Towards a Decision Making Support System for the Capacitated Vehicle Routing Problem

Takwa Tlili, LARODEC Laboratory, High Institute of Management, University of Tunis, Tunis, Tunisia
Saoussen Krichen, LARODEC Laboratory, High Institute of Management, University of Tunis, Tunis, Tunisia
Sami Faiz, LTSIRS Laboratory, National Engineering School of Tunis, Tunis, Tunisia

ABSTRACT

Distribution of goods is of importance in logistics and supply chain management. The target of a distribution network is to specify the beneficial way for delivering goods and commodities from supply to demand points. In distribution domain, this activity can usually be viewed as a capacitated vehicle routing problem (CVRP). As the CVRP solutions remain computationally intractable, we develop in this paper an interactive routing decision making support system (R-DMSS) that integrates a swarm based approach into a geographical information system (GIS). The empirical experiments include benchmarking instances as well as a case study over the Ezzahra area in Tunisia. The R-DMSS interfaces are presented to better understand the operational aspect of the system.

Keywords: Capacitated Vehicle Routing Problem (CVRP), Decision Making Support System, Geographical Information System (GIS), Particle Swarm Optimization (PSO), Routing Decision Making Support System (R-DMSS)

INTRODUCTION

The delivery of goods to customers is considered to be one of the most challenging activities in logistic sectors. It has a major effect on the overall costs of industrial firms as well as on the environmental resources. Transportation and distribution problems are generally modeled as a capacitated vehicle routing problems (CVRPs) since it consists in minimizing the overall cost while satisfying routing constraints and customers’ ordering. Over the past five decades, the CVRP, first evoked by Dantzig and Ramser (1959), has been one of the widely

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studied optimization problems in logistics and supply-chain management due to both its hardness and relevance in practice (Escobar et al., 2013; Xiao et al., 2012; Fung et al., 2013). In order to better fit real life applications, the CVRP has been enriched with additional constraints, e.g., time windows to visit customers, pick-up and delivery operations and heterogeneous fleet of vehicles.

As today’s logistic field is dynamic and complex, the decision maker needs interactive tools to identify the most appropriate solution. The complexity of routing problems led to the development of a new kind of an interactive computer-based system, namely the Decision Making Support System (DMSS), which aids logistic managers to achieve lower costs and greater flexibility.

Basically a DMSS aims to:

- Supply DMs with easy access to data to support poorly structured or unstructured tasks;
- Satisfy the DM needs through the embedded expert system and the modeling engine;
- Provide the requested inputs and outputs in a user friendly way;
- Display geographical features such as the transport network, workable roads and administrative boundaries.

The main contribution of this paper is the modeling and development of a routing DMSS (RDMSS) for solving the CVRP. Specifically, the framework integrates an optimization engine, based on a metaheuristic, into an open source GIS tool. The proposed approach that combines the Dijkstra and the particle swarm optimization algorithms, is tested on a set of benchmark instances and the use of the RDMSS is described in a case study.

The rest of the paper is organized as follows. Section 2 presents an overview of related works. Section 3 provides a brief description of the CVRP. Section 4 describes the architecture of the proposed DMSS. In section 5, a brief review of the proposed approach is provided in solving the CVRP by presenting its pseudocode and the simulation results. The case study, explaining the use of the RDMSS and its process flow, is provided in section 6.

Related Work

The inability of optimization algorithms alone to fully handle decision makers’ preferences becomes obvious in transportation field due to their spatial nature (Butler et al., 2005). Indeed, because of its effectiveness to collect, organize and display spatial data, GIS is a key component of the DMSS (Scheibe et al., 2006, Zambelli et al., 2012). The growing interest on integrating GIS technologies and the appropriate optimization methodologies has attracted significant attention from researchers. In this vein, Mendoza et al. (2009) developed an evolutionary-based DSS targeting to solve the CVRP at a public utility in Colombia. Their tool, named EAAB-VRT, integrates SAP/R3 and ArcGIS with the Clarke and Wright heuristic. Similarly, Lopes et al. (2008) proposed a decision-support tool for the capacitated location-routing problem that enables the access to online geographic data through Web Map servers. Their system incorporates heuristic methods and CPLEX solver.

More recently, Santos et al., (2011) developed a DMSS based on the coupling of the ant colony metaheuristic and Google Maps. GIS-based DMSS is developed for various practical routing applications. Examples include planning milk collection (Butler et al., 2005), tourism planning (Dye & Shaw, 2007), ambulance dispatching (Derekenaris et al., 2001), and poultry litter management (Kang et al., 2008). Hong et al. (2013) develop a simulation-based approach to obtain accurate information from GPS and GIS integrated applications for transportation.

A sizeable chunk of the literature has focused on developing a system that integrates both GIS and optimization routines. This paper follows a different direction as we created a plug-in for quantum GIS to solve the CVRP.

Problem Statement

The CVRP is described as the problem of finding least cost routes for a heterogeneous fleet
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