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Quantum algorithms for scheduling problems: a survey

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Abstract

Quantum algorithms have the potential to solve combinatorial optimization problems faster than classical algorithms. A particular example for combinatorial optimization problems are scheduling problems. This work provides summarizes quantum or quantum-inspired algorithms for scheduling problems, providing an overview of 20 years of research. We categorize the approaches by problem type and algorithm type. A condensation of the reviewed literature to the main ideas and details about the considered problem size, solvers and evaluation metrics enables a quick comparison with and placement into the current state of research for future works. We further critically assess the comparability of the reviewed literature and present crucial metrics for future comparison.

Keywords: Scheduling Problems; Quadratic unconstrained binary optimization; Mixed-integer linear programming; Quantum genetic algorithms

1 Introduction

Scheduling problems are immensely important for production, healthcare, traffic, logistics, distributed systems, and many other application areas Abdalkareem et al. [1], Ikeda et al. [95], Pinedo [165]. There are many variants of scheduling problems in the literature, such as job shop scheduling problems Xiong et al. [224], open shop scheduling problems Anand et al. [9], flow shop scheduling problems Reza Hejazi and Saghafian [174], and flexible versions where more than one machine is available for at least one operation Chaudhry and Khan [41], Xie et al. [223]. See Allahverdi [7] for an excellent reference on scheduling problems and their classification.

Standard job shop scheduling problems consider a collection of jobs, consisting of operations, and a collection of machines. The operations within a job must be executed in a given order. A job is done once its last operation is done. Each machine is designed to handle one of the operations and can only execute one operation at a time. The goal is to find a schedule of the operations onto the machines such that some metrics are optimized, typically, one aims at minimizing the makespan, i.e., the time until the last job is finished. For such problems, Garey et al. [80] showed that finding a schedule that minimizes the makespan is NP-hard.