第７回先進スーパーコンピューティング環境研究会（ASE 研究会）開催報告

東京大学情報基盤センター　特任准教授　片桐孝洋

　2010 年 4 月 2 日（金）10 時 20 分～17 時 10 分、東京大学情報基盤センター４階遠隔講義室にて、第７回先進スーパーコンピューティング環境研究会（ASE 研究会）が開催されました。なお、本研究会は科学技術振興費補助金基盤（Ｂ）、自動チューニング研究会との共催研究会であり、数値計算ソフトウェアにおける先進自動チューニングに関するワークショップ（Workshop on Advanced Auto-tuning on Numerical Software（AANS2010））として開催したものです。

　国内の大学・研究機関および企業からの参加者が 19 名あり、活発な議論がなされました。

　招待講演として、米国カリフォルニア大学バークレー校（現、Reservoir Labs, Inc.）から Kaushik Datta 博士、台湾国立中央大学から Feng-Nan Hwang 博士、米国ローレンスバークレー国立研究所から Tony Drummond 博士の３名をお呼びしました。

　Kaushik Datta 博士の講演は、差分法などに現れる規則的な計算パターンのコード（Stencil Code）の性能チューニングについて、現存するマルチコア型の並列計算機上で詳細にチューニング効果を調べることで、効果的な技法に関する知見の蓄積とチューニング作業の自動化に向けた研究であり、大変興味深いものでした。

　Feng-Nan Hwang 博士の講演は、広く用いられている数値計算ライブラリ PETSc を用いて実装された固有値ライブラリ SLEPc に関する話題でした。大規模疎行列を係数に持つ多項式固有値問題を Jacobi-Davidson 法を用いて求解する数値解法とライブラリ実装の説明がなされ、固有値問題の数値解法としてたいへん興味深いものでした。

　Tony Drummond 博士の講演は、米国エネルギー省（DoE）の支援のもと整備されている Advanced CompuTational Software（ACTS）collection の話題でした。このソフトウェアパッケージは、数値計算の基盤ソフトウェアとして保守管理を含め重要な位置づけにあり、活発な議論がなされました。

　さらに、国内の大学・企業から４名の研究者をお呼びし、研究者間で交流がなされました。当日のプログラムを以下に載せます。

● 会議プログラム
   ➤ 10:20- 10:30 Opening
      Takahiro Katagiri (The University of Tokyo)
   ➤ 10:30 – 11:10 *Kaushik Datta (University of California, Berkeley)(Currently, with Reservoir Labs, Inc.）*
      "Auto-tuning Stencil Codes for Cache-Based Multicore Platforms"
      　As clock frequencies have tapered off and the number of cores on a chip has taken off, the challenge of effectively utilizing these multicore systems

has become increasingly important. However, the diversity of multicore machines compels us to individually tune for each platform. This is especially true for low computational intensity kernels like stencil codes. In order to achieve performance portability, we have created an automatic stencil code tuner that incorporates several optimizations into a single software framework. We determined that our auto-tuner can achieve over 95% of the attainable performance for all three stencils in our study.

➤ 11:10- 11:50 *Takao Sakurai, Ken Naono (HITACHI Ltd.), Takahiro Katagiri (The University of Tokyo), Hisayasu Kuroda (Ehime University/The University of Tokyo) and Kengo Nakajima (The University of Tokyo)*

"OpenATLib: A Generalized Auto-tuning Facility and Xabclib: Adaptation to Numerical Algorithm Selection on an Iterative Method"

Reusability for implementation of Automatic Tuning facility(RIAT) is needed to establish low-cost construction of auto-tuning software. In this presentation, we propose Auto-tuning interface named OpenATLib to realize RIAT for numerical libraries. OpenATLib is API library and have two key function that restart frequency adjustment and sparse matrix-vector multiplication functions at run-time. To evaluate the effectiveness of the OpenATLib, we have developed sparse iterative solvers named Xabclib_LANCZOS and Xabclib_GMRES with OpenATLib. Performance evaluation of OpenATLib using several U. Florida matrices with T2K Open Supercomputer (U. Tokyo) on 1 node indicated that the maximum speedup established 22.4x (Xabclib_LANCZOS) and 3.5x (Xabclib_GMRES).

➤ 13:30 – 14:10 *Feng-Nan Hwang (National Central University, Taiwan)*

"A PETSc-based Jacobi-Davidson Approach for Large Sparse Polynomial Eigenvalue Problems with Application in Computational Science and Engineering"

We introduce a newly developed parallel scientific software package, called the parallel Jacobi-Davidson (PJDPack) package, using the PETSc and the SLEPc which is suitable for finding a few eigenvalues of polynomial eigenvalue problems (PEPs). Our target applications include cubic and quintic PEPs arising in semiconductor quantum dot simulations as well as cubic and quadratic acoustic with damping problems. Our numerical results showed the PJDPack with an additive Schwarz preconditioned GMRES for the correction equation can achieve a satisfactory parallel strong scaling performance up to 2048 processors on Blue Gene/P.

➢ 14:20- 15:00 *Satoshi Ohshima (The University of Tokyo)*

　"GPGPU and Auto-tuning Framework"

　GPGPU (General-Purpose computing using Graphics Processing Units) is attracting attention for the high performance. But the programming and tuning of GPU is difficult and complex because it is necessary to use advanced and specific programming environment such as CUDA and OpenCL. Also there are hardware-specific tuning parameters and techniques in GPU. So we are now developing GPGPU and auto-tuning framework for reducing the programmer's labor. Our GPGPU framework currently in development named OMPCUDA can convert from normal OpenMP programs to GPGPU programs, and now we are planning to create several tuning mechanisms and build it into OMPCUDA. In this workshop, we show and discuss our approach and implementation.

➢ 15:00-15:40 *Tony Drummond (Lawrence Berkeley National Laboratory)*

　"Maintaining, Porting and Tuning computational Kernels in The US DOE Advanced CompuTational Software (ACTS) collection"

　The US DOE ACTS Collection Project has pursued and implemented mechanisms to bring a set of advanced and portable tools that can be used in the development of high performance simulation codes to a broad community of computational scientists. The projects goals have included the promotion and support of high quality software libraries. Here, we describe a software infrastructure that enables ACTS tools to evolve in emerging hardware technologies. At the core of this infrastructure, we implement a software dependency graph to address the portability and optimization of computational kernels. We present some preliminary results of using some numerical tools in the collection.

➢ 15:50 - 16:30 *Reiji Suda (The University of Tokyo)*

　"Automatic Tuning Math Core Library"

　In an abstract formulation, automatic tuning is an optimization problem of performance with software parameters as variables under various hardware and software conditions. Desirable properties of automatic tuning methods are: asymptotic optimality (optimal solution is found with infinite experiments), experimental efficiency (good solution is found with fewer experiments), knowledge utilization (a priori knowledge is utilized for efficient optimization), and stability (good solution is found even with a priori knowledge deviated from the truth). We will talk about a project of Automatic Tuning Math Core Library, which provides automatic tuning methods

of those desirable properties. Applicability to sparse matrix libraries is also discussed.

- ➢ 16:30 – 17:00 *Takeshi Fukaya (Nagoya University), Yusaku Yamamoto (Kobe University), and Shao-Liang Zhang (Nagoya University)*

  "A Dynamic Programming Approach to Auto-Tuning the Blocking Strategy For the Householder QR Decomposition"

  In matrix computing, blocking techniques are widely used for high performance implementation. However optimal blocking strategy differs depending on the target architecture and the problem size. In this talk, we present an approach to auto-tuning the blocking strategy for computing the Householder QR decomposition, which is one of the basic matrix decompositions. We parameterize blocking strategies using binary trees and find the near-optimal one using dynamic programming. Experimental results show that our approach can achieve the same level of performance as that obtained by manual tuning.

- ➢ 17:00 – 17:10 Closing

  Reiji Suda (The University of Tokyo)

ASE 研究会の開催情報はメーリングリストで発信をしております。研究会メーリングリストに参加ご希望の方は、ASE 研究会幹事の片桐（katagiri@cc.u-tokyo.ac.jp）までお知らせください。

以上