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Quantum Computing for Vehicle Routing Problems: State of the Art and Challenges

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Numerous variants of the vehicle routing problem (VRP) are important in operations research and practice. Last-mile delivery problems attract particular attention because of the large numbers of customers, products, and vehicles involved. These problems are usually formulated as mixed-integer linear programming (MILP) or other combinatorial optimization models. Real-life problems of large scale, as they appear in business and logistics, are often not solvable with traditional MILP or heuristic algorithms due to their high computational complexity, especially when realistic constraints such as time windows, vehicle capacities, service priorities, or multi-depot structures must be taken into account. The rapid progress of quantum computing in recent years has enabled the first experimental applications of quantum methods to routing and logistics. Quantum annealing, in particular, has shown promise for handling larger problem instances and for delivering high-quality heuristic solutions within short runtimes. This makes it suitable for hybrid approaches, where many smaller subproblems are decomposed from a large initial model and solved on a quantum device, while the overall coordination relies on classical optimization. At the same time, important challenges remain, such as limited solution accuracy, overhead of mapping logical variables to physical qubits, and restricted problem sizes. These challenges continue to constrain applicability, while the adequate representation of rich real-world constraints in quantum formulations is still an open research issue. This talk reviews the state of the art in applying quantum computing to

solving large-scale VRPs. We describe first examples of realistic problem solving, outline the potential for building real-world applications with the emphasis on last-mile delivery, and highlight current hardware and algorithmic approaches. The relative advantages of quantum annealing devices are discussed, along with key challenges that must be addressed before practical adoption becomes possible.