Contribution ID: **7** Type: **Keynote**

Parallel solution of large sparse systems by direct and hybrid methods

Tuesday, 5 November 2019 08:45 (45 minutes)

We discuss a range of algorithms and codes for the solution of sparse systems that we have developed in an EU Horizon 2020 Project, called NLAFET, that finished on 30 April 2019.

We used two approaches to get good single node performance. For symmetric systems we used task-based algorithms based on an assembly tree representation of the factorization. We then used runtime systems for scheduling the computation on both multicore CPU nodes and GPU nodes [4]. The second approach was to design a new parallel threshold Markowitz algorithm [2] based on Luby's method [5] for obtaining a maximal independent set in an undirected graph. This was a significant extension since our graph model is a directed graph.

We then extended the scope of these two approaches to exploit distributed memory parallelism. In the first case, we base our work on the block Cimmino algorithm [3] using the ABCD software package coded by Zenadi in Toulouse [6]. The kernel for this algorithm is the direct factorization of a symmetric indefinite submatrix for which we use the above symmetric code.

To extend the unsymmetric code to distributed memory, we use the Zoltan code from
Sandia [1] to partition the matrix to singly bordered block diagonal form and then use the above unsymmetric code on the blocks on the diagonal. We show the performance of our codes on industrial strength large test problems on a heterogeneous platform. Our codes that are available on github are shown to outperform other state-of-the-art codes.

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