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Management and Logistics

Integrating First and Last-Mile Logistics in Megacities: Introducing the Two-Echelon Vehicle Routing Problem with Pickups, Deliveries, and Deadlines

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This paper introduces the Two-Echelon Vehicle Routing Problem with Pickups, Deliveries, and Deadlines (2E-VRP-PDD), a new and emerging routing variant addressing the operations of logistics companies connecting consumers and suppliers in megacities. Logistics companies typically organize their logistics in such megacities via multiple geographically dispersed two-echelon distribution systems. The 2E-VRP-PDD is the practical problem that needs to be solved within each of such a single two-echelon distribution setting, thereby merging first and last-mile logistics operations. Specifically, it integrates forward flow, reverse flow, and vehicle time-synchronization aspects such as parcel time windows, satellite synchronization, and customer-dependent deadlines on the arrival of parcels at the hub. We solve the 2E-VRP-PDD with a tailored matheuristic that combines a newly developed Adaptive Large Neighborhood Search (ALNS) with a set-partitioning model. Our ALNS provides high-quality solutions on established benchmark instances from the literature. On a new benchmark set for the 2E-VRP-PDD, we show that loosening or tightening time restrictions, such as parcel delivery deadlines at the city hub, can lead to an 8.5% cost increase, showcasing the overhead associated with same-day delivery compared to next-day delivery operations. Finally, we showcase the performance of our matheuristic based on real-life instances which we obtained from our industry collaborator in Jakarta, Indonesia. In these instances, which we share publicly and consist of 1500 - 2150 customers, we show that using our ALNS can significantly improve current operations, leading to a 17% reduction in cos