格子 QCD を用いた並列言語 XcalableACC の
性能評価
中居昌広 (理化学研究所 計算科学研究機構)
小田嶋哲哉, 田渕晶大, 津金佳祐, 村井均, 朴泰祐, 佐藤三久

XcalableACC parallel language

Overview
XcalableACC (XACC) is a directive-based language extension of C and
Fortran for accelerated cluster systems (C++ on the table).
- High productivity by directives
- High performance by direct communication between accelerators

Components
- XcalableMP (XMP) for distributed-memory parallelism
- OpenACC for offloading works for accelerators
- XACC for communication of data on accelerators

Memory Model

XMP function defines "Template" as a
dummy array that represents a global
index space.

OpenACC function enables users to transfer
data between accelerators and between
accelerator and host memory directly.

Implementation of Lattice QCD code using XcalableACC

What is Lattice QCD?
- Solve the quantum chromodynamics (QCD) theory of quarks and gluons
  \[ D_{x,y} = \delta_{x,y} - \kappa \sum_j \{ (1 - \gamma_\mu)U_{\mu}(x)\delta_{x+y} + (1 + \gamma_\mu)U_{\mu}^\dagger(x - \mu)\delta_{x-y} \} \]
- The four-dimensional space-time continuum is replaced by a four-
dimensional hypercubic lattice
- We have used the Lattice QCD mini-application developed by
  Hideo Matsufuru (KEK)
- The Lattice QCD mini-application uses a part of the Bridge++, which is a real
  world application
  (http://bridge.kek.jp/Lattice-code/)
- Typical stencil application

A part of code
A programmer adds XMP and OpenACC
directives into the sequential Lattice QCD code.

Evaluation on HA-PACS/TCA

Productivity
- Count code changes for developing a parallel code from a serial code
- Total code changes of XcalableACC is the smallest of all

Performance
- Data size is 32 x 32 x 32 x 32 with strong scaling
- The performance of XcalableACC is 100 - 104% of that of
  MPI+OpenACC, and 95 - 99% of that of MPI+CUDA