

Research Title:

A Two Stage Dynamic Delivery Problem

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Coordinating fulfillment operations across two interdependent stages is a critical challenge across industries such as logistics, e-commerce, and food services. In this work, we introduce the Dynamic Two-Stage Order Fulfillment Problem (DTSOFP), a new class of problems that unifies several logistical challenges in a cohesive manner. The DTS-OFP captures the complexities of real-world fulfillment systems and emphasizes the need to simultaneously optimize both preparation and delivery stages under dynamic and stochastic conditions. We model the problem class as Markov Decision Process and introduce a novel theory-driven policy decomposition formulation. To exploit this decomposition, we propose an innovative solution framework that integrates operations research elements and machine learning. Our framework advances beyond prior research, which often treats fulfillment stages independently or sequentially, and offers a new approach to handling interdependencies between sequential operations. Our framework is applied to three real-world DTS-OFP contexts: warehouse picking operations, production-delivery systems, and food delivery platforms. Numerical experiments using datasets from Meituan, ORTEC, and Iowa City show that our framework consistently outperforms existing methods.