

Challenges and Solutions for Peta- and Exa-Scale Programming

Daisuke Takahashi
University of Tsukuba, Japan

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WPSE2009 Panel Session

When Exa-scale system will come?

- 1964: First Megaflops system
 - CDC 6600 (Roots of RISC)
- 1983: First Gigaflops system
 - NEC SX-2 (Vector)
- Jun. 1997: First LINPACK Teraflops system
 - Intel ASCI Red (Parallel)
- Nov. 2008: First LINPACK Petaflops system
 - IBM Roadrunner (Heterogeneous)
- **Nov. 2018?: First LINPACK Exaflops system**

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Issues on Peta- and Exa-scale programming

- Nov. 2008 TOP500 Supercomputing Sites
 - Roadrunner: 1,105.00 TFlops (129,600 Cores)
 - Jaguar (Cray XT5 QC 2.3GHz): 1,059.00 TFlops (150,152 Cores)
 - The number of cores will be increasing.
- Systematic issues
 - Communications (esp. latency)
 - By reducing the number of MPI processes required, the scaling of application programs should be improved.
- Algorithmic issues
 - Degree of parallelism
 - Accuracy (quad-precision arithmetic?)

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Programming style

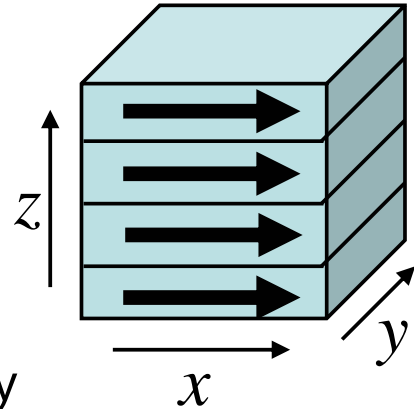
- The combination of MPI and OpenMP will remain in wide use through the decade of the 2010's.
- The MPI has been successful as a portable way to program HPC applications.
- MPI + OpenMP programs remain portable while exploiting hardware capabilities.
- Most application programmers are too conservative.
 - Fortran has been in use for more than fifty years!

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My challenges

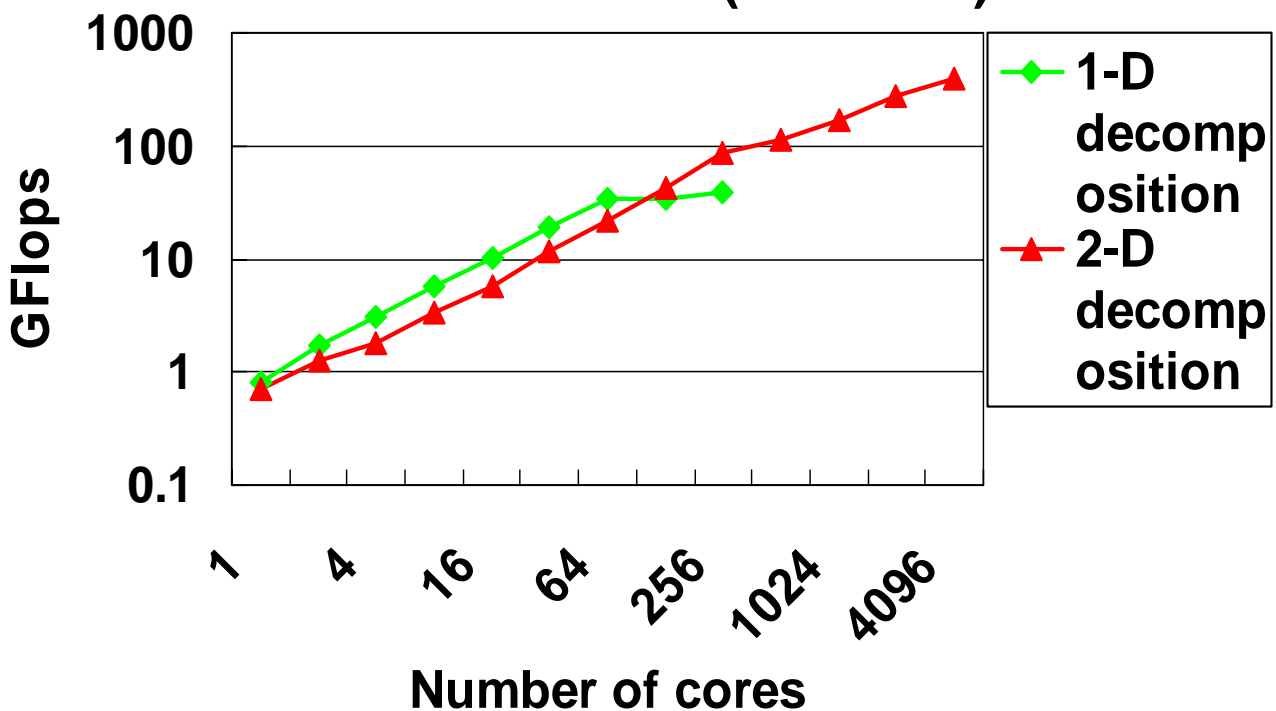
- The fast Fourier transform (FFT) for Peta- and Exa-scale system.
- A typical decomposition for performing a parallel 3-D FFT is slabwise.
 - A 3-D array $x(N_1, N_2, N_3)$ is distributed along the third dimension N_3 .
 - N_3 must be greater than or equal to the number of MPI processes.
- This becomes an issue with very large node counts for a massively parallel cluster of multi-core processors.



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Performance of parallel 3-D FFTs on T2K-Tsukuba ($N=256^3$)



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