Dynamic Core Binding（DCB）approach for load balancing in parallelization with MPI/OpenMP

Masatoshi Kawai (Information Technology Center, Nagoya univ) E-mail: kawai@itc.nagoya-u.ac.jp

Background

- One of the critical issues in achieving good parallel performance is load imbalance.
- Load balance has to be kept at both thread and process levels with MPI/OpenMP parallelization.

A Dynamic Core Binding (DCB) approach mitigates process-level load imbalance at the thread-level.

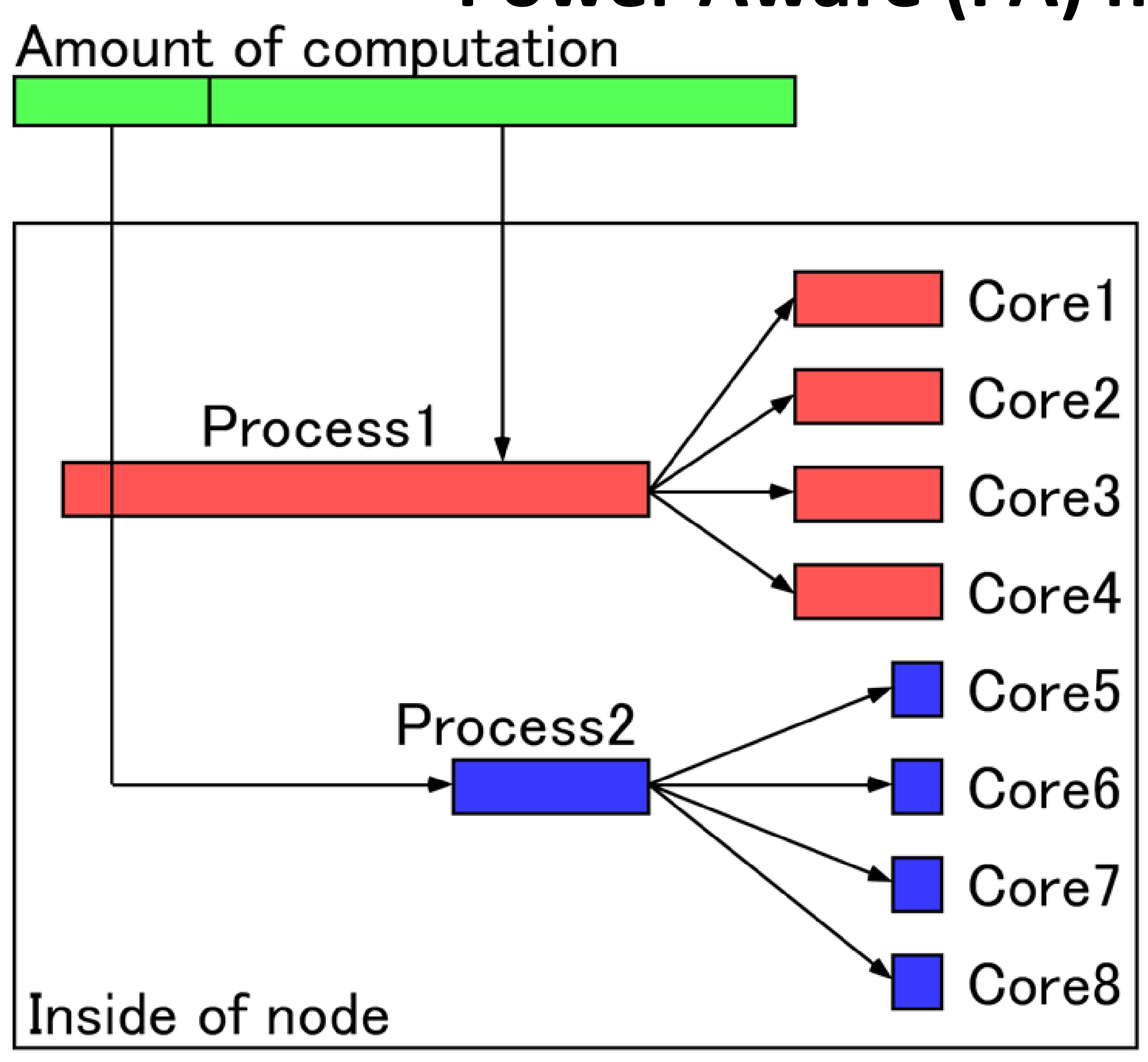
Dynamic Core Binding (DCB)*1

Idea of DCB : Changing the number of cores bound to each process based on loads of the processes

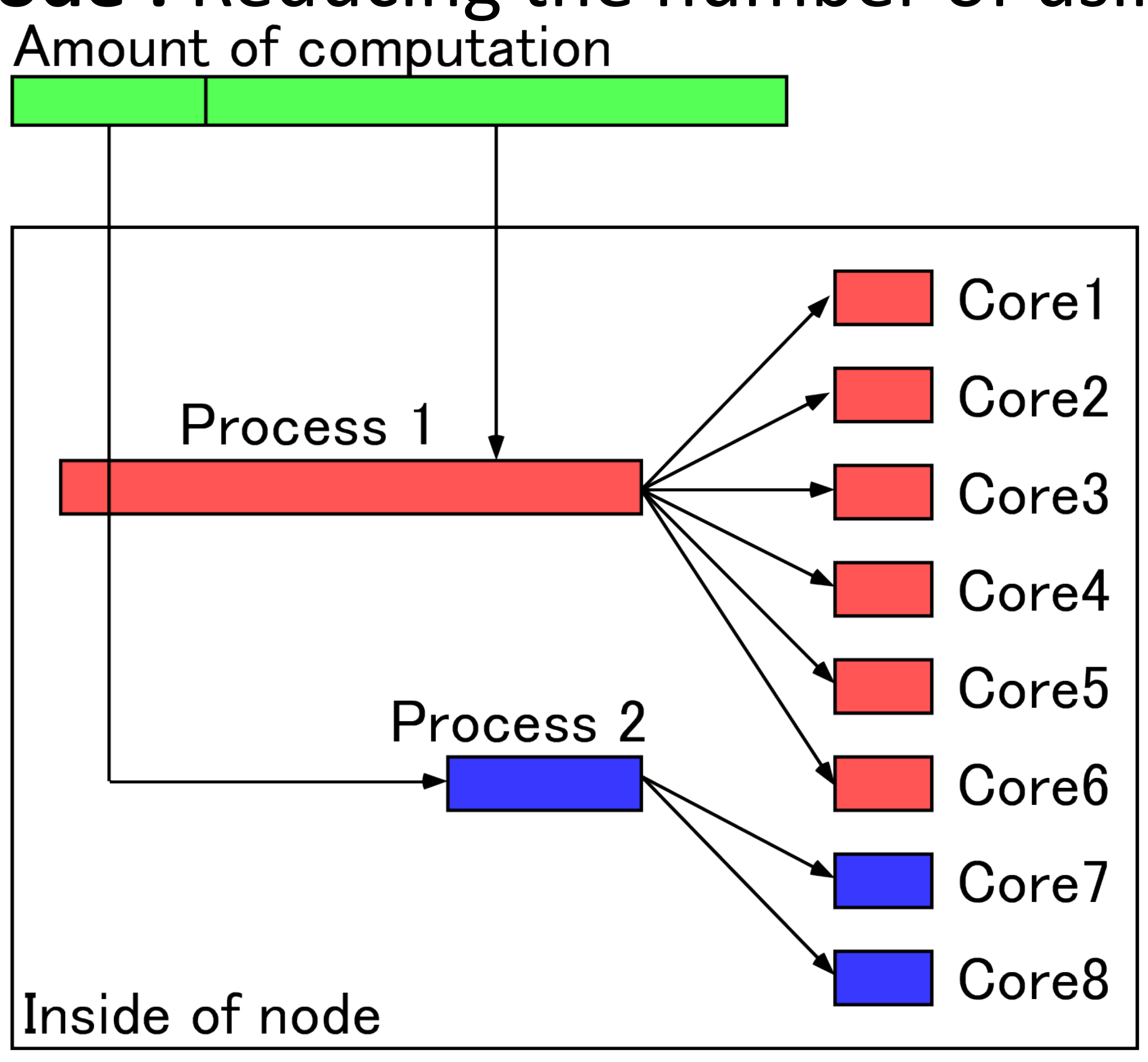
➡ **Load imbalance among the processes is balanced at the thread level.**

Preparing two modes based on different policies in the DCB approach

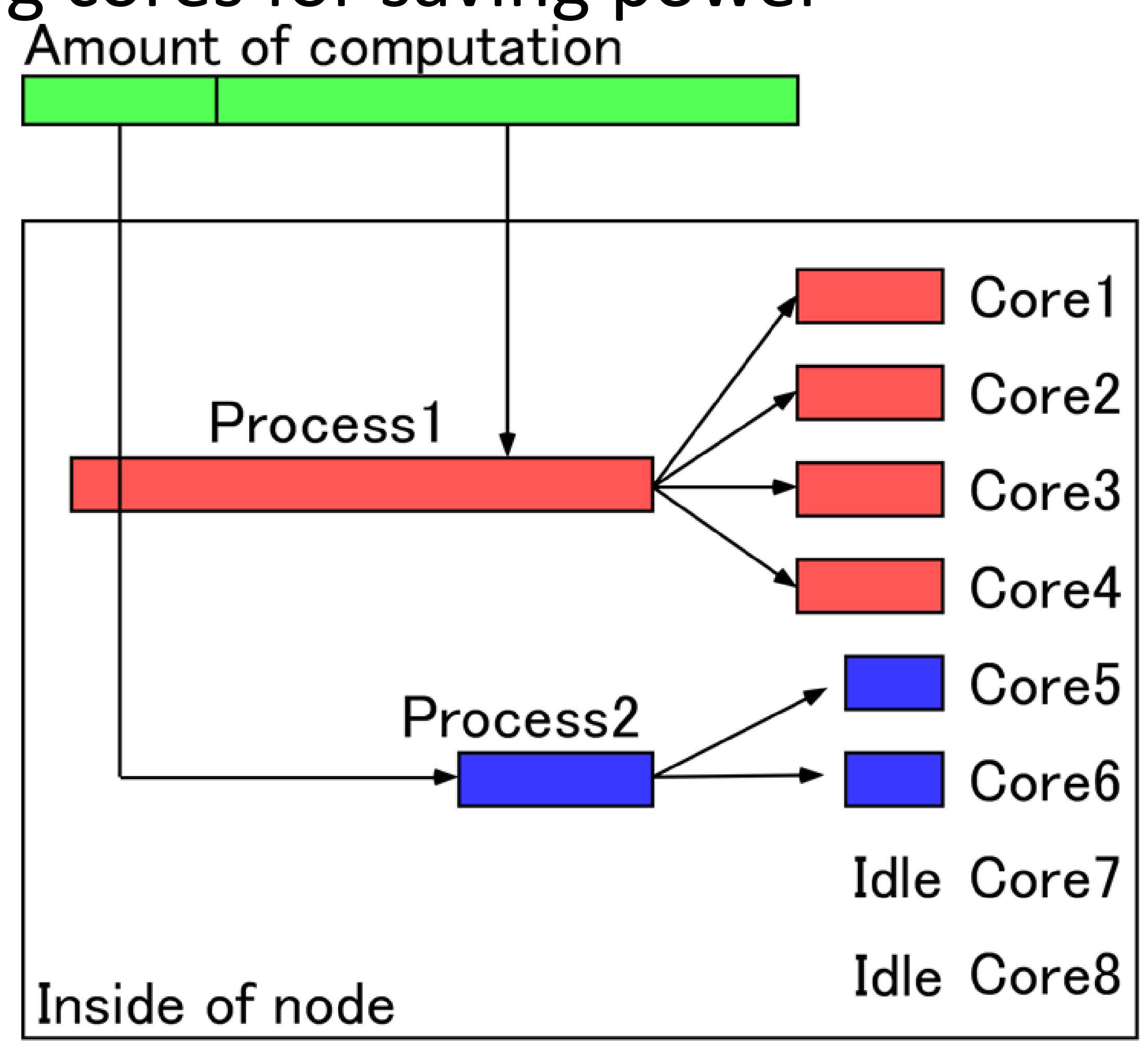
- **Reducing Computational-time (RC) mode :** Using all cores
- **Power Aware (PA) mode :** Reducing the number of using cores for saving power



General Environment



DCB (RC mode)



DCB (PA mode)

DCB only supports load balancing inside each node : we also consider load balancing among nodes.

Load balancing among the nodes is translated to a combinatorial optimization problem (COP)

➡ Solving the COP by quantum annealing

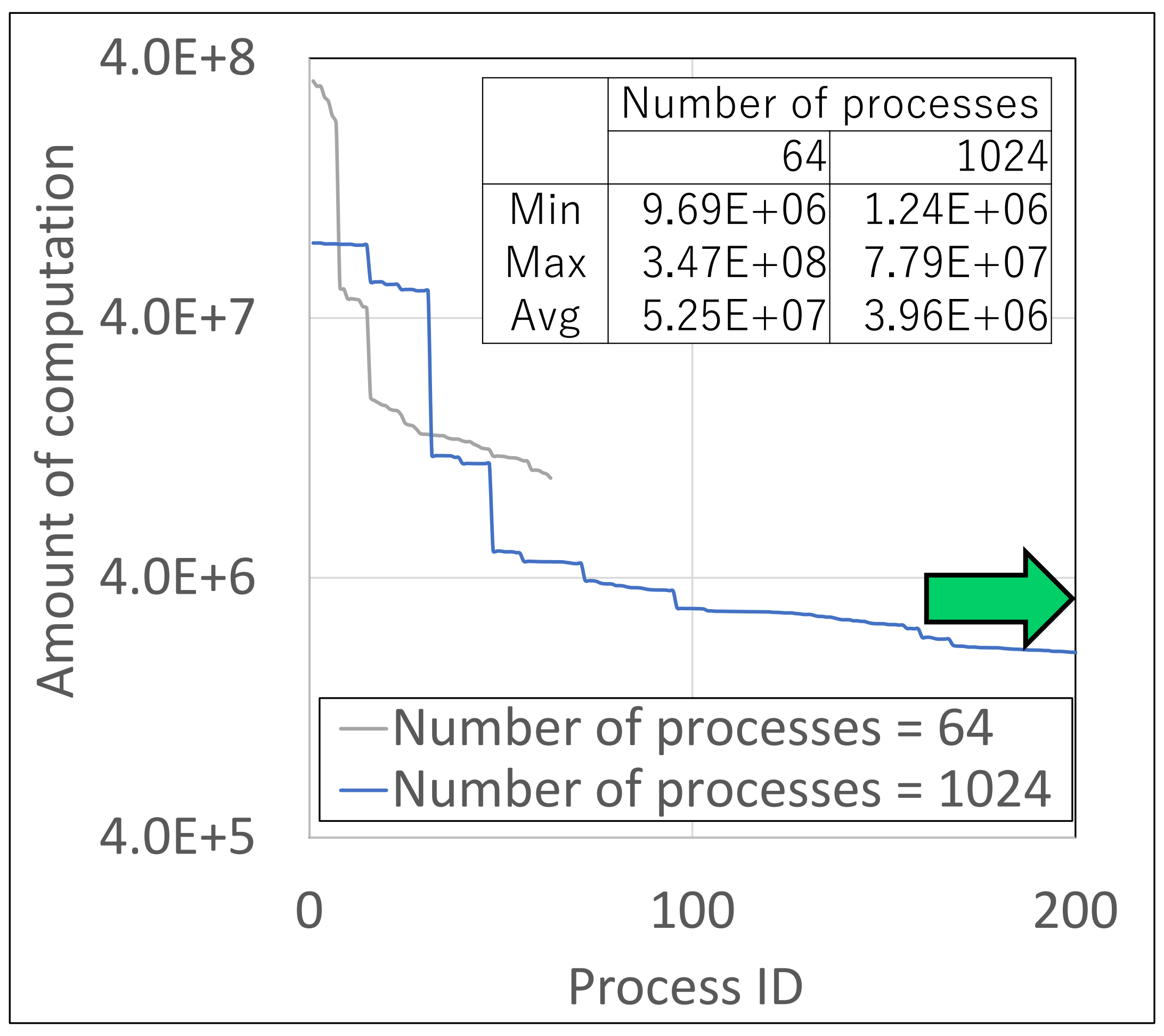
Using an approximate solution from the quantum annealing for load balancing among the nodes.

Result of numerical evaluations

Applying the DCB library to a lattice $\mathcal{H}$-matrix*2, which is optimized communication from the original.

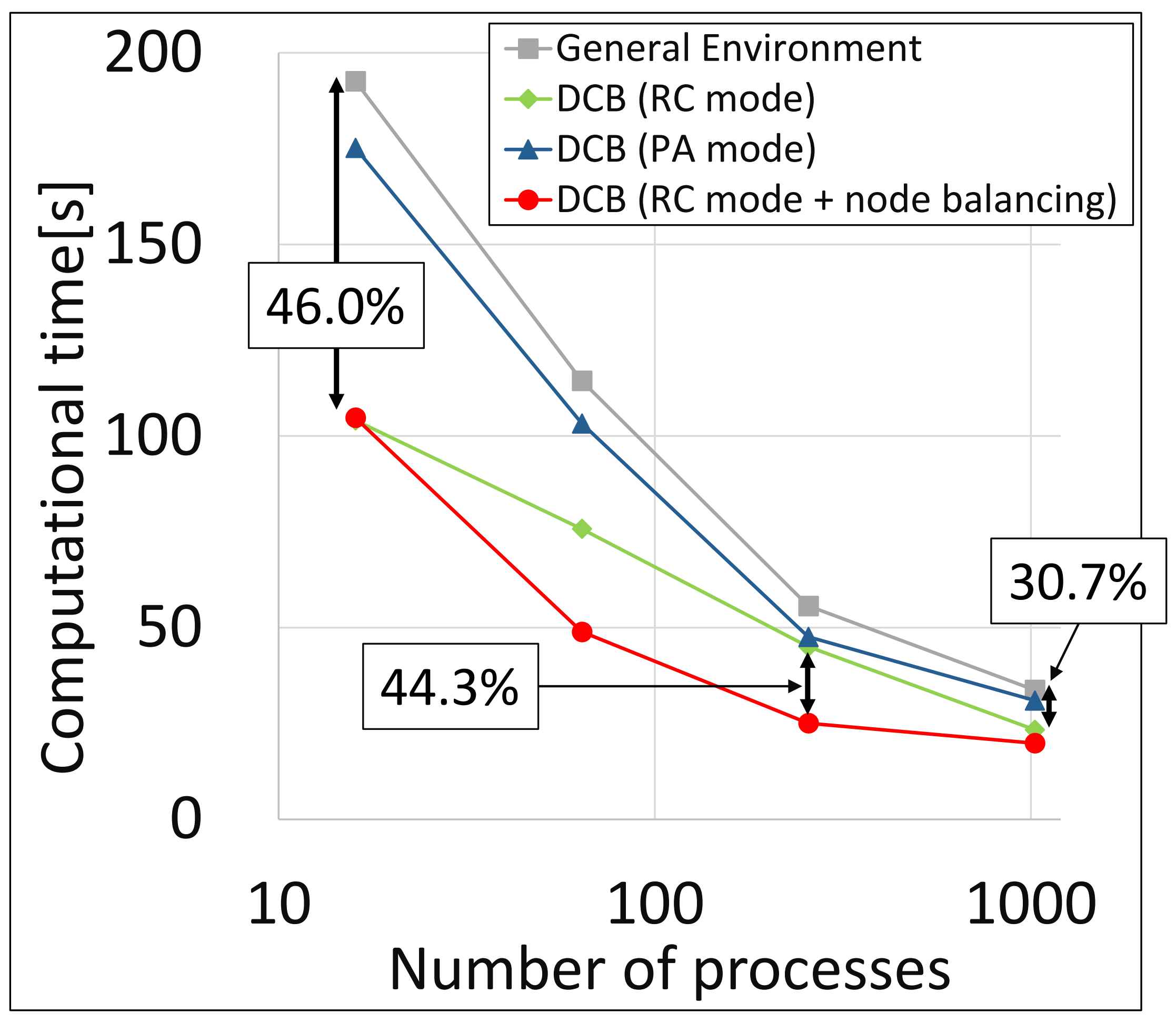
We use the Oakbridge-CX supercomputer for numerical evaluation.

It evaluates the performance of 50 times multiplications of the lattice $\mathcal{H}$-matrix and vector .

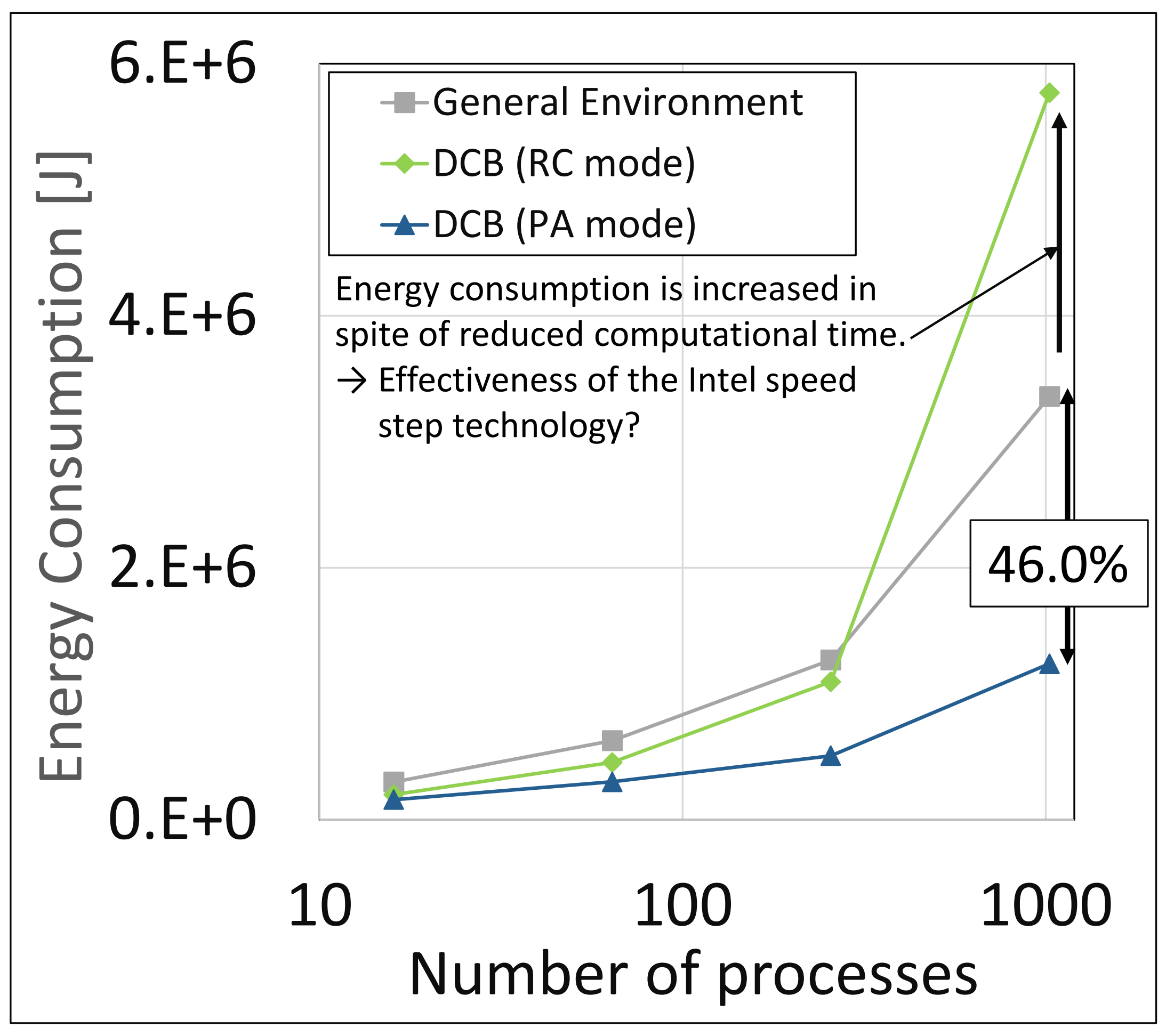


	Number of processes	
	64	1024
Min	9.69E+06	1.24E+06
Max	3.47E+08	7.79E+07
Avg	5.25E+07	3.96E+06

Load imbalance among nodes



Effectiveness on computational time



Effectiveness on energy consumption

*1 A. Ida "Lattice H-matrices on distributed-memory systems." 2018 IEEE International Parallel and Distributed Processing Symposium (IPDPS). IEEE, 2018

*2 M. Kawai, A. Ida, T. Hanawa and K. Nakajima "Dynamic Core Binding for Load Balancing of Applications Parallelized with MPI/OpenMP." ICCS 2023. Springer

Information Technology Center, Nagoya University
http://www.icts.nagoya-u.ac.jp/en/center/