# Integrating Classical and Quantum Computing for Combinatorial Optimization Using the QUBO Model

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**Abstract**

We have witnessed the remarkable discovery in recent years that the Quadratic Unconstrained Binary Optimization (QUBO) model unifies a wide variety of combinatorial optimization problems, and moreover is the foundation of adiabatic quantum computing – the realm that underlies the quantum computers developed by D-Wave Systems and actively being explored for its research and practical applications by Google and Lockheed Martin in the commercial realm and by Los Alamos National Laboratory and Oak Ridge National Laboratory in the public sector. Computational experience is being amassed by both the classical and the quantum computing communities that highlights not only the potential of the QUBO model but also its effectiveness as an alternative to traditional modeling and solution methodologies. We survey, in a tutorial manner, a variety of applications of the QUBO model and highlight state of the art solution methods. These developments disclose a rich potential for integrating classical and quantum computing, by using appropriately designed classical systems to provide pre-processing and post-processing functions for quantum systems. We describe a recent software innovation in the classical area to support such an integration and relate the combined classical/quantum research to machine learning.