Title:

Framework for efficient computing in distributed quantum systems.

Abstract:

In the current NISQ era, it becomes important to combine and efficiently utilize multiple quantum processors for a collective use of computing power. In order to do so, we need an optimal strategy for efficient task distribution and resource utilization. This can be modeled as an optimization problem under some constraints and chosen objective functions. In this project, we will design an inclusive framework for modelling a realistic and the best possible scenario of the general class of such problems, and explore quantum and classical approaches to solve them for a system of quantum processors, performing multiple tasks in parallel. We will also work towards building open source software for simulating such systems of distributed quantum processors in general.

Research Plan (6 Weeks):

Week1:

We will conduct literature survey and identify existing techniques used for modelling and solving such problems. It will include those mentioned in references and few other existing articles. This will include identification of both quantum and classical approaches for hybrid and purely quantum systems.

Week2:

Modelling the problem with constraints and objective functions for a general class of problems. This will include modelling for hybrid and purely quantum systems. Some of interns will work on hybrid system and some on purely quantum. I'll work with interns during this phase for proper modelling.

Week3:

Once the model is ready, we will propose novel solution to the problem. This could be a hybrid quantum-classical algorithm, purely classical or a purely quantum algorithm. Interns will work with me on proposing and validating feasible approaches.

Week4:

Now we will start coding for the proposed technique and perform experiments. This will involve finding code/ implementing code for at least two of the existing techniques, and implementing the proposed method as well. In this week, I'll design experiments that we will be doing in the coming weeks.

Week5:

During this week, interns will continue implementation and experiments. I'll help in case any of them face issues during coding.

Week6:

Finally, we will make the presentation and report as required by the program. I will work with interns for deciding, reviewing and editing the content.

Future Work (6-12 weeks):

- Based on the outcome of the project, we will decide on pending and additional tasks to be done, before writing the paper. Timelines of future work will depend upon outcome of the intership.
- Writing research paper on the proposed techniques.
- Writing software for simulation framework of the general class of problem.

References:

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2. Nguyen, Hoa T., Muhammad Usman, and Rajkumar Buyya. "iQuantum: A toolkit for modeling and simulation of quantum computing environments." *Software: Practice and Experience* 54, no. 6 (2024): 1141-1171.
3. Giortamis, Emmanouil, Francisco Romão, Nathaniel Tornow, Dmitry Lugovoy, and Pramod Bhatotia. "Orchestrating quantum cloud environments with qonductor." *arXiv preprint arXiv:2408.04312* (2024).
4. Mantha, Pradeep, Florian J. Kiwit, Nishant Saurabh, Shantenu Jha, and Andre Luckow. "Pilot-Quantum: A Quantum-HPC Middleware for Resource, Workload and Task Management." *arXiv preprint arXiv:2412.18519* (2024).
5. Sane, Bernard Ousmane, Michal HajduĹĄek, and Rodney Van Meter. "Optimizing Resource Allocation in a Distributed Quantum Computing Cloud: A Game-Theoretic Approach." *arXiv preprint arXiv:2504.18298* (2025).
6. Nguyen, Hoa T., Muhammad Usman, and Rajkumar Buyya. "DRLQ: A Deep Reinforcement Learning-based Task Placement for Quantum Cloud Computing." In *2024 IEEE 17th International Conference on Cloud Computing (CLOUD)*, pp. 475-481. IEEE, 2024.