to the success of SAMG is a continuous enhancement to meet customer requirements, including close consultancy relationships.

Application areas

SAMG covers a substantial variety of application fields. In several cases, enabled in intense customer relations, it has become an integral part of essential simulation packages.

A selection of areas (simulators):

- **Material Design** (LS-DYNA)
- **Automotive:** Fluid dynamics, mechanical engineering (OpenFOAM, Adventure Cluster)
- **Oil & Gas** (ADGPRS, 3DSL)
- **Molding and Casting** (MAGMASOFT)
- **Groundwater Flow** (MODFLOW)

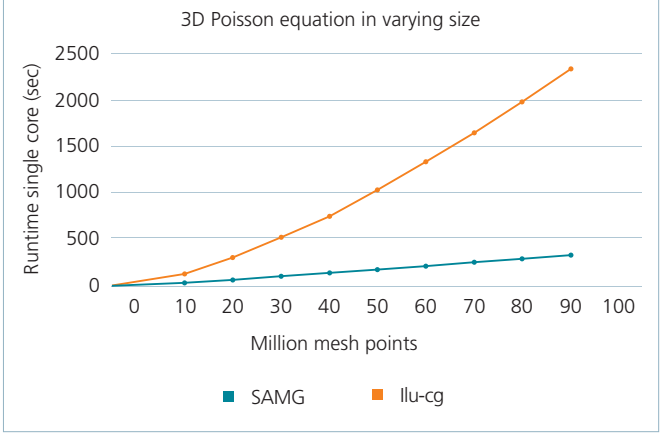

Fig. 1: Superior performance and almost ideal scaling of SAMG

"SAMG-Core": features and performance

The central SAMG library component is "SAMG-Core" (see Fig. 2). It includes all of the SAMG functionality available for solving problems described purely in terms of the sparse linear system. Exploiting additional information about the numerical/physical model of the application is not possible with SAMG-Core – but a feature of the extension modules (presented below).

A selection of industrial use cases:

- **VW** has deployed SAMG-Core, more recently complemented by the MPP module (see Fig. 2), for significantly enhancing the performance of CFD and other analyses from OpenFOAM.
- **AUDI** uses SAMG-Core for heat and radiation simulation.
- **Streamsim** uses SAMG-Core as an integral part of their simulator.

> **We have been using SAMG as our primary solver in our simulator since 1998. The extraordinary speed of our software is – to a large extent – due to the efficiency of SAMG. We highly appreciate the excellent support and the fruitful cooperation with Fraunhofer's SAMG group."**
>
> Streamsim Technologies Inc.

Prerequisites and product portfolio

SAMG is a "plug-in" library for Windows, Linux, and MacOS. Parallelism by MPI, OpenMP, or a mix is implemented. Target systems are all manycore CPU-based HPC clusters. Licenses are tailored flexibly to the customer's needs.

The portfolio is structured around the mandatory "SAMG-Core", complemented by optional extension **"modules"**. A module is a specialization for a certain application class. Additional physical information is passed through the module interface and exploited within SAMG to properly select of algorithmic strategies.

Each module requires a separate license.

"SAMG-Coupled"

This module incorporates the facility to exploit additional information about the physical background of the linear system. In particular, when a system of coupled physical entities (e.g., velocity, pressure, x-y-z-displacements) underlies the linear equations or when geometric data like mesh coordinates are available, this can be passed to SAMG for a dedicated selection of additional strategies.

SAMG-Coupled is **automatically included** in the modules **SAMG-Oil, SAMG-Elasticity,** and **SAMG-Constraints.**

Please refer to the separate product sheets that all modules (except SAMG-Coupled sketched above) are endowed with.

This portfolio is under continuous development to feature state-of-the-art multigrid approaches.

Fig. 2: SAMG and its extension modules.

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SAMG Core

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