Erasmus Mundus Master QuanTEEM
Master Internship

TITLE	Implementing SAT solvers on a quantum software plateform
SUPERVISOR	Frédéric Holweck - frederic.holweck@utbm.fr
INSTITUTION	ColibrITD
COLLABORATIONS	ICB laboratory
TYPE OF PROJECT (theory / experiment)	Project developed in a start-up company working on quantum computing

Summary

ColibrITD (https://www.colibritd.com/) is a start-up company working in the field of quantum computing. ColirITD has developped a platefom that aims at implementing quantum algorithms for use-case development and compatible with different quantum computer backends (IBM, Amazon, Eviden, etc).

In classical computing SAT problem is a difficult problem with exponential complexity. Roughtly speaking the problem consist in checking if a collection of boolean expression is correct or not, i.e. if there is a solution to a set of boolean equations. As part of the problems of the NP-class complexity there is currently no hope to solve it with a classical computer. For practical applications, classical heuristic algorithms have been developed and are used to solve SAT for a large set of industrial application including : logistic, cryptography, model checking [1].

As a NP problem, SAT could be interpreted as looking for a solution in a large data base. Therefore a first naive approach to take it from quantum computation perspective would be to try to use Grover's algorithm. The use of Grover's algorithm to solve SAT [2] would not change the complexity of the problem but would provide a quadratic improvement over the exponential class and will provide a full check of the space of solution (which is not provided by the current heursitic algorithm). For practical applications in logistic this quadratic improvement could be of interest to obtain exact solutions that are not achiveable today. Moreover other algorithms have been proposed and could be implemented to test up-to date efficiency of SAT solver based on quantum methods.

More precisely the goals of the intership will be :

- Provide a review on the literature on quantum solutions of SAT with an emphasize on practical application
- Implement one or two quantum solutions to solve SAT based on Grover's algorithm [2,3]

- Provide a user-case scenario where the quantum solution could be implemented and develop with ColibriTD developers a user-friendly interface to solve that specific problem using a quantum SAT solver
- Estimate the quantum resources that would be expected to provide a quantum advantage in the specfic problem that would have been chosen.

Bibliography

[1] https://en.wikipedia.org/wiki/SAT_solver

[2] Varmantchaonala, Charles Moudina, et al. "Quantum hybrid algorithm for solving SAT problem." *Engineering Applications of Artificial Intelligence* 121 (2023): 106058.

[3] Cheng, Sheng-Tzong, and Ming-Hung Tao. "Quantum cooperative search algorithm for 3-SAT." *Journal of Computer and System Sciences* 73.1 (2007): 123-136.

[4] Zhang, Ying, et al. "Quantum Solution for the 3-SAT Problem Based on IBM Q." *International Conference on Cloud Computing*. Cham: Springer International Publishing, 2019.

Additional Information

The candidate should have followed the course on quantum algorithms and have good background in mathematics and coding. The candidate is expected to have interest in quantum computing and how to bring quantum computing to all, which is the mission of ColibriTD.

The internship will be taking place in Paris at Station F (https://stationf.co/), the world largest start-ups campus in France. The supervision at ColibriTD will be done by Dr. Henri de Boutray who works as a quantum researcher at ColibriTD and Dr. Frédéric Holweck who is an associate professor at ICB.

The project may continue after the internship with a potential hiring position at the company and/or a PhD contract on quantum technologies.