Some approximation algorithms and their applications to scheduling problems

Bui Anh Duong

Abstract: This thesis investigates approximation algorithms for scheduling problems, a class of combinatorial optimization challenges central to operations research and computer science. Given that many scheduling problems are NP-hard, exact solutions are computationally infeasible for large instances, necessitating efficient heuristic approaches. The research focuses on the design and analysis of novel approximation algorithms with provable performance guarantees, specifically addressing makespan minimization and total completion time objectives. We explore both classic models, such as parallel machine scheduling, and more complex variants involving precedence constraints and resource limitations. The proposed algorithms leverage techniques including linear programming rounding, greedy strategies, and local search. A significant contribution is the development of a polynomial-time approximation scheme (PTAS) for a specific constrained scheduling problem. Furthermore, the thesis demonstrates the practical applicability of these algorithms through case studies in cloud computing resource allocation and manufacturing production planning. Experimental evaluations on synthetic and real-world datasets validate the theoretical bounds, showing that the algorithms achieve near-optimal solutions with high computational efficiency, thereby bridging the gap between theoretical computer science and practical scheduling needs.

Keywords: approximation, algorithm, scheduling, application