Attempt for Quantitative Evaluation of Warm Water Cooling using LINPACK and GeoFEM on the JCAHPC OFP

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1 INTRODUCTION

Energy efficiency is already an important topic for the HPC sites as we can observe from the activities of the EE HPC WG (Energy Efficient HPC Working Group) [1]. Its importance has become even more evident with the steep rise in global energy prices, triggered by some military conflicts with no foreseeable end. The warm water cooling technique has been widely recognized as an effective approach for improving the energy efficiency of HPC and Data Centers. In 2020, we could verify that in practice, using the OakForest-PACS (OFP) supercomputer and the Joint Center for Advanced High-Performance Computing (JCAHPC) cooling facility, via their "Large-Scale HPC Challenge" program [3]. We could confirm in practice that the Power Usage Effectiveness (PUE) and Coefficient of Performance (COP) can be improved using higher cooling water temperature settings (from 12 °C to 18 °C). We could also observe the impact of the cooling water temperature on the performance by using single-node Intel LINPACK, a generalization of the LINPACK 1000 benchmark [2]. In addition, we tried to evaluate the impact of cooling water temperature by running production-class parallel simulation (GeoFEM) under different temperature settings [4].

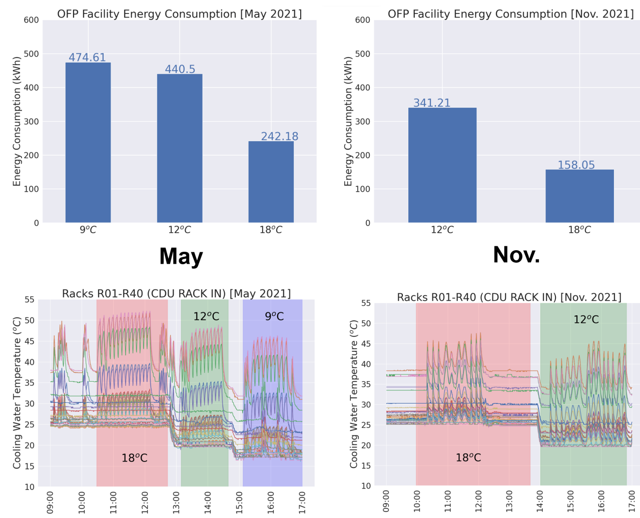

Figure 1: JCAHPC facility's energy consumption and the inlet water temperature during the Large-Scale HPC Challenge.

2 QUANTITATIVE EVALUATION

We had the opportunity to do the experiments twice in 2021 (May and November). Considering the average temperature difference between these months, we dig into the obtained data from the experiments trying to quantitatively evaluate the warm water cooling, focusing on the energy consumption and performance, when using LINPACK and GeoFEM applications on the JCAHPC OFP. It is worth mentioning that May is not the hottest period of the year, and in the same way, November is not the coldest period by observing the Japan Meteorological Agency (JMA) Automated Meteorological Data Acquisition System (AMeDAS) Data from Abiko-City close to the Kashiwa-City where the JCAHPC is placed. The upper portion of Fig. 1 shows the JCAHPC facility's energy consumption (chillers, pumps, heat control system, and cooling tower) during the execution of LINPACK and GeoFEM for different cooling water temperature settings. The graphs in the bottom part show the cooling water temperature in the inlet side of the compute racks during the experiments. Although we cannot make a direct comparison between these two experiments because of the use of different configurations (simultaneous use of up to 2,048 nodes in May and 4,200 nodes in November), we can observe better results in the colder compared to the hotter season. In this poster, we will try to shed light on the possible influence of the external temperature on the facility's energy consumption as well as the influence of the cooling water temperature on the performance of the selected benchmark applications. The evaluations include some considerations on the contrastive behaviors for groups of compute nodes related to the influence of the cooling water temperature on the LINPACK and GeoFEM performance. We also grouped the compute nodes, based on each single-node GeoFEM performance, to evaluate the possible influence on the parallel GeoFEM performance among the groups.

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REFERENCES

[1] Energy Efficient High Performance Computing Working Group (EE HPC WG). [n. d.]. https://eehpcwg.llnl.gov/.

[2] Jorji Nonaka, Toshihiro Hanawa, and Fumiyoshi Shoji. 2020. Analysis of Cooling Water Temperature Impact on Computing Performance and Energy Consumption. In *2020 IEEE International Conference on Cluster Computing (CLUSTER)*. 169–175. https://doi.org/10.1109/CLUSTER49012.2020.00027

[3] Jorji Nonaka, Toshihiro Hanawa, and Fumiyoshi Shoji. 2020. Analysis on the Impact of the Cooling Water Temperature on the HPC System and Facility - Case Study: OakForest-PACS (OFP) System and Facility. Research poster of ISC 2020.

[4] Fumiyoshi Shoji, Jorji Nonaka, and Toshihiro Hanawa. 2023. An attempt for the quantitative evaluation of the warm water cooling efficiency. Supercomputing News (ITC, The University of Tokyo) Vol. 25, No. 1, pp. 52-57 (in Japanese).