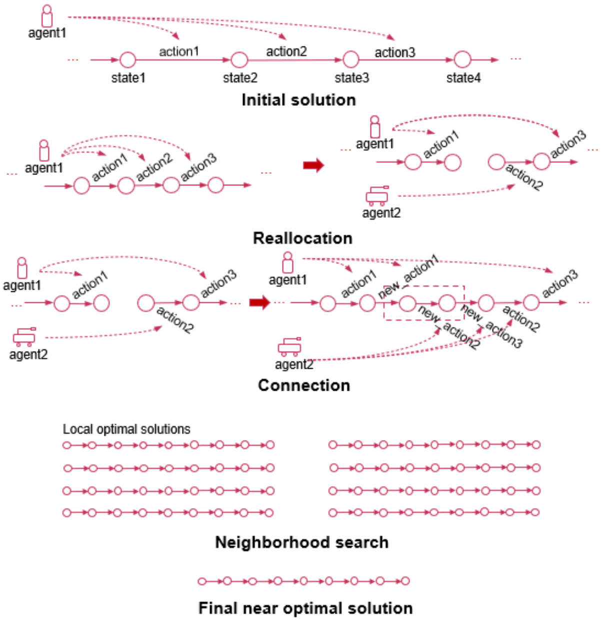
Stepwise Large-Scale Multi-Agent Task Planning Using Neighborhood Search

Multi-agent task planning aims to obtain a solution that can achieve goals using a group of agents by maximizing the overall performance of a system. This is a fundamental problem common in various fields, including robotics, transportation, logistics, and manufacturing. In terms of domain description, the STRIPS-style language [1] is often utilized because it allows the world to be described using predicates, which are statements that can be either true or false. Although this language facilitates scaling up to solve highly complex problems by adding more states and actions, the search space for finding solutions grows exponentially with the number of predicates. Bylander [2] reported that such planning problems are PSPACE-complete and more difficult to solve compared to the NP-complete problems. We present a stepwise method for solving multi-agent task planning problems in large-scale STRIPS-style problems described by the Planning Domain Definition Language (PDDL) [3] within a realistic time frame. While existing planners [4, 5] can promptly solve problems containing only a small number of agents, addressing large-scale problems efficiently remains a challenge. Our method solves this problem by initially achieving the goals of the given problem using a minimum number of agents and then iteratively refines the solution through reordering and partially reallocating actions to other agents. During the local refining process, the reordering and reallocating may disrupt the original logical connections between adjacent actions, so our proposed method reconnects them by searching for optimal connections using a plangraph. The time complexity of obtaining a new solution using the connection of adjacent actions is linearly related to the length of the solution, which reduces the complexity to a polynomial level. The pursuit of realizing an optimal solution is abandoned since developing scalable and quick algorithms to realize optimality is not plausible. The refining process adopts a neighborhood search approach, treating reallocated and reordered solutions as neighbors. Additionally, tabu search is employed to iteratively escape the local optimal solution and ultimately obtain a near-optimal solution.



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