An Approach to the Highest Efficiency of the HPCG Benchmark on the SX-ACE Supercomputer
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Introduction

HPCG (High Performance Conjugate Gradient) has been developed to narrow the large performance gap between real applications and the HPL benchmark. The major features of HPCG are:
- including major communication and computational patterns of real applications.
- Easy to understand, optimize, and run. patterns of real applications.
- Including major communication and computational

Scalability and efficiency

HPCG solves a linear system of a sparse matrix.
\[ Ax = b \]
\( A \) is a large sparse matrix discretized by the finite element method. The linear system is solved by multigrid preconditioned conjugate gradient with the symmetric Gauss-Seidel smoother.

Overview of the SX-ACE Supercomputer

The SX-ACE supercomputer consists of 512 nodes. Each node is equipped with an SX-ACE processor, which can provide a high memory bandwidth for practical HPC applications.
- High vector computational performance by a 4-core vector processor
- High sustained memory bandwidth by a strong memory subsystem
- ADB ( Assignable Data Buffer ) to keep a high sustained memory bandwidth
- Scalable multinode system by a two-stage fat-tree custom network

ADB of SX-ACE

- Private on-chip memory
- 1 MB, 4-way, 16-bank
- 256 GB/s bandwidth
- Customized for fast random accesses

Software controllable function

- Compiler and user can specify the use of the ADB.
- A bypass mechanism for memory instructions
- Avoiding cache pollution
- Enhancement of indirect memory access

Preliminary Evaluation before Optimization

To decide the optimization plan, the reference HPCG is executed.

Preliminary Evaluation Environments

Supercomputer : SX-ACE
- # of nodes : 1
- Compiler : NEC SX C/C++ Compiler Version 1.0
- HPCG version : Release 2.4
- Problem size : 104 x 104 x 104 (default)
- Parallelization : Flat-MPI

HPCG-Benchmark-2.4.yaml

These low performances are caused by quite low vectorization rates and inefficient memory accesses. Optimization for efficient vector calculations and memory accesses are essential.

Conclusions

To exploit high potential of the SX-ACE supercomputer on the HPCG benchmark, this poster discusses the optimization techniques:
- Data reordering for efficient continuous memory accesses
- Various sparse matrix memory allocation
- The eight-coloring method and the hyperplane method for parallelization
- Selectively data stored in ADB, and the problem size tuning.

As a result, the SX-ACE supercomputer successfully achieves the highest efficiency of 11.4% in the latest HPCG ranking.