Davide Venturelli
NASA QuAIL

Deterministic Embedding Methods for Integer Linear Programming on Chimera Graphs and beyond

Quantum Annealers are being considered as a possible platform to solve challenging Integer Linear Programming Problems (ILP). The current approaches to hard-code an ILP employ graph minor embedding algorithms that require a significant overhead of resources (number of qubits, computing power) with respect to the number of logical variables in the ILP. This overhead is arguably the primary problems for practitioners of quantum annealing. We present a new method to deterministically embed an arbitrary ILP in a generic class of annealing chip layouts such that the timings and performance beats the current methods. The method is flexible on the chip structure and it is based on directly crafting the optimization formulation by modifying the penalty functions and casting the instance into an intermediate form which is known to be embeddable. It is shown on the latest D-Wave chips to allow programming of problems, relevant for database and space sciences, which would not be embeddable in reasonable time or space with the current approaches. The discussed methods can be easily adapted to any chip that supports a tiling in unit cells, or to irregular chips by means of pre-processing techniques, and also inform the design of next-generation of quantum annealers.