Master's Research Internship Offer

Quantum Computing for Solving Combinatorial Optimization Problems

Keywords: Quantum Computing, Operations Research, Combinatorial Optimization, Algorithms

1 Research Context

Quantum Computing (QC) has emerged as a promising computational paradigm capable of addressing classes of problems that are intractable for classical computers [1, 2, 5]. Among its potential applications, the use of quantum algorithms for solving combinatorial optimization problems has attracted considerable attention in recent years. These problems are ubiquitous in fields such as logistics, scheduling, and network design, and are often NP-hard, making them difficult to solve efficiently using classical methods.
Despite significant progress, the applicability of quantum computing to the real-world optimization problems remains limited by several factors, including noise, modeling complexity, etc.
This internship aims to contribute to this growing body of research by investigating how quantum computing techniques can be tailored and integrated to solve representative combinatorial optimization problems effectively.

2 Objectives

The overarching goal of this internship is to explore the use of quantum computing techniques to tackle some combinatorial optimization problems that frequently arise as a sub-problem in various applications (e.g., facility layout, logistics, and communication network design) [3, 4], and serves as a benchmark for evaluating the performance of both classical and quantum optimization methods.
Here is an outline of the internship and its specific objectives:

- A literature review on the existing papers, models, and algorithms related to quantum computing for addressing different combinatorial optimization problems.
- Model Formulation: Reformulate the selected combinatorial optimization problems as *Quadratic Unconstrained Binary Optimization* (QUBO) models.
- Algorithmic Development: Implement and adapt the *Quantum Approximate Optimization Algorithm* (QAOA) and *Quantum Annealing* (QA) to solve these QUBO models and exploring various configurations [1, 2]. Moreover, at this step of the project, we will develop some innovative contributions based on quantum as well as classical algorithms.
- Experimental Evaluation: Conduct computational experiments to evaluate and compare the performance of the proposed algorithms versus classical optimization solvers/algorithms in terms of solution quality, scalability, and computational efficiency.
- Writing of a final report and a presentation.

By the end of the project, the intern should provide all materials, i.e., codes, data, results, and report and presentation files.

Potential PhD Thesis: Successful accomplishment of this internship can lead to a PhD thesis. Opportunities to continue with a PhD thesis on the same or other topics could be discussed with the interested applicants.

3 Required Profile and Skills

We are looking for a final-year engineering or master's student having the following characteristics:

- He/she holds required degree and qualifications in operations research, computer science, applied mathematics, or in any other closely-related field.
- He/she has a good knowledge in algorithmic and in operations research (mathematical optimization, algorithm analysis, exact algorithms, heuristics, and metaheuristics).
- Having good knowledge in quantum computing is not mandatory, but it is considered as a advantage.
- He/she has excellent computer programming skills in Python. Experiences with optimization solvers, e.g., Gurobi, Hexaly, etc. is not compulsory, but it is desired.
- He/she has good organizational and communication skills.
- He/she has excellent communication and writing skills in English.

4 Supervision and Location

The internship will be supervised by:

- Mahdi MOEINI, Associate professor in Computer Science (Operations Reserach) at the ensIIE (Ecole Nationale Supérieure d'Informatique pour l'Industrie et l'Entreprise) and affiliated to the research lab. SAMOVAR of the Télécom SudParis.

The location of the internship is the research lab. SAMOVAR of the Télécom SudParis, Institut Polytechnique de Paris (IP Paris).
Both institutions (ensIIE and SAMOVAR) are located at the center of Évry, within 10-minute walk distance from each other. Évry is located at 20km distance from Paris, reachable by RER D, etc.

5 Contact Information and Application Process

Supervisor:

- Mahdi MOEINI (mahdi.moeini@ensiie.fr & moeini.mahdi@gmail.com)

Application: Please send the following documents **in a single pdf file** to both e-mails addresses

- Motivation letter (at most one page)
- Detailed Curriculum Vitae (maximum 2 pages)
- Academic transcripts

Duration: 6 months
Start Date: February or March 2026.
Honorary: Standard internship stipend according to the French regulations.
Application Deadline: The position remains open until we find a suitable applicant.

References

[1] Nicolás Borrajo, Juan Marcos Ramírez, Farzam Nosrati, Jose Aguilar, Vincenzo Mancuso and Antonio Fernández. New QUBO Transformations to Improve Quantum and Simulated Annealing Performance for Quadratic Knapsack. *GECCO'25 Companion, July 14–18, 2025, Malaga, Spain*, 203–206, 2025.

[2] Taku Mikuriya, Shintaro Fujiwara, Kein Yukiyoshi, Giuseppe Thadeu Freitas de Abreu, and Naoki Ishikawa. Grover Adaptive Search for the Higher-Order Formulation of Quadratic Assignment Problems. *https://arxiv.org/pdf/2410.12181*, October 10, 2025.

[3] Mahdi Moeini, Do Thanh Dat Le. Multiple Traveling Salesman Problem with a Drone Station: Using Multi-Package Payload Compartments. *Recent Challenges in Intelligent Information and Database Systems, Communications in Computer and Information Science (CCIS)*, Vol. 2144: 226–237, Springer, 2024.

[4] Daniel Schermer, Mahdi Moeini, and Oliver Wendt. The traveling salesman drone station location problem. *Advances in Intelligent Systems and Computing*, Vol. 991: 1129–1138, 2019.

[5] Thomas G. Wong. Introduction to Classical and Quantum Computing. Rooted Grove, Omaha, Nebraska, 2022.