A Power Management Method to Improve Energy Budget Utilization

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Background

- The power consumption of HPC systems has been increasing with their computing power.
- The available energy budget of an HPC system will be predefined.
  - The goal of most related studies is to minimize the energy consumption.
  - The goal of this work is to improve the energy budget utilization, i.e, use up 100% of the energy budget.

➢ This work proposes **a power management method that dynamically adjust the power cap of each job so as to maximize the energy budget utilization.**

Parameters

- S_j : Surplus energy when job j finished
- PC_j : Power cap of job j
- $PC_{default}$: Default value of the power cap
- PC_{max} : The maximum power cap of the system
- T_j : Execution time of job j
- $\hat{T}_j$: Predicted execution time of job j
- E_j : Energy consumption of job j

Proposed Method

- We define surplus energy as the difference between the energy budget and actual energy consumption.
  - The surplus energy at the end of the job is calculated by
    $$S_j = PC_{default}\, T_j + S_{j-1} - E_j$$
    and, the power cap of the next job execution is update by
    $$PC_{j+1} = \min(PC_{default} + \frac{S_j}{\hat{T}_{j+1}}, PC_{max})$$
- Once a job is assigned to a node, the power cap is calculated, and upon completion, the surplus energy is updated.

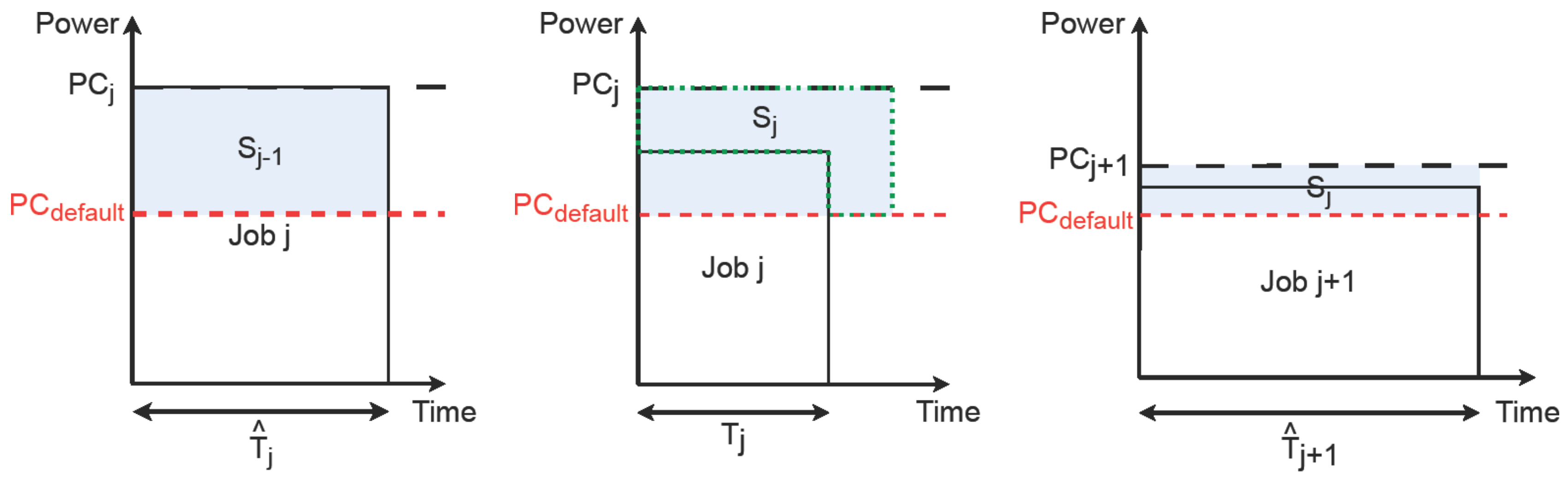

Fig. 1. Overview of the proposed method.

Evaluation Results

- We experimented under two conditions: with and without sharing surplus energy among the nodes of the system. When sharing, the surplus energy of each node is the average surplus energy of the system.
- We calculate the energy consumption and execution time of a job by energy model proposed by Choi et al. [1].
- We compared the proposed method with a baseline case where the power cap is fixed.
- The job set is constituted by computed-intensive jobs and memory-intensive jobs.

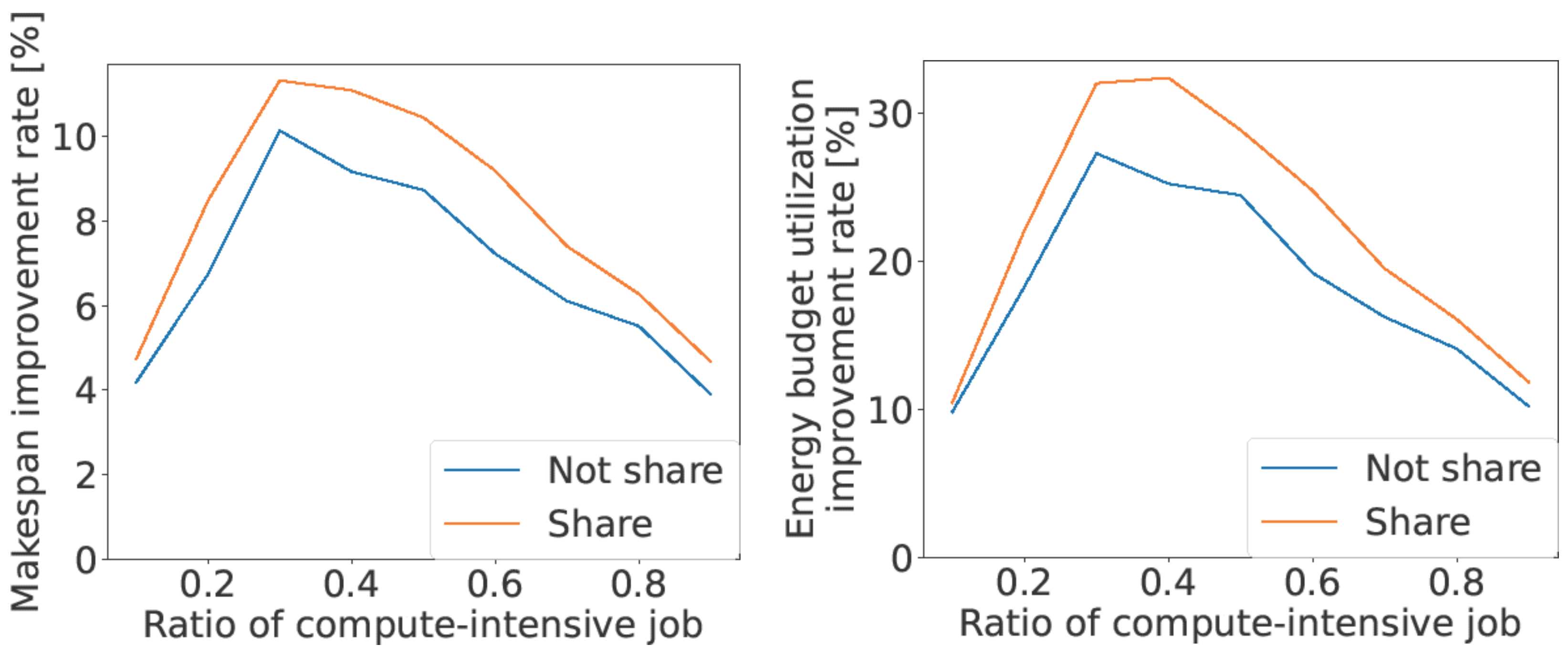

Fig. 2. Impact of the ratio of compute-intensive and memory-intensive jobs to the performance characteristics.

Result of changing the composition ratio of the job set

- The effect of the proposed method is the most pronounce when the ratio of compute-intensive jobs to memory-intensive jobs is 3:7.
- When the best result is obtained, the makespan is reduced by 11.3%, and the energy budget utilization is increased by 32.0%.

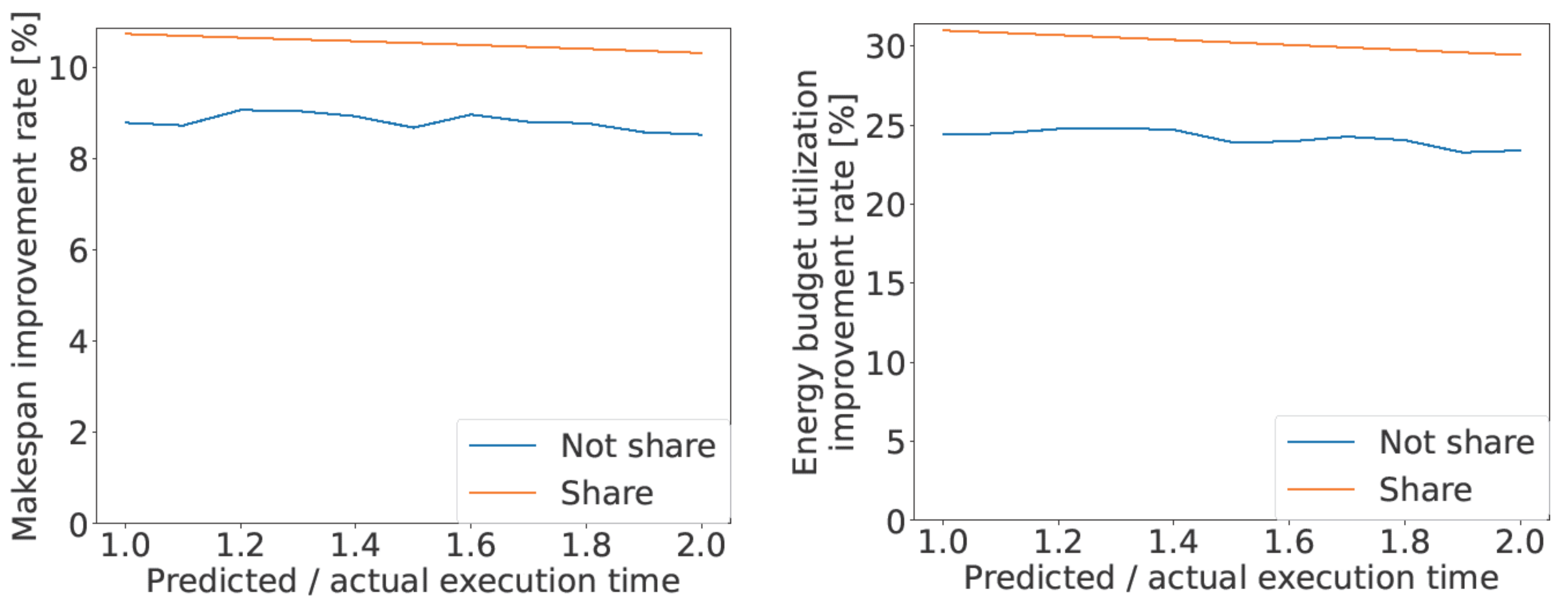

Fig. 3. Impact of job runtime prediction accuracy.

Result of changing prediction accuracy of job runtime

- As the predicted job time was moved away from the execution time, the effectiveness of the proposed method diminished.
- This is because the rate of increase in the power cap decreases as the accuracy of the execution time prediction worsens.

[1] J. Choi et al., "Algorithmic Time, Energy, and Power on Candidate HPC Compute Building Blocks," IPDPS 2014.

Conclusion

- The proposed method can be used to improve the energy budget utilization of the system and reduce the makespan.
- Although the proposed method is affected by the characteristics of the job set, even in the worst case, makespan is reduced by about 4% and energy budget utilization is improved by about 10%.

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