Energy Efficient Green Vehicle Routing Problem

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ABSTRACT

The greenhouse gas emissions from the transportation sector are one of the major contributors to global warming today. Freight share to GHG emissions is likely to increase 2-fold by 2050. This makes it critical for CO₂ emissions to be reduced through an optimized transportation strategy. Vehicle routing, when done efficiently, can reduce these emissions across countries. In this attempt, the traditional distance minimization objective of the vehicle routing problem has been replaced with an energy-emission-centric objective. A model is formulated taking energy and emissions into simultaneous consideration and a typical VRP problem has been evaluated using a genetic algorithm. The application of the proposed model is observed to reduce emissions significantly compared to conventional models. Considering the possibility of increase in carbon tax in future, energy-emission minimized routing would not only aid “green logistics,” but also reduce the environmental costs incurred.

KEYWORDS
Emission, Genetic Algorithm, Green Vehicle Routing Problem, Optimization

1. INTRODUCTION

Growth in international trade has been characterised by globalisation and supply chains have become longer and more complex, as logistics networks link more and more economic centres across oceans and continents. Transportation, which is one of the most important parts of logistics, is the irreplaceable fundamental infrastructure for economic growth. However, Transportation being characterized as one of the major sources of environmental pollutants, affects the environmental, ecological and social wellbeing (Canhong Lin et al., 2013). It is also one of the hugest petroleum consumers and accounts for a large part of the overall pollutants (Salimifard et al., 2012). According to the INCCA reports, in 2007, the emission from the transportation sector was 142.04 million tons of CO₂ equivalents. Road transport, being the principal mode of transport in India, has contributed to 87% of the total CO₂ equivalent emissions from the transport sector. Greenhouse gas emission (GHG) from human activity is the major reason for the climatic changes across the world (https://www.epa.gov/climate-indicators/greenhouse-gases). Logistics process (transporting, storing, handling) across various industries today are not sustainable in the long term. Reduction of the carbon footprint in the logistics would lead to the sustainability of the supply chain (Anbuudayasankar et al., 2010). Thus, supply chain management will also imbibe environmental and social concern to its reincarnation as Sustainable Supply Chain Management (Abidi et al., 2017).

India is the third highest contributor of carbon emissions next to The United States and China.
India emits about 1,523,767 Giga grams of CO₂ according to the United Nations Framework Convention on Climate Change (UNFCCC, 2015) reports. However, India has promised to reduce the emission intensities of its GDP by 33%-35% by 2030 from 2005 level in its action plan submitted to the UNFCCC. Similarly, governments across the world have begun to propagate environmental centric schemes and legislations. The carbon cap and trade are one such mechanism under which a firm producing emissions exceeding its allowable limit is forced to buy the rights to do so. Similarly, a firm also has the right to sell its carbon credits to other firms (Yushan Jiang et al., 2015). The intense pressure of being environmentally sustainable has caused Green Supply Chain Management concept to emerge as an important corporate environmental strategy for manufacturing companies (Savita et al., 2016). It is therefore important to incorporate these ideas and concerns in the daily route management of real companies by searching for high-quality routes to offset environmental costs (Faulin et al., 2011).

In the traditional Vehicle Routing Problem (VRP), the focus is on the economic impact of vehicle routes on the organization that carries out the distribution service. Consideration of wider objectives and more operational constraints that are concerned with sustainable logistics issues lead to new vehicle routing models and new application scenarios, which naturally result in more complex combinatorial optimization problems. (Lin et al., 2013, Anbuudayasankar et al., 2014)

Green Vehicle Routing Problem (GVRP) is characterized by the objective of harmonizing the environmental and economic costs by implementing effective routes to meet the environmental concerns and financial aspects. Many in their attempt, have confined VRP with green transportation consideration to only those problems with explicit objectives of environmental costs. It is noted that there is still room for investigation to explore GVRP in energy consumption, emission control, and reverse logistics. For practical purposes, it is hoped that these idealized models can help governments, and companies to evaluate the possible economic and environmental significance of real-world transportation problems and to act at different levels to contribute to Green Logistics. This reinforces the need for pursuing efficient and eco-friendly strategies for the transportation process.

2. BACKGROUND AND LITERATURE REVIEW

VRP is a typical route allocation problem where a fleet of vehicles should visit a number of customers over the best possible route such that the total distance is minimized and thus the fossil fuel usage (Erdoghan et al., 2011). There are extensive literatures on several VRP variations and optimization-based approaches to solve them. VRP is a NP hard problem and there are several methodologies to obtain solution through exact or approximate algorithms. Most of the models optimize energy, cost or emission.

The VRP first introduced by Dantzig and Ramser (1959), described a real-world problem concerning dispatching gasoline delivery trucks between a bulk terminal and a large numbers of service stations. The Capacitated VRP (CVRP) defined by Dantzig and Ramser used distance as the representation for cost function. The several models suggested later are based on this approach. Most of the traditional models considered only distance and could not account for the effect of load carried on the energy consumed.

Kara et al. (2007) came up with a load-centric cost function called the Energy Minimizing VRP (EMVRP) which included the load carried by the vehicle as a part of the cost function. Thus, the new cost function is the product of distance travelled and loads on the vehicle. However, they used ‘work’ to represent the energy so as to simplify the relationship between minimizing the consumed energy and the variability in the conditions of the vehicles.

Suggestions on providing smooth trips which include fewer stop and go driving state as well as shorter stopping times were also considered by Jabbarpour et al. (2016) in decreasing the CO₂ gas emissions. Truck payload and emissions due to waiting times were also considered as critical aspects for routing (Suzuki, 2011). In congested urban areas with significant speed changes due to varying
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www.igi-global.com/article/anp-based-model-effective-green/70588?camid=4v1a

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