Green open Vehicle Routing and Schedulling Problem Considering the Time Spent in Traffic Congestion

Almira, Herman Mawengkang, Saib Suwilo, Tulus

Abstract:*The current world has seen technology emerge as a field that plays a significant role in promoting sustainable development. Technological provisions are projected to form the key determinant of attaining enterprise objectives. This projection accounts for the manner in which different technology-related firms continue to grapple with inventions and innovations, as well as explorations of theories responsible for understanding the people's adoption of new systems. The process of adopting a new product, behavior, or idea constitutes an innovation. Notably, the diffusion process does not take place simultaneously in social systems. Rather, some people end up being more apt to adopt the system; compared to others.This paper discusses a green open vehicle routing and scheduling problem (GOVRSP) model with aim to minimize CO_2 emissions in logistics systems. A heuristic algorithm of MILP and iterated neighborhood search is addressed to solve the problem.*

Index terms: Green vehicle routing problem, Scheduling, Traffic congestion, Neighborhood search

I.INTRODUCTION

Wireless modes of communication have received attention to such an extent that some of the cities in the world cannot operate without digital control systems. Notably, developments have been implemented beyond operations such as WLAN and mobile phones, witnessing the arrival of green open vehicle routing and scheduling problems in cities such as London and Stockholm.

According to Dargie and Poellabauer (2010)[2], green open vehicle routing and scheduling problems are established through communication nodes that are autonomous. The communication processes are realized via radio, excluding backbone infrastructures. Therefore, two nodes that are not within a range of mutual transmission can communicate using intermediate nodes to relay messages [5]. Green open vehicle routing and scheduling problems can be applied in fields such as community mesh networks, disaster relief, data gathering, monitoring, and surveillance. Notably, technological demands in the field of green open vehicle routing and scheduling problems have led to further research to address the current challenges that smart cities face while providing services to the citizens. In vehicular networking, green open vehicle routing and scheduling problems aid in establishing routing systems, medium access control, deployment strategies, topology control, and the design of energy efficient systems. The following figure shows a probable outlook of an ideal smart city (in which green open vehicle routing and scheduling problems are effective).

A study by Azimi, Bhatia, Rajkumar and Mudalige (2011) focused on the role of sensor networks in minimizing collisions among vehicles. Findings indicated that the evolution of green open vehicle routing and scheduling problems accounts for the significant reduction of collisions at the intersections. In a similar study, Dargie and Poellabauer (2010)[2] affirmed that there is a direct correlation between technology incorporation and safety among vehicles. Specifically, the improvement in safety was attributed to the real-time form of communication that the sensors offer. According to Kemal and Mohamed (2005)[4], green open vehicle routing and scheduling problems play a critical role in routing in which communication modes and signal provision may alert the drivers on possible routes that may be deemed safe and, with little traffic.

A study by Magno,[5] Boyle and Brunelli et al. (2014) indicated that vehicular network and the incorporation of technologies accounts for the reduction of human errors that could, otherwise, emerge if transit operations in smart cities were solely reliant on the drivers' ability to establish the best routes and, preferable speeds. Kemal and Mohamed (2005) [4] asserted that highly integrated forms of wireless sensing have led to improved forms of communication and safety, with the assertion suggesting that vehicular networking is critical because it strives to alleviate adversities on the road.

II.LITERATURE RIVIEW

In the field of green open vehicle routing and scheduling problems, the aspect of routing messages from one source to another or from one source to multiple destinations is crucial. Information within smart cities is disseminated by routing systems, either as anycast, broadcast, multicast, or unicast. It is worth noting that standard approaches have been established to achieve the routing processes ─ through the broadcast technique. The implication is that the green open vehicle routing and scheduling problems are geared towards achieving efficiency in routing systems while seeking to serve the optimal amounts of overhead ─ generated by logarithms. However, the manner in which information is disseminated in smart cities in unicast, multicast, or anycast modes remains challenging [4]

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According to by Magno[5], Boyle and Brunelli et al. (2014), future transportations are perceived to gain from vehicular networking. Some of the key features of vehicular networking include the efficient management of traffic systems, standardization, infotainment, and road safety [4]. Particularly, the process of installing communication devices in roadside infrastructure components and cars has the moving vehicles communicate with other vessels in the network ─ because of the establishment of ad hoc networks that are ephemeral and rapidly changing. Furthermore, it is projected that moving vehicles will directly access network infrastructure, which will be fixed on the roadside, with smart cities perceived to be unexceptional.

In a study by Dargie and Poellabauer (2010),[2] it was asserted that smart modern cities have numerous luxury cars in which central computers are embedded to serve the purpose of connecting various networks and systems. Furthermore, the cars are equipped with communication devices of wireless nature; including cell phones that provide telematics and Internet connection services when needed. In the end, ad hoc sensors and the concept of vehicular networking play a crucial role in enhancing safety by promoting real-time communication between vehicles. The following photograph illustrates how vehicular networking is applied in smart cities to minimize destruction during dangers such as fire. In the photo, cars that surround the region of disaster are fed with information from a central point of dissemination, upon which alternative routes are sought without necessarily causing traffic jams. Notably, the drivers establish alternative routes upon receiving information about the appropriate routes on which smooth traffic flows have been observed.

Gentry (2010) identified and categorized the achievement levels that green open vehicle routing and scheduling operators adopt. The categories include user acceptance, fulfillment of system integrations, problem-solving, triggering of effective flow of information, meeting the objectives of company budgets, meeting the goals of company schedules, dominant support from the managerial teams and fulfilling, as well as the implementation the goals of respective IT firms. Additionally, the study revealed that three factors of performance enhancement, project management, and empirical investigation undergo integration through green open vehicle routing and scheduling implementation.

Mircea, Ghilic and Stoica (2011)[6] found that green open vehicle routing and scheduling system implementation could assume the form of an early success and a failure in later stages of firm performance in the IT sector, or assume the form of an early failure and success in later stages of firm operation. Furthermore, the study indicated that little evidence exists regarding actual assimilations of green open vehicle routing and scheduling system implementations (that surpass initial implementations) among organizations. Therefore, green open vehicle routing and scheduling adoption does not mark the climax of firm operations. A similar study by Misra and Mondal (2010) indicated that IT firms strive to embrace continuous monitoring and management of EUDs in quests to reverse the failure or sustain success. Indeed, the complexity of green open vehicle routing and scheduling system implementation implies that the achievement of a perfect fit is less likely [8]. These studies suggest that system stabilization is critical towards the realization of effective green open vehicle routing and scheduling system values. However, the observations fail to account for trends in the adoption of green open vehicle routing and scheduling system in IT management. Rather, the studies focus on the existing firms that have adopted green open vehicle routing and scheduling, ignoring companies that are at the take-off stage ─ regarding green open vehicle routing and scheduling system implementation and its accompanying consequences.

III.PROBLEM DESCRIPTION AND FORMULATION

A. Formulation Models

The criticality of green open vehicle routing and scheduling problems and the promotion of vehicular networking mechanisms arise in the case of traffic congestion and impact monitoring. Traffic noise pollution, air quality pollution, and the emission of greenhouse gases result from the urban traffic. Thus, smart cities have devised mechanisms for minimizing the adverse effects of traffic congestion in a quest to reduce socio-economic losses. Specifically, ad hoc networks have enabled the realization of online monitoring of the times of travel and the behavior of drivers from the points of origin to the destinations. Other benefits that have resulted from green open vehicle routing and scheduling problems and vehicular networking mechanisms include the reductions of air pollution and the reduction of the length of queues among city traffic systems.

Variable

x_{ijkh} $\{0,1\}$ variable is arc (i, j) traversed by vehicles h in the period*k* (1) or otherwise (0)

y_{ijh} $\{0,1\}$ variable isarc (i, j) served by vehicles*h* (1) or otherwise (0)

The total travel time is stated as $\tau_{ij} = \sum_{k \in T} t_{ijk}$, provided t_{ijk} it does not fully utilize the time available in period *k*.

The decision variable for the GOVRSP models, 1), $x_{ijkh} = 1$ if the vehicle trip *h* comes from the customer $i \in V$ to the customer $j \in V$ in period *k*, and $x_{ijkh} = 0$ otherwise; 2), $y_{ijh} = 1$ if the arc (i, j) is traversed by vehicles*h* in several periods, and $y_{ijh} = 0$ otherwise.

The objective function to minimize total travel time is formulated as:

$$Min\ R = \sum_{h \in H} \sum_{k \in T} (\sum_{(i,j) \in E} t_{ijkh} e_{ih} x_{ijkh} + \sum_{i \in I} r_i e_{ih}) \quad \textbf{(1)}$$

Constraint :

$$\sum_{h=1}\sum_{i=1} y_{ijh} = 1, \quad \forall h \in H \tag{2}$$

$$\sum_{h=1}\sum_{j=1} y_{ijh} = 1, \quad \forall h \in H \tag{3}$$

$$\sum_{h=1}\sum_{j=1} x_{ojkh} = 1, \quad \forall h \in H;\ \forall i = 1,2,....,n \tag{4}$$

$$0 \le \sum_{i=1} x_{ijkh} - \sum_{j=1} x_{jikh} \le 1, \quad \forall h \in H;\ \forall i = 1,2,....,n;\ \forall j = 1,2,....,n \tag{5}$$

$$\sum_{i=1} d_i \left(\sum_{h=1} y_{ih}\right) \le Q_h, \quad \forall h \in H \tag{6}$$

$$\sum_{h \in H}\sum_{j \in I} x_{fjkh} \le b_f, \quad \forall k \in T;\ \forall f \in F \tag{7}$$

$$\sum_{(i,j)E} t_{ijkh} \le u_k - v_k, \quad \forall h \in H;\ \forall k \in T \tag{8}$$

$$e_{ih} + r_i + t_{ij} \le e_{jh}, \quad \forall i, j \in I;\ \forall h \in H \tag{9}$$

$$f_i \le v_k + t_{ijkh} - v_m\left(1 - \sum_{k \in T} x_{ijkh}\right), \quad \forall k \in T;\ \forall h \in H \tag{10}$$

$$f_i = g_i + r_i + Y_i, \quad \forall k \in T;\ \forall h \in H \tag{11}$$

$$g_j \ge u_k + t_{ijkh} - v_m\left(1 - \sum_{k \in T} x_{ijkh}\right), \quad \forall k \in T;\ \forall h \in H \tag{12}$$

$$g_j \ge f_i + \sum_{k \in T}\sum_{h \in H} t_{ijkh} - v_m\left(1 - y_{ij}\right), \quad \forall k \in T;\ \forall h \in H \tag{13}$$

B. Optimization algorithm using simulated annealing

{ I. Preparation}
Read input data;
If the link cost are not given from the input data, calculate the minimum path cost pk,l
between all pair of tasks k, l including the depot 0;
{II. Initialization} Generate a random initial feasible solution x_0; x := x_0; x:= x;*
T := INITTEMP; Set N as the averaged neighbourhood size;
{III. Optimization by SA} Minimize E by repetition of applying randomly one of the three
transformation rules to the string model corresponding to x in the framework of SA;
{IV. Output} Output the best solution x.*
Step III, that is the main part of this algorithm, is detailed as follows.

Repeat
trials := 0; changes := 0;
Repeat
trials := trials + 1;
Generate a new state x´ from the current state x by applying randomly one of the three transformation rules to the string model of x;
If x´ is feasible Then
Calculate ΔE = E(x´) −E(x);
If ΔE < 0 Then x´ is accepted as a new state;
If E(x´) < E(x) Then x*:= x´*
Else x´ is accepted with probability exp (−ΔE/T)
If x´ is accepted Then changes := changes + 1; x := x´
Until trials ≥ SIZEFACTOR · N or changes ≥ CUTOFF · N;
T := T · TEMPFACTOR
Until T ≤ INITTEMP / FINDIVISOR

IV.CONCLUSION

In conclusion, smart cities are characterized by a good economy, smart environments, smart mobility, smart living, smart people, and a smart system of governance. The aspect of information communications and technology (ICT) has emerged towards the future realization of perfect smart cities.

The paper has examined the application of green open vehicle routing and scheduling problems in smart cities. The manner in which green open vehicle routing and scheduling problems can function has been highlighted, focusing on probable future applications of the sensor systems. The field of vehicular networks has received attention because of the need to reduce traffic congestion. Additionally, sensor application has been associated with impact monitoring. Green open vehicle routing and scheduling problems have also led to the realization of online monitoring of the times of travel and the behavior of drivers from the points of origin to the destinations, accounting for significant reductions in traffic noise pollution, air quality pollution, and emissions of greenhouse gases in the urban traffic.

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