Department of Systems Science and Industrial Engineering

DESIGN OF ROBUST DYNAMIC ORDER PICKING SYSTEMS WITH CONGESTION EFFECT

DISSERTATION DEFENSE

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ABSTRACT

In recent years, the role of warehouses and distribution centers (DCs) in the supply chain has gained significant importance. In addition to being strategic storage centers, these facilities are becoming more responsible for managing end customer demand, which enhances the supply chain agility and responsiveness. However, the development of e-commerce technologies allows customers to place, modify, and cancel orders at any time, which creates many disruption events that increase the total order picking time and urges the need for re-planning the order fulfillment process. To handle these disruption events and meet customer demand in short time, warehouses and DCs should introduce adaptation and robustness to their order picking systems. This research proposes and adaptive and robust order picking system that is capable of adjusting its strategy in the presence of disruption events, such as new order arrivals, order modification, and unexpected congestion. For this purpose, we first formulate a congestion-aware order batching and sequencing model (COBS) to generate batching and sequencing decisions considering aisles congestion. Then, we propose a dynamic order picking framework (DOP) that executes re-batching and re-routing via D-COBS model once new orders are received. In addition, we develop a scenario-based robust optimization formulation (R-COBS) to consider uncertainty in picking and travel times when generating batches and routes for pickers. Due to the $\mathcal{NP}$-hardness of the problem, a Tabu Search (TS) algorithm is employed to solve the models. The results demonstrate that the proposed model successfully provides batching and sequencing decisions that minimize the total tardiness and reduce picker congestion. The experimental results show that the proposed model reduces tardiness by 7.6% and congestion time by 47% on average for small problem sizes, and reduces tardiness by 16.7% and congestion time by 19.9% on average for practical problem sizes compared to order batching and sequencing models with no congestion consideration. The results also demonstrate the effectiveness of the DOP when compared to the online order picking (OOP) strategy over different values of system dynamism, arrival rates, and due date tightness. In addition, the results show the proposed R-COBS model performs better than the COBS model in 70% of the cases providing 15% less tardiness on average. Furthermore, the robust dynamic model (RD-COBS) provides similar or better performance than the D-COBS model generating 13.1% less tardiness on average in the cases where statistical difference exists.