

Doctoral School of Information and Biomedical Technologies

Polish Academy of Sciences (TIB PAN)

SUBJECT: Scalability and performance of massively parallel
computations on supercomputers

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DESCRIPTION

The rapid advancement of information technologies, driven by significant progress in artificial intelligence, machine learning, and data analysis, has led to a growing demand for high-performance computational resources. Supercomputers, as a key component of modern computing environments, play a crucial role in executing tasks that require massive computational power. The advancement of supercomputers has opened a new chapter in scientific research, making it possible to address problems that were once out of reach. Today, they play a central role in driving both scientific discovery and technological innovation [1]. In particular, current trends focus on the deployment of computing nodes equipped with multiple GPUs and high-speed interconnects, allowing for efficient intra-node data communication [2].

In this context, issues related to computational scalability and the effective utilization of available resources are gaining increasing importance. These aspects form one of the main areas of research in high-performance computing (HPC) systems.

The aim of this proposed PhD project is to conduct a comprehensive analysis of the potential of supercomputers in advanced engineering research, with particular emphasis on their computational capabilities and the limitations encountered by researchers during complex computational processes. The research will cover both theoretical and practical aspects, including performance analysis and scalability studies in terms of both strong and weak scalability. Based on the conducted experiments and case studies, conclusions will be drawn regarding the efficiency of supercomputer utilization in engineering computation environments. The results of this doctoral research are expected to lead to multiple publications in international journals and presentations at conferences.

REQUIREMENTS

- Holding an MSc degree in computer science, technical informatics, or computational engineering,

- Good understanding of supercomputers, HPC systems (High Performance Computing), and parallel/distributed computing environments (e.g. commercial solutions),
- Ability to analyze the performance and scalability of computational applications (including both strong and weak scaling),
- Knowledge of HPC-related libraries and frameworks utilized for parallel computations (e.g. MPI, OpenMP),
- Ability to conduct independent research, design computational experiments, and formulate conclusions based on results,
- Ability to work effectively as part of a research team and a strong motivation for academic development,
- Very good command of English (spoken and written), sufficient to prepare scientific publications and deliver conference presentations.

References

- [1] Ravinder Lohiya and Prof Kumar. “Harnessing the Power of Supercomputers: Solving Complex Mathematical Problems and Queueing Theory”. In: *International Journal for Research Publication and Seminar* 15.1 (Jan. 2024), pp. 166–172. DOI: 10.36676/jrps.v15.i1.1398.
- [2] Daniele De Sensi et al. *Exploring GPU-to-GPU Communication: Insights into Supercomputer Interconnects*. Aug. 2024. DOI: 10.48550/arXiv.2408.14090.