

TOWARDS EXASCALE IN ENGINEERING SIMULATIONS

Alya code scaled to 100,000 cores on Blue Waters supercomputer

The Barcelona Supercomputing Center (BSC) and the Private Sector Program at the National Center for Supercomputing Applications (NCSA) have collaborated to scale BSC's Alya multi-physics code to a previously unprecedented 100,000 cores of NCSA's Blue Waters supercomputer, simulating engineering complex problems such as airflow in the human body, contraction of the heart or combustion in a kiln furnace.

While the majority of multi-physics codes are not prepared for large-scale simulations in supercomputers, with efficiency dropping as problems are scaled to a wider number of processors, Alya achieved more than 85 percent parallel efficiency running on Blue Waters.

"These unprecedented results contradict the common belief that engineering simulation codes do not scale efficiently in large supercomputers, opening a new wide horizon of potential applications in the industrial realm," says Seid Koric, the senior technical lead for industrial projects with NCSA's Private Sector Program and an adjunct professor of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign. According to Koric, "it would take 17.4 years for a serial code to do what Alya on 100,000 cores of Blue Waters can do in less than two hours."

"Thanks to the high parallel efficiency attained in codes like Alya, exascale supercomputers will allow engineers and scientists to keep dreaming in projects that today are hard to imagine. Alya is a clear example of BSC's efforts to scale complex codes and make these dreams come true," says Mateo Valero, Director at Barcelona Supercomputing Center.

Alya, a multi-physics parallel code, has been under development at BSC since 2004 and is used to simulate complex engineering problems. Blue Waters is one of the most powerful supercomputers in the world, capable

of performing quadrillions of calculations per second and working with quadrillions of bytes of data.

Staff from BSC and NCSA's Private Sector Program collaborated to push the scaling of Alya on Blue Waters. Koric worked closely with BSC staff, specially Mariano Vázquez, Guillaume Houzeaux and Antoni Artigues, over a couple of months to port Alya to Blue Waters; the code had never previously been run on a Cray platform of such size, so they had to overcome some porting and optimization challenges before the code could run efficiently.

Three cases covering a wide range of engineering simulation needs were chosen to run on Blue Waters: airflow in the human respiratory system, coupled electrophysiology and mechanical contraction in the heart, and combustion in the gaseous phase of a kiln furnace, which is used in the cement industry. All were simulated on Blue Waters at unprecedented levels of scalability.

NCSA's Private Sector Program and BSC plan to continue collaborating to test and improve Alya and to use it to solve large multi-physics problems for NCSA's industrial partners.

ALYA APPLICATIONS' IMAGES:

[Engineering applications](#), [Heart simulation](#)

TECHNICAL PAPER:

[Alya: Towards Exascale for Engineering Simulation Codes](#)

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More about BSC

Barcelona Supercomputing Center (BSC) is the Spanish national supercomputing centre. BSC specialises in high performance computing (HPC) and its mission is two-fold: to provide infrastructure and supercomputing services to European scientists, and to generate knowledge and technology to transfer to business and society. BSC's CASE department has a strong record on applied computational science, specially in the industrial realm.

BSC is a Severo Ochoa Center of Excellence and a first level hosting member of the European research infrastructure PRACE (Partnership for Advanced Computing in Europe). BSC also manages the Spanish Supercomputing Network (RES).

More about NCSA

The National Center for Supercomputing Applications (NCSA), located at the [University of Illinois at Urbana-Champaign](https://www.uiowa.edu/), provides computing, data, networking, and visualization resources and services that help scientists and engineers across the country better understand our world. Learn more at www.ncsa.illinois.edu.