

## Special issue on Rich Vehicle Routing Problems

### Editorial

The *Vehicle Routing Problem* (VRP) is a key to efficient transportation management and supply-chain coordination. In broad terms, it deals with the optimal assignment of a set of transportation orders to a fleet of vehicles, and the sequencing of stops for each vehicle. The VRP has a large number of real-life applications and comes in many guises, depending on the type of operation, the time frame for decision making, the objective, and the types of constraint that must be adhered to. Outside of transportation logistics, the VRP has less intuitive but still important applications, e.g. in robotics and VLSI design.

The VRP is a computationally hard, discrete optimization problem. It has been a main subject for thousands of researchers since it was introduced by Dantzig and Ramser in 1959. A large variety of optimization and approximation methods have been proposed and studied. Depending on variant and response requirements, exact VRP methods of today have a size limit of 50-100 orders. Hence, there has been much research on algorithms that are able to find high quality solutions in limited time.

Our ability to find good solutions to practical variants of the VRP in a reasonable response time has increased tremendously since this problem was introduced. Improvements are not only due to a general increase in computing power, but also to substantial advances, both in exact methods and heuristics. VRP research is regarded as one of the great successes of Operations Research. The results have led to a tool industry in route design and fleet management, through which research results have yielded huge economical and environmental savings.

VRP research has often been criticized for being too focused on idealized models with non-realistic assumptions for practical applications. The methodological evolution has led to a situation where the classical problems are now more or less regarded as being solved from a pragmatic point of view. As a result, the research community has turned to variants of the VRP which before were considered too difficult to handle. The variants include aspects of the VRP that are essential to the routing of vehicles in real-life. The family of those extended problems are often called *Rich Vehicle Routing Problems*. In addition to the internal motivation in the research community alluded to above, the growing tool industry and their end users provide external forces in the direction of richer VRP models.

This is the backdrop for our call for papers for a special issue of the Central European Journal of Operations Research on Rich Vehicle Routing Problems. Of the many submitted papers, we have carefully selected 7 high quality contributions that span different aspects of richness, illustrate state-of-the-art, and exemplify novel types of VRP application.

The first paper by Reimann and Ulrich considers a VRP variant highly relevant to supply chain coordination. Here, there is much to be gained from combining linehauls and backhauls. The authors study the VRP with backhauling and time windows, and compare alternative

mixing strategies. An experimental study based on Ant Colony Optimization metaheuristics provides a comparative assessment of these strategies. Hoff and Løkketangen study related issues with inspiration from the beverage industry, where there are practical problems with combining delivery and reverse logistics. Their paper focuses on the TSP with pickups and deliveries with side constraints derived from practical considerations on vehicle loading and unloading. VRP with pickup and delivery requests is also the general topic of the paper by Ileri et al. The authors study the so-called drayage operations in truck/rail intermodal transportation, i.e., the movement of loaded or empty equipment between customer locations and rail ramps. The paper presents an optimization methodology based on a set partitioning formulation and column generation for the daily drayage operation problem.

Moving on to temporal richness aspects, the paper by Fügenschuh studies a coupling constraints extension to the recently much studied VRP with Time Windows. A practical application is the integrated optimization of school starting times and bus public services. The paper presents a formulation, and suggests a solution method based on a combination of MIP-techniques and metaheuristics. Magalhães and de Sousa have studied a real-life dynamic vehicle routing problem in pharmaceutical distribution. They present the application in detail, and propose an algorithmic approach. Experimental results based on real case data are presented and compared with results from traditional planning. Sörensen presents an approach to the general problem of stability in the maintenance of routing plans. Tactical routing plans need to be maintained when external events occur. Organizational and other concerns will typically impose constraints on plan disruption. To address this issue the author proposes a bi-objective optimization method. A second objective component based on a distance metric on the solution space is added to the ordinary objective.

The paper by Bolduc et al. extends the VRP in the direction of supply chain management (SCM) by considering the routing decisions together with inventory and production decisions over time in an integrated manner. Different heuristics are generated and are evaluated out of which the heuristic motivated by the earliest due date rule seems to perform best.

We are confident that the recent trend in the VRP research community of more efforts devoted to studies of rich problems will increase for many years. Results will certainly make a difference to industry and society.

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