Final Report for Small ARC Grant F96042: Achieving Optimum Performance for Dense Linear Algebra Computations on Parallel Computers

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1 Introduction

This report will refer to the original Proposal for this Project (July 1995), which accompanied the application for the Small ARC Grant F96042, and the End of Grant Report (December 1997).

This report will give an update of the Project since 1997; for the overview and its milestones (up to 1997), see the End of Grant Report.

See also the Project's web page,

http://cs.anu.edu.au/people/Peter.Strazdins/projects/ExtendScaLAPACK

which also makes available the LU and Cholesky factorization routines.

2 Recent Milestones

A study of two new techniques (called *pipelining with lookahead* and *panel scattering*) that could also improve the performance of parallel block-partitioned algorithms was mnade in 1997. [11]. Preliminary results indicated that these techniques would only yield at best a small improvement over algorithmic blocking (and in some cases, would be slower). This, combined with the large increase in the complexity of implementation that these techniques entailed, argued that these are not viable new directions for the Project to take.

In 1998, detailed studies on the Fujitsu AP1000 and AP+ confirmed this, resulting in the publications [14, 15]. Publication [14] has been submitted to the International Journal of Parallel and Distributed Processing. These papers provided further analysis and refinements to the the algorithmic blocking techniques, showing how worthwhile performance improvements could still be made on computers with higher communication penalties. Over 1998, the DBLAS distributed BLAS library was enhanced to support these improvements [13].

Work has continued on Aim II.3, with successful ports to the Fujitsu AP+ (March 1998), Intel Paragon (Sep 1998) and Fujitsu AP3000 (March 1999) completed.

For the Fujitsu AP+, a performance improvement of 50%–30% (20%–30%) was found for LU (Cholesky) factorization was found over the ScaLAPACK 1.6 (May 1998). On a 64 node Intel Paragon, the performance improvement for LU (QR) factorization was 40% (30%) for small matrices and 17% (10%) for matrices at the limit of memory. On the Fujitsu AP3000, our codes similarly have yielded the performance gains over the ScaLAPACK codes (using the same UltraSPARC BLAS) of 40%, 16% & 18% for small matrices, and 23%, 16% & 15% for large matrices, for LU, Cholesky & QR factorizations respectively on an 8 node 170 MHz 128 MB AP3000.

These results confirm that the combined effect of algorithmic blocking, reduction of software overheads, and memory access pattern optimizations (in the case of LU) combined can achieve a significant benefit over the storage blocking methods currently used in ScaLAPACK, even on contemporary parallel computing platforms.

The work of this Project has aroused strong interest in members of the ScaLAPACK team, based at the University of Tennessee, Knoxville. This resulted in a teleconference presentation to the team in March 1998 [12]. This was followed up by a visit by the Chief Investigator to UTK in September 1998, where results for the recently enhanced algorithmic blocking versions of the LU, Cholesky and QR factorizations was presented in a formal seminar at the end of the visit.

The algorithmic blocking technique is now supported by the UTK Parallel BLAS (PBLAS) library (fully released Nov 1999), although algorithmic blocking was implemented in the ScaLAPACK matrix factorizations routines, due to funding for the ScaLAPACK project being ended in December 1998 and to other commitments preventing the Chief Investigator from taking on this task.

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