

## IBM and ETH Scientists Advance Supercomputing Simulations to Improve the Diagnosis and Treatment of Osteoporosis

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*The computer simulations of human bone structures that **IBM** and **ETH** have enabled will help doctors across the globe analyze fragile bones and fracture risk enabling treatment and prevention critically, to begin at an earlier stage*

Zurich and Dubai, 23<sup>rd</sup> December 2008: Using a Blue Gene supercomputer, scientists at the Swiss Federal Institute of Technology, Zurich (ETH) and the IBM Zurich Research Laboratory have demonstrated the most extensive simulation ever of real human bone structures providing doctors with a "high definition" view of fragility or strength of bones that has not been possible before. The achievement will allow doctors better clinical tools to improve the diagnosis and treatment of osteoporosis, a widespread disease that affects 1 in 3 women and 1 in 5 men over the age of 50.[1]

'It is **IBM's** huge research operations which are bridging the gap between high end technologies and the general public, allowing us to offer real solutions to real problems that affect all of us' said Takreem El Tohamy, General Manager, **IBM Middle East and North Africa**. 'This collaborative and innovative research into relevant problems allows **IBM** to stay ahead of the field by sharing knowledge across our global network'

The early detection of osteoporosis is crucial in order to prevent its progress into a debilitating bone disease. The breakthrough simulations will greatly enhance a clinician's ability to treat fractures and analyze and detect osteoporotic fragility, in turn allowing them to take preventative measures before osteoporosis has the chance to advance.

Osteoporosis is the most widespread bone disease worldwide, affecting 75 million people in the US, Europe and Japan alone, and causing health costs second only to those associated with cardiovascular diseases. Literally "porous bone", this disease is characterized by loss of bone density, results in a high risk of fractures and is a major cause of pain, disability and death in older persons.[2] Unfortunately, in many cases, osteoporosis is not diagnosed until a fracture has occurred, but by then the disease is already in an advanced stage, requiring implants or surgical plates to treat or prevent further fractures.

Today, osteoporosis is diagnosed by measuring bone mass and density using specialized X-ray or computer tomography techniques? a highly empirical process. Studies have shown, however, that bone mass measurements are only a moderately accurate way to determine the strength of the bone because bones are not solid structures. Inside the compact outer shell, bones have a sponge-like center. This complex microstructure accounts for the bone's capability to bear loads and therefore represents a better indicator of a bone's true strength.

Aiming for an accurate, powerful and fast method to automate the analysis of bone strength, scientists at the Departments of Mechanical and Process Engineering and Computer Science at ETH Zurich teamed up with supercomputing experts at **IBM's** Zurich Research Laboratory. The breakthrough method they developed combines density measurements with a large-scale mechanical analysis of the inner-bone microstructure.

Using large-scale, massively parallel simulations, the researchers were able to obtain a dynamic "heat map" of strain, which changes with the load applied to the bone. This map shows the clinician exactly where and under what load a bone is likely to fracture.

"Knowing when and where a bone is likely to fracture, a clinician can also detect osteoporotic damage more precisely and, by adjusting a surgical plate appropriately, can determine its optimal location," explains Dr. Costas Bekas of **IBM's** Computational Sciences team in Zurich. "This work is an excellent example of the dramatic potential that supercomputers can have for our everyday lives."

Utilizing the massively large-scale capabilities of the 8-rack Blue Gene /L supercomputer, the research team was able to conduct the first simulations on a 5 by 5 mm specimen of real bone. In just 20 minutes of computing time, the supercomputer simulation generated 90 Gigabytes of output data.

"It is this combination of increased speed and size that will allow solving clinically relevant cases in acceptable time and unprecedented detail," says Professor Ralph Müller, the director of the Institute for Biomechanics at ETH Zürich.

"Ten years from now, the performance of today's supercomputers will become available in desktop systems, making such simulations of bone strength a routine practice in computer tomography," predicts Dr. Alessandro Curioni, manager of the Computational Sciences group at **IBM's** Zurich Research Laboratory.

Professor Peter Arbenz of the Institute of Computational Science, who initiated the collaboration among the involved groups, explains that state of the art numerical algorithms were also necessary to solve these extremely large problems in this surprisingly short time. This work is the first fundamental step towards a clinical use of large scale bone simulations. "We are at the beginning of an exciting journey and we need to further continue this line of research in order to achieve this goal," he states.

In future work, **IBM** and ETH scientists plan to aim to advance their simulation techniques to go beyond the calculation of static bone strength and to be able to simulate the actual formation of the fractures for individual patients, thereby taking another step towards achieving a fast, reliable and early detection of people with high fracture risk.

The work "Extreme Scalability Challenges in Analyses of Human Bone Structures" by ETH scientists Peter Arbenz, Cyril Flaig, Harry van Lenthe, Ralph Mueller, Andreas Wirth and ZRL researchers Costas Bekas and Alessandro Curioni was presented at the IACM/ECCOMAS 2008 conference in Venice, Italy, on July 2.

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