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A Self-organized Approach for Real-Time Railway Timetable Rescheduling

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Effective rail traffic management is necessary to mitigate the impact of unforeseen train service disturbances. Traditional decomposition methods, while effective in managing complexity, often struggle to maintain global optimality and real-time responsiveness. In this paper, we propose a novel approach that decomposes the rescheduling problem by means of a self-organising paradigm where trains are intelligent autonomous agents deciding on their decisions after reaching a consensus. The proposed Self-Organized Train Rescheduling (SOTR) algorithm is inspired by the Distributed Constraint Optimization Problem (DCOP) framework. This algorithm treats trains as intelligent agents capable of constructing their own traffic plans, communicating with neighbouring agents, and making decisions that lead to an optimal timetable. Each train, acting as an agent, assesses its situation, predicts conflicts, and negotiates with other trains to find the most efficient solution in regard to total delay. This distributed decision-making process allows for rapid adaptation to dynamic disturbances and ensures scalability to large networks. We validate the effectiveness of our approach by using a micro-simulation tool, demonstrating its ability to minimize secondary delays and maintain network continuity in perturbation scenarios.