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Coordinated vehicle routing with uncertain demand

Numerical optimization methods have been developed and applied successfully to many deterministic variants of the so-called vehicle routing problem (VRP). Unfortunately, existing numerical methodologies are not as effective for planning and design problems when uncertainty is a significant issue. In view of this, this presentation will show how approximation models for large-scale uncertain VRP's can complement conventional optimization methods and allow for the exploration of a broader set of design and operating strategies than is currently possible. The presentation will consider vehicle routing problems where vehicles have a finite capacity and demand is uncertain, focusing on strategies that coordinate the actions of all vehicles in the fleet in real time as information becomes available.

When uncertainty exists, systems should be designed with degrees of flexibility that allow for efficient control in real time. In the case of "single-period" vehicle routing problems we should determine two things: (i) the system configuration, including the fleet size and composition and an initial set of vehicle routes, and (ii) a dynamic control plan (algorithm) which specifies how vehicle routes are modified in real time as information becomes available. Uncertainty should be considered when designing both the system configuration and its control algorithm. Furthermore, configuration decisions should be made with both the flow of information and the control method in mind. For the capacitated VRP with uncertain demand, the desirability and feasibility of specific designs will depend on how and when lot size information becomes available and the degree of control that a dispatcher can exert over en-route vehicles.

Researchers have attempted to obtain optimal designs minimizing expected operating costs for problems in which customer lot size information becomes known only after the arrival of a vehicle. Unfortunately, all the solutions proposed to date are based either on configurations that are unlikely to be feasible in practice, such as single-vehicle fleets, or on feasible operating plans that are too restrictive to be appealing in practice. A possible alternative system design that may be more practical and efficient would allow tour failures to be consolidated into secondary "sweeper" routes. The approach here would be to plan initial routes as if the vehicle capacity were smaller (q- ¡ q) to ensure that few primary tours would fail, and then to serve the overflow customers with a set of secondary tours where vehicles are allowed to cooperate. Unfortunately, although this configuration is simple to describe, it is already too difficult to optimize exactly. More promising designs where vehicles would be allowed to cooperate during the primary tours are even more difficult to treat exactly.

The presentation will show how a system in which vehicles are allowed to co-

operate during the primary phase can be designed and operated by minimizing and approximate "logistic cost function" of key design parameters. The effectiveness of the proposed strategies is compared against (a) current strategies in which there is little or no coordination, and (b) against deterministic strategies for equivalent problems without uncertainty. It is shown that the introduction of coordination in proper ways lowers the operation cost from the best levels that can be achieved without coordination (a) to levels close to (b).