Syracuse University

EECS Department Talk

Solutions of Extremely Large Integral Equations and Their Applications: Computational Electromagnetics and Parallel Computing

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Abstract: Since 2006, the world's largest integral-equation problems in computational electromagnetics have been solved at Bilkent University Computational Electromagnetics Research Center (BiLCEM). Most recently, breaking the latest world record actually required the solution of 550,000,000x550,000,000 dense matrix equations! This achievement is an outcome of a multidisciplinary study involving physical understanding of electromagnetics problems, novel parallelization strategies (computer science), constructing parallel clusters (computer architecture), advanced mathematical methods for integral equations, fast solvers, iterative methods, preconditioners, and linear algebra.

In this seminar, following a general introduction to our work in computational electromagnetics, I will continue to present fast and accurate solutions of large-scale electromagnetic modeling problems involving three-dimensional geometries with arbitrary shapes using the multilevel fast multipole algorithm (MLFMA). Accurate solutions of real-life problems require discretizations with tens or even hundreds of millions of unknowns. To achieve the solution of such extremely large problems, maximizing the computational resources by parallelizing MLFMA on distributed memory architectures is needed. However, due to its complicated structure, parallelization of MLFMA is not trivial. Recently, we proposed a hierarchical parallelization strategy to increase the efficiency of parallelization to enable the solution of electromagnetics problems with overall sizes in the orders of hundreds or thousands of wavelengths. Solving the world's largest computational electromagnetics problems has important implications in terms of obtaining the solution of previously intractable physical, real-life, and scientific problems in various areas, such as (subsurface) scattering, optics, bioelectromagnetics, metamaterials, nanotechnology, remote sensing, etc. For more information, please visit www.cem.bilkent.edu.tr.

Prof. Levent Gürel (*Fellow, IEEE*) is the Director of the Computational Electromagnetics Research Center (BiLCEM) at Bilkent University, Ankara, Turkey. He received the M.S. and Ph.D. degrees from the University of Illinois at Urbana-Champaign (UIUC) in 1988 and 1991, respectively, in electrical and computer engineering. He joined the IBM Thomas J. Watson Research Center, Yorktown Heights, New York, in 1991. Since 1994, he has been a faculty member in the Department of Electrical and Electronics Engineering of the Bilkent University, Ankara, where he is currently a Professor, and a Visiting/Adjunct Professor at UIUC since 2003. Among the recognitions of Prof. Gürel's accomplishments, the two prestigious awards from the Turkish Academy of Sciences (TUBA) in 2002 and the Scientific and Technological Research Council of Turkey (TUBITAK) in 2003 are the most notable. Prof. Gürel is currently serving as an associate editor of *Radio Science*, *IEEE Antennas and Wireless Propagation Letters (AWPL)*, *Journal of Electromagnetic Waves and Applications (JEMWA)*, and *Progress in Electromagnetics Research (PIER)*. He is named an IEEE Distinguished Lecturer for 2011-2013 and invited to address the 2011 ACES Conference as a Plenary Speaker.

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