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Optimal Delivery of Two Similar Products to N Ordered Customers

Authors : Epaminondas G. Kyriakidis, Theodosis D. Dimitrakos, Constantinos C. Karamatsoukis

Abstract : The vehicle routing problem (VRP) is a well-known problem in Operations Research and has been widely studied during the last fifty-five years. The context of the VRP is that of delivering products located at a central depot to customers who are scattered in a geographical area and have placed orders for these products. A vehicle or a fleet of vehicles start their routes from the depot and visit the customers in order to satisfy their demands. Special attention has been given to the capacitated VRP in which the vehicles have limited carrying capacity of the goods that must be delivered. In the present work, we present a specific capacitated stochastic vehicle routing problem which has realistic applications to distributions of materials to shops or to healthcare facilities or to military units. A vehicle starts its route from a depot loaded with items of two similar but not identical products. We name these products, product 1 and product 2. The vehicle must deliver the products to N customers according to a predefined sequence. This means that first customer 1 must be serviced, then customer 2 must be serviced, then customer 3 must be serviced and so on. The vehicle has a finite capacity and after servicing all customers it returns to the depot. It is assumed that each customer prefers either product 1 or product 2 with known probabilities. The actual preference of each customer becomes known when the vehicle visits the customer. It is also assumed that the quantity that each customer demands is a random variable with known distribution. The actual demand is revealed upon the vehicle's arrival at customer's site. The demand of each customer cannot exceed the vehicle capacity and the vehicle is allowed during its route to return to the depot to restock with quantities of both products. The travel costs between consecutive customers and the travel costs between the customers and the depot are known. If there is shortage for the desired product, it is permitted to deliver the other product at a reduced price. The objective is to find the optimal routing strategy, i.e. the routing strategy that minimizes the expected total cost among all possible strategies. It is possible to find the optimal routing strategy using a suitable stochastic dynamic programming algorithm. It is also possible to prove that the optimal routing strategy has a specific threshold-type structure, i.e. it is characterized by critical numbers. This structural result enables us to construct an efficient special-purpose dynamic programming algorithm that operates only over those routing strategies having this structure. The findings of the present study lead us to the conclusion that the dynamic programming method may be a very useful tool for the solution of specific vehicle routing problems. A problem for future research could be the study of a similar stochastic vehicle routing problem in which the vehicle instead of delivering, it collects products from ordered customers.

Keywords : collection of similar products, dynamic programming, stochastic demands, stochastic preferences, vehicle routing problem
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