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SMART ROUTING FOR SOLID WASTE COLLECTION

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SMART ROUTING FOR SOLID WASTE COLLECTION

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requirements for the degree of Bachelor of Computer Science with Honours

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ABSTRACT

This project aims to design and develop a route optimization and decision support system for solid waste collection in Malaysia. The problem of waste management in Malaysia has become increasingly complex due to an increase in waste generation and insufficient technology, manpower, and facilities. The current method of waste collection, used by both private and government agencies, is to conduct a real-time study of citizens' habits and movements before formulating a route plan. However, this method has proven to be inefficient and costly due to weak scheduling, inadequate road networks, a lack of advanced technologies, and poor routing. The proposed solution is to implement a route optimization algorithm to predict the probability of each feasible route for the garbage truck collection. The algorithm will take into account factors such as the capacity and power of the truck, and the workload assigned to the crew. The algorithm will be evaluated through simulations and field testing in a residential area in Kuching. The results of the evaluation will be used to design and develop a web-based application for route management, which will be made available to waste collection companies and garbage truck drivers. Based on the chosen methodology, details requirement analysis, system design, database design, and wireframe for proposed system have also been completed, and will be used to develop the system in the next phase. The implementation phase involves detailed requirement analysis, system design, database design, and wireframe creation. The system will provide waste collection companies and garbage truck drivers with a user-friendly platform for optimizing routes. Testing is conducted to validate the functionality and performance of the system. Finally, the conclusion highlights the accomplishments of the project, including the successful development of the route optimization algorithm and the web-based application. Limitations and constraints are identified, such as data availability and hardware limitations, which suggest areas for future work. Overall, this project contributes to improving waste collection operations in Malaysia, but further enhancements and advancements are needed to address the identified limitations and constraints.

ABSTRAK

Projek ini bertujuan untuk merancang dan membangunkan sistem optimasi laluan dan sokongan keputusan untuk pengumpulan sisa pepejal di Malaysia. Masalah pengurusan sisa pepejal di Malaysia semakin kompleks disebabkan peningkatan jumlah sisa pepejal yang dihasilkan dan kekurangan teknologi, tenaga manusia, dan kemudahan yang mencukupi. Kaedah pengumpulan sisa pepejal semasa, digunakan oleh agensi swasta dan kerajaan, adalah dengan melakukan kajian masa nyata terhadap tabiat dan pergerakan warga sebelum merancang pelan laluan. Walau bagaimanapun, kaedah ini terbukti tidak efisien dan mahal disebabkan penjadualan yang lemah, rangkaian jalan yang tidak mencukupi, kekurangan teknologi canggih, dan pemilihan laluan yang tidak baik. Cadangan penyelesaian adalah untuk melaksanakan algoritma optimasi laluan untuk meramalkan kebarangkalian setiap laluan yang memungkinkan bagi pengumpulan trak sampah. Algoritma ini akan mengambil kira faktor seperti kapasiti dan kuasa trak, dan beban kerja yang ditugaskan kepada kru. Algoritma ini akan dinilai melalui simulasi dan ujian lapangan di kawasan perumahan di Kuching. Keputusan penilaian akan digunakan untuk merancang dan membangunkan aplikasi berdasarkan web untuk pengurusan laluan, yang akan diberikan kepada syarikat pengumpulan sisa pepejal dan pemandu trak sampah. Berdasarkan metodologi yang dipilih, analisis keperluan terperinci, reka bentuk sistem, reka bentuk pangkalan data, dan wireframe untuk sistem yang dicadangkan juga telah selesai, dan akan digunakan untuk membangunkan sistem dalam fasa seterusnya. Fasa pelaksanaan melibatkan analisis keperluan terperinci, reka bentuk sistem, reka bentuk pangkalan data, dan pembuatan wireframe. Sistem ini akan menyediakan platform mesra pengguna kepada syarikat pengumpulan sisa pepejal dan pemandu trak sampah untuk mengoptimakan laluan. Ujian dilakukan untuk mengesahkan fungsi dan prestasi sistem. Akhirnya, kesimpulan menekankan pencapaian projek, termasuk pembangunan berjaya algoritma optimasi laluan dan aplikasi berdasarkan web. Kelemahan dan batasan dikenal pasti, seperti ketersediaan data dan had peranti keras, yang menunjukkan bidang untuk kerja masa depan. Secara keseluruhan, projek ini memberi sumbangan kepada peningkatan operasi pengumpulan sisa pepejal di Malaysia, tetapi penambahbaikan dan kemajuan lanjut diperlukan untuk mengatasi kelemahan dan batasan yang dikenal pasti

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CHAPTER 1: INTRODUCTION

1.1 Project Title

Smart Routing for Solid Waste Collection

1.2 Background

In Malaysia, solid waste generation has recently gained more importance, particularly in quantity and type. According to a media report on Malaysia's garbage collection statistics, waste creation has significantly increased recently. Roslan and Said (2022) stated that in 2018, about 36,843 tonnes of waste were generated daily; 2019 (37,462); 2020 (38,081); 2021 (38,699); and 2022 (39,936). Roslan and Said (2022) stated that medical waste contributed to the spike in solid waste disposal after the COVID-19 pandemic started in March 2020 due to the widespread use of face masks and COVID-19 self-test kits that are disposed of as domestic waste and not as clinical waste.

Figure 1.1: Residents in Rural Area Throw Waste in Non-Designated Ares during the COVID-19 Pandemic and Not Being Disposed

Badgie et al. (2019) stated that Malaysia, being a developing country, also encounter problems in term of technology, manpower, and land scarcity, as well as facilities that are insufficient to cope with the ever-increasing rate of waste generation. Moreover, the performance of solid waste collection is measured by indicators such as operating cost, travel distances of trucks, quantity of collected waste, number of waste containers hauled, and labour hours (Sulemana et al., 2018). For this reason, the limitation of the performance of solid waste collection is weak scheduling, an inadequate road network, a lack of advanced technologies, and poor routing. While developing a smart method to address the previously described issue, the developer must consider these limitations and State regulations.

Table 1.1: Waste Collection Services Responsible Organisation at the Different States in Malaysia

State name	Distinct	Responsible name	Organisation type
Johor	Johor Bahru	SWM Environment Sdn Bhd	Private agency
Kedah	Alor Setar	E-Idaman Sdn. Bhd	Private agency
Kelantan	Kota Bharu	MPKB (Majlis Perbandaran Kota Bharu)	Government department
Malacca	Malacca City	SWM Environment Sdn Bhd	Private agency
Negeri Sembilan	Seremban	SWM Environment Sdn Bhd	Private agency
Pahang	Kuantan (Penang Island)	SWCorp Malaysia (Perbadanan Pengurusan Sisa Pepejal dan Pembersihan Awam)	Government department
Penang	Tanjong Tokong (Penang Island)	Cahaya Delima Enterprise Sdn. Bhd.	Private agency
	Pulau Tikus (Penang Island)	Paper Plane Sdn Bhd	Private agency
	Padang Kota Lama (Penang Island)	Hayara Sdn. Bhd.	Private agency
	Jelutong (Penang Island)	RT Jaya Sdn. Bhd.	Private agency

	Gelugor (Penang Island)	Firwan Merican Sdn. Bhd.	Private agency
	Batu Maung (Penang Island)	Era Bumiway	Private agency
	Air Itam (Penang Island)	SP Maju Sdn. Bhd.	Private agency
	Balik Pulau/Teluk Kumbar (Penang Island)	Majlis Bandaraya Pulau Pinang	Government department
Perak	Ipoh	Town Services Division	Government department
Perlis	Kangar	E-Idaman Sdn. Bhd	Private agency
Selangor	Shah Alam	KDEB Waste Management Sdn Bhd (KDEBWM)	Private agency
Terengganu	Kuala Terengganu	MBKT (Majlis Bandaraya Kuala Terengganu)	Government department
Sarawak	Kuching	Trienekens (Sarawak) Sdn. Bhd.	Private agency
Sabah	Kota Kinabalu	Jabatan Kesihatan Persekitaran Bandaraya, Dewan Bandaraya Kota Kinabalu	Government department

As seen in Table 1.1, the waste collection services are accountable to the District Council in particular States. For example, the Jabatan Kesihatan Persekitaran Bandaraya, Dewan Bandaraya Kota Kinabalu is responsible for the waste collection services in Kota Kinabalu, Sabah. In addition, some states have outsourced the existing services needed to private agencies. For instance, the Trienekens (Sarawak) Sdn. Bhd. are in charge of waste collection services in Kuching, Sarawak. State issues of different approaches in terms in term of collection method, scheduling, etc since there are different operators, therefore not easy to standardise. This project will consider residential areas and the waste collection method used in Kuching as a case study.

Figure 1.2: One of the Actual Route for Waste Collection Services at Jalan Matang

As seen in Figure 1.2 shows, the actual route for waste collection services at Jalan Matang which is usually serviced on Tuesday by the Trienekens (Sarawak) Sdn. Bhd. The areas consist in this route are Sungai Cina, Jambatan Merah, Kampung Sungai Atas Baru, Kubah National Park, Kampung Sungai Agas Lama, Politeknik Kuching Sarawak, SMK Agama Matan, Matang Wildlife Centre, Kampung Sri Kandong, Kampung Jaya Bakti.

Most of the time, the Trienekens (Sarawak) Sdn. Bhd. conducts the door-to-door waste collection method. Riwukore and Habaora (2019) stated that the door-to-door waste collection method is carried out using a garbage truck that travels around the environment accompanied by three to four workers to raise garbage from the shelter to the truck.

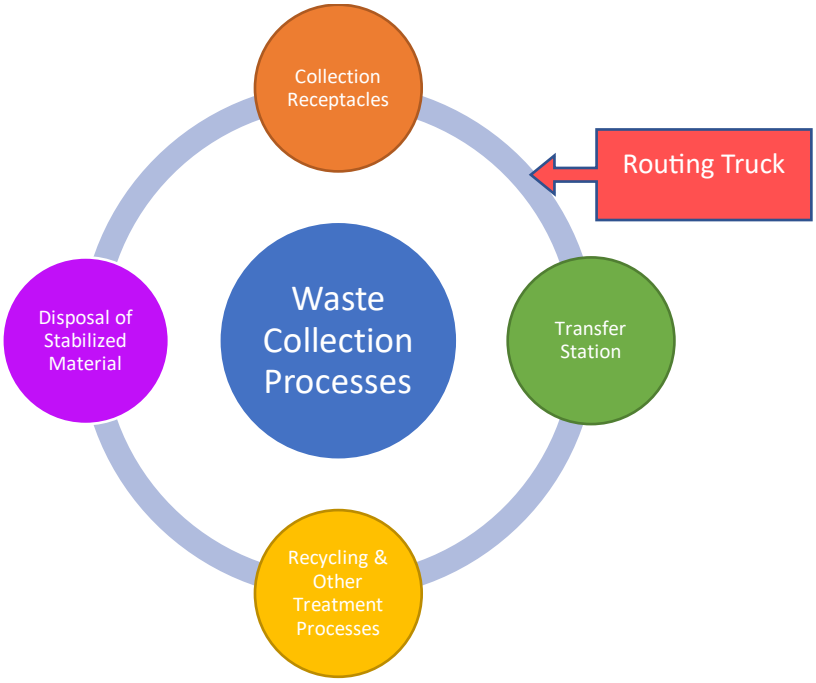

Figure 1.3: Solid waste collection and transportation process

As seen in Figure 1.3 shows, the gathering or picking up and carrying of solid wastes from numerous sources to the transfer station. Because of the high labour requirements and extensive usage of garbage trucks, routing is undoubtedly the most significant and expensive part of solid waste management, as highlighted by Tuan Leong Tze Fui, who is the Solid Waste Management Department director from DBKK (Dewan Bandaraya Kota Kinabalu) in a recent interview. Thus, garbage disposal unit runs with the involvement of many expenditures like personnel cost, scientific sanitary landfill cost, general expenses, maintenance charges (Parekodi et al., 2019). From the interview study, officer salary, establishment compensation, and labour pay are all included in personnel costs. Costs associated with scientifically based sanitary landfills include approach routes, major collection centres' construction, and landfill improvement projects. Garbage truck maintenance is included in maintenance fees. Fees for consulting services, the cost of hiring a garbage truck, and fuel costs are examples of general expenses. Consequently, the expenditures mentioned above are the parameters

that may affect the cost of operations for a company doing waste collection business, which will be the important factor to consider in this study.

1.3 Problem Statement

The Trienekens (Sarawak) Sdn Bhd as private agency organisation and Solid Waste Management Department from DBKK as government sector have been selected to conduct research. The research has found that two organisations have used the same and even the highly essential method, which is both will do a real-time citizen's motion and habit study before formulating the garbage collection route plan. Then, the waste collection route will be structured based on the study outcome. Once completed structure, all the waste collection route information will be printed out a copy to each driver and ensure drivers will follow it. Besides, the daily garbage truck activities of both organisations typically operate garbage trucks six days a week, with a few running on Sundays. However, Tuan Leong Tze Fui, who is the Solid Waste Management Department director from DBKK, mentioned that issues such as weak scheduling, an inadequate road network, a lack of advanced technologies, and poor routing incite impact the increase of overall operating expenses, whose key components are vehicle repairment costs, vehicle variable costs, and labour expenses. Furthermore, the issues mentioned before further cause extensive numbers of garbage trucks driving through the housing area and commercial area (central business district area and rural area), thereby affecting the overall safety and attractiveness of the community.

Figure 1.4: A Garbage Truck Collect the Waste in Housing Area

Even though it seems like all the routes have been planned properly and Malaysia's government has indicated increasing the number of garbage trucks to solve the growing amount of waste. Waste management concessionaire SWM Environment Sdn Bhd will invest some RM22mil to purchase 40 new compactor vehicles to replace its fleet of ailing garbage trucks in Negeri Sembilan, Malacca and Johor (Singh, 2011). Singh (2011) stated that its executive chairman Dr Uzir Abdul Malik said the move was aimed at improving its services. Nevertheless, due to variations in a garbage truck's primary features, such as power, capacity, and oil tank volume, it is difficult and more expensive to manage the increased number of garbage trucks to resolve the ever-increasing rate of the waste in the short term. Other than that, the garbage truck occurs emergency suddenly and the advent festival that may take a few days to celebrate may cause urgent rerouting or rescheduling the waste collection route. For instance, if garbage truck A has an emergency while collecting solid waste, garbage truck B's collection route would be redirected to finish the remainder of garbage truck A's route, but only after finishing its present journey.

With the ever-increasing proportion of garbage trucks in the fleet, the need for efficient tools to guide the fleet, mainly enabling it to reduce operating costs, has never been more important. Since solid waste management in Malaysia is becoming more and more complex, owing to laws and regulations. A powerful and efficient route decision support system is required. Although the management for a fleet has been widely dissertated, the garbage truck routing as a combinatorial optimisation problem has neither been deliberate from the perspective of balancing the workload assigned to garbage trucks crew nor balancing the routes assigned to each vehicle (Książek et al., 2021).

1.4 Aim and Objectives

The project aims to design and develop route optimization and route decision support system for solid waste collection.

The objectives of the project are:

i. To design a route optimization module to predict the probability of each feasible route for the garbage truck collection.
ii. To evaluate the route optimization algorithm.
iii. To design and develop a web-based application for route management.

1.5 Scope

The development of the project will mainly concentrate on residential area in Kuching, waste collection companies and indirectly the garbage truck drivers as stakeholders. The stakeholder uses the system to get the optimised and reasonably route which enables solving the problem stated in the problem statement instead of increasing the share of a garbage truck which harmfully consumes time and cost.