Research on Truck and Drone Collaborative Delivery Systems: A Quantum Optimization-Based Last-Mile Solution

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ABSTRACT

This paper explores applying a collaborative truck and drone delivery system to address the last-mile delivery challenges in e-commerce. In recent years, the burgeoning e-commerce market has dramatically increased parcel volumes for logistics providers, with last-mile delivery emerging as a critical bottleneck. An innovative approach combining trucks and drones has emerged to enhance efficiency and reduce costs, leveraging drones' rapid aerial transport capabilities to overcome traditional truck delivery's limitations. The vehicle routing and scheduling optimization problem is classified as NP-hard, posing considerable challenges to finding solutions. To effectively address this complexity, this research introduces quantum computing methods, specifically quantum annealing, which exhibits the potential to surpass traditional classical computing in handling combinatorial optimization problems. The objective is to minimize the total system cost by constructing a parcel delivery system model that integrates a single truck and multiple drones. This model is further transformed into a Quadratic Unconstrained Binary Optimization (QUBO) model, suitable for quantum annealing computation. Methodologically, this research loads the proposed QUBO model into a real quantum computer to perform quantum annealing operations and validate its solution performance. Experimental results demonstrate that the proposed quantum annealing algorithm outperforms the traditional Simulated Annealing (SA) algorithm in both system cost and execution time, validating the potential of quantum annealing for this problem.