Solving routing problems using quantum annealing

Mentor: Paweł Gora
Expected time availability of the interns: at least 20 hours per week.
Expected number of interns: 5
Requirements: experience with quantum annealing, Leap framework, and designing QUBO formulations for combinatorial optimization problems.

The project's goal is to investigate quantum annealing approaches to solve the Capacitated Vehicle Routing Problem with Time Windows (CVRPTW). We've identified 2 suitable QUBO formulations for this problem, but would like to reduce the number of necessary qubits, implement the solution, and conduct the experiments using D-Wave's Leap framework.

Plan for the internship:

1. In the first week, the interns will familiarize themselves with 2 QUBO formulations for CVRPTW proposed in this project. One of them was defined in [1], the second in [2]. They can also look for some other QUBO formulations.
2. In the next 2-3 weeks, the interns will investigate how to implement these QUBO formulations efficiently, they will also review approaches for reducing the number of qubits and variables and will be welcome to propose optimized QUBO formulations. In particular, they will learn about the hybrid approaches in which the CVRPTW instances are first preprocessed using classical algorithms (e.g., graph clustering, graph coarsening), then quantum annealing is applied, and finally, classical postprocessing is used to generate the final solution.
3. In the last 2-3 weeks, the interns will finalize the implementation and conduct experiments using QPU, hybrid solvers, and simulators of quantum annealing. The experiments will be run on the standard benchmark dataset - Solomon's dataset [3]. Finally, the interns will analyze the results, draw conclusions regarding the efficiency of different approaches, and prepare the final presentation.

4. The implementations will be available in a publicly available repository under an open-source license. Depending on the results, we will also consider the preparation of a research publication after the QIntern program.

References:

1. Holliday J.B., Blount D., Osaba E., and Luu K., “Advanced Quantum Annealing Approach to Vehicle Routing Problems with Time Windows”, arXiv:2503.24285, 2025.
2. “Solving the CVRPTW: Quantum Annealing vs. Exact Optimization”, Master’s Thesis by Oscar Axel Vargas Salomón, 2019.
3. Transportation Optimization Portal of SINTEF Applied Mathematics, VRPTW dataset: https://www.sintef.no/projectweb/top/vrptw