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Optimizing conflict-free routing for workstation-capacitated tow trains in just-in-time assembly line feeding system

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Efficient and conflict-free routing is essential to ensure the timely delivery of parts to assembly line workstations, avoiding delays, bottlenecks, and potential collisions. This study proposes an innovative solution to achieve conflict-free tow train routing by combining pathfinding and optimization techniques tailored for just-in-time (JIT) environments.

In our approach, the production layout is modeled as a grid-based system, where the layout is partitioned into uniform "pixels" that represent discrete navigable units. We employ a shortest path algorithm on this pixel-based layout to generate a distance matrix between workstations. To optimize the routes for multiple tow trains delivering parts to various workstations, we implement a heuristic. This heuristic minimizes total travel distance and prevents potential congestions while ensuring that delivery schedules meet workstation demands by balancing the workload among tow trains.

The proposed algorithms are tested on a variety of benchmark instances representing different production layouts, varying numbers of tow trains, and workstations with diverse part demands. We evaluate the performance of our conflict-free routing solution across these instances, analyzing the impact of layout complexity, tow train density, and part-demand variability on the overall system performance.