Time-Dependent Shortest Path Optimization and Capacitated Arc Routing Problems

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Congestion in city centers causes massive economical losses and a wide range of adverse effects on inhabitants. Transit times can widely vary during peak hours. With the advent of a multitude of sensors, mobile tracking devices and large databases of historical events, driving speeds can be modeled more precisely to optimize urban transportation in metropolitan areas. In response to these challenges, the amount of literature on vehicle routing problems considering time-dependent travel times (TDVRP) has quickly grown.

Most recent works on TDVRPs have been based on a complete graph representation of the network in which each vertex corresponds to a customer (or depot) location. In the seminal article of [1], piecewise-constant vehicle speed functions were applied to the arcs of this (complete) graph to model time-dependent driving speeds. Under these assumptions, travel times are known to satisfy the first-in first-out property (i.e., leaving earlier cannot result in a later arrival) and a unique shortest path between any two locations needs to be considered. This is, however, only a rough approximation of reality. In practical conditions, time-dependent travel times are specific to each street or neighborhood in an urban network. In such conditions, the quickest path between two locations can change over time, but the FIFO property remains valid.

In this work, we focus on the time-dependent CARP (TD-CARP) and propose state-of-the-art mathematical programming algorithms and metaheuristics. To our knowledge, this is the first study on a capacitated arc routing problem with multiple vehicles and time-dependent travel times. We consider a deterministic setting, assuming that travel speed estimates (i.e. based on traffic history) are available. To deduce travel time information between visit locations, we pre-process all-pairs *continuous travel time profile functions* using efficient quickest-path algorithms instead of discrete travel time information at particular time points. This reduces memory consumption and makes the algorithms tractable on larger datasets. We report computational experiments on artificial instances as well as on real datasets based on speed information from Rio de Janeiro's radars.

References

[1] S. Ichoua, M. Gendreau, J.-Y. Potvin, "Vehicle dispatching with time-dependent travel times", *European Journal of Operational Research* 144(2) 379–396, 2003.