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Routes Transportation Problem for Waste Collection System at Sitiawan, Perak, Malaysia

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Abstract: ***Green logistic concept has emerged and inherently driven by the environmental sustainability challenges. The implementation of Vehicle Routing Problem (VRP) in real world relates with Green Vehicle Routing Problem (GVRP). The research is discussing about solving GVRP for waste collection system in Sitiawan, Perak. The purpose of this research is to design a vehicle routes selection for waste collection system using general optimization method and to examine the result associates with GVRP. Travelling Salesman Problem (TSP) is used as main optimization method and simulated using MATLAB Programming. The expected outcome shown in this paper would be statistical analysis between actual routes and suggested routes to find the best routes. Result shows that routes suggested by TSP had better efficiency about 0.32% which had less distance and 7% (392 minutes) less time than actual routes. However, the actual routes had only had slight differences with the suggested TSP routes. Therefore, the result illustrates that the application of actual route selection by the driver is efficient and the suggested routes by TSP can be applied in real world applications.***

Keywords: ***About four key words or phrases in alphabetical order, separated by commas.***

I. INTRODUCTION

Managing waste is a problem worldwide due to its direct effect on the environment. Rapid urbanization in the recent years become array of problem leading to the increase of waste from residential, commercial or industrial areas across the world. 24 million populations in Malaysia are facing with the generation and accumulation of waste every day. Overall, the generation of 16000 tonnage of domestic form the local communities generate per days and the amount per capita vary from 0.45 to 1.44 kilograms (kg) per day depending on the economic status of the areas concern. Average in waste generation is about 1kg per capita per day [1] and according to transportation costs represent 70 percent (%) and 80 percent (%) of all operational costs in waste collection [2]. This is important because even a small upswing in collection routes may lead to substantial savings.

Thus, increasing attention has been paid to optimization of waste collection including the improvement of waste allocation with the aid of vehicle routing strategies.

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There is a lot of optimization technique can be use in order to optimize the operational of waste management. Transportation is a basic necessity in order to operate in daily work routine depended on what types of business is it. One of the examples is waste collection system in logistic sectors. The developing countries such as Malaysia cannot escape from environmental problems such as pollution due to recent urbanization and increased in population. So, the needs to maintain and optimize in transportation sector in terms of Green Vehicle Routing Problem (GVRP) will help in minimizing the impact of environmental problems. Therefore, in this paper, waste collection system at Sitiawan, Perak, Malaysia is selected to solve GVRP using Travelling Salesman Problem (TSP) method that able in achieving the research objectives. The objectives of GVRP include minimizing the time travelled, reducing fuel consumption, reduces the cost and distance implied as well as reducing the carbon emission to achieve green aspects. This research will positively give benefits to the government, organization, companies and society towards environment impacts. The sample area of this research focuses on the small compact residential and industrial area in the states of Perak, Malaysia that covered at Sitiawan district. This comprise about 1100.74 km^2 from total waste collection area.

II. LITERATURE REVIEW

Transportation

Green concept in transportation are referring on the environment adaptation toward with the urban system that advocates in decreasing in the usage of road – motor transportation [3]. Besides that, [4] also evaluates that intermodal transportation the implementation of green logistic will reduce the air pollutants especially carbon emission produced by the transportation sector. The issue arises in transportation sector which give great impact to environmental problem such as air pollution, congestion, noise pollution, waste pollution and others. Green intelligent transport system evaluates by differentiates the distribution strategies, reducing green energy usage, reducing waste and managing the logistic activities. As the transportation network is significant towards global needs, Green Vehicle Routing Problem (GVRP) is selected to manage the transportation system efficiently and effectively for better solution and decision making. As the GVRP comes from assimilation of Vehicle Routing Problem (VRP) which is cater more on the environment issues such as pollution, carbon emission and waste management system.

Green Vehicle Routing Problem

Most GVRP literature review proposed objectives to minimize the gap with real applications that generate opportunities for application in enterprises wishing efficient and sustainable operation as well as offer insights for interested researchers such as [5] and [6].The basic variant can be seen in [4] research which explains the purpose is to identify the optimal route for a set of commodities with minimum carbon emission.

The fuel consumption energy usage such as speed need to be taken into account as it effect the cost and distances in the given range of time. GVRP also used to verify the practical implementation of strategy and planning analysis for the problem [7] describes that implementing green logistic ideas in VRP and its variants give rise to GVRP. Thus, it can be claimed that GVRP helps in reducing cost and pollution as well as giving best optimum routes. Environmental issues leads problem arises from few factors such as pollution, recycled collection, carbon emission, fuel consumption and waste management system in transportation sectors.

Waste Collection System

In waste collection system, there are several literatures that focuses on way to collect waste such as dynamic scheduling, paradigm waste management and others. A smart green waste collection system must be design to create more sustainable waste management systems in the future and shows that separate collection outperforms co-collection in the real-life instance with multi-constraints. [8] and [9] supported dynamic scheduling and travel speeds in waste collection problems. Dynamic scheduling evaluated on synthetic and real data proved to be consistent in real time and the dynamic travel speeds of vehicles in a waste collection problem greatly influenced the total travel time, total travel distance and the number of vehicles needed. [10] show that waste management paradigms that would curb the menace of poor solid waste handling and improvement opportunities to the exact specification of facilities, if correctly applied is capable of reducing the total cost of waste disposal in the metropolis by 70 percent (%).

III. METHODOLOGY

Research Framework

There are two methodologies that have been used which are collecting data and analyzing data. Collection of data will be focusing on interview sessions. The data is analyze using simulation program, route selection decision and data presentation. Figure 1 below shows the preliminary framework of this paper.

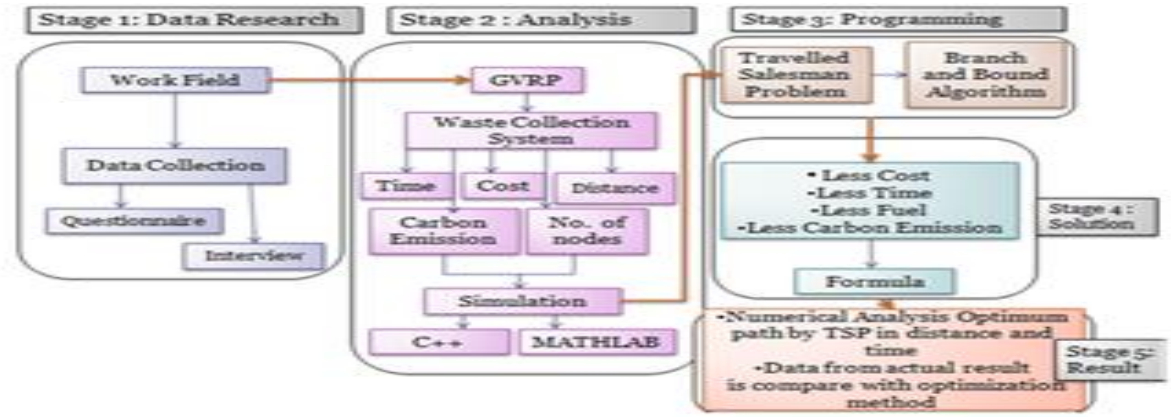

Fig. 1 Research Framework

In this research there are five steps to be highlighted. Step one Interview session are take part in step one of collecting data process. This research is more towards the routes taken by the dump truck from Manjung Municipal Council (MMC) and back to MMC after collection of waste trip. The second step is the analysis. After collecting both primary and secondary data, the data were based on the Green Vehicle Routing Problem (GVRP) elements on the waste collection system which includes time, cost, distance, carbon emission and number of nodes. This data is analyzed into the simulation system which known as MATLAB software. TSP methods is used as a way to determine the optimal route for solving the GVRP on the waste collection system. The fourth step is the solutions. The elements of less cost, less time travelled, less fuel consumption and less carbon emission should be achieved to proof the optimization is working on waste collection system when compare to the current condition. Numerical analysis is made and compared to select the best optimal routes. The best optimize routes is simulated using the data from the actual result to proof the difference between current condition and simulation condition which will be benefited the industry in the future in order to improved waste collection system in Sitiawan Perak.

Optimization Method

Optimization methods in this research are simply by using the Travelling Salesman Problem.

Travelling Salesman Problem (TSP) is a representative of a combinatorial optimization problem. The challenges of TSP are complete nodes must be visited only once to find the minimum total length of tours among possible of tours. Given a set of cities and distance between every pair of cities, the problem is to find the shortest possible tour that visits every city exactly once and returns to starting point.

This algorithm is influence by the calculation of cost. When the cost increases, it will branch to other nodes to find the best possible routes. So, the objective is to minimize the total distance traveled by MPM dump truck.

IV. RESULT AND DISCUSSION

Actual Routes

The research objective one for this paper is to design a vehicle routes selection for waste collection system using selected optimization method.

The route selected is taken from the drivers that drive MMC dump truck's AFN 646 through observation, interview and field trips toward every selected routes. Table - I below shows the location and routes taken by the trucks.

Table. 1 Nodes of Actual Routes Taken By AFN 646

Nodes	Location	Position		Distance (km)
		Latitude	Longitude	
1----2	MMC	4.21831	100.6986	5
2----3	TM 1	4.21061	100.69251	1
3----4	TM 2	4.21014	100.69031	0.842
4----5	FTSM	4.207526	100.68983	0.321
5----6	TM 2	4.20898	100.69101	1.636
6----7	FTS	4.20777	100.6898	1.584
7----8	Rest	4.2065	100.6855	0
8----9	Rest	4.21409	100.68526	0
9----10	TSS 2	4.20737	100.68526	1.8
10---11	TS 1	4.21557	100.67528	2.534
11----12	Recycle Centre	4.20638	100.67706	6.127
12----13	ZH	4.20638	100.67592	3.849
13----14	Chicken factory	4.20647	100.67656	1
14----15	ZME	4.24681	100.66979	1.657
15---16	BAW	4.24619	100.66831	1.5
16----17	KCT	4.2541	100.66563	0.5
17---18	ABM	4.24571	100.67205	1.1
18--1	Segari Landfill	4.39993	100.67253	29.5
1	MMC	4.21831	100.6986	32.05

Nodes/ Location Name:
MMC: Manjung Municipal Council
TM: Taman Muhibbah
FTSM: Flat Taman Setiawan Maju
FTS: Flat Taman Sentosa
TSS: Taman Sejati Suria
TS: Taman Sejati
ZH: Zee Huat Auto Part Trading Sdn Bhd
ZME: Zarine Marine Enterprise
BAW: Big Asia Worldwide Sdn Bhd
KCT: Kok Chang Trading
ABM: Akademi Binaan Malaysia

Routes taken using latitude and longitude and Figure 2 below shows the actual routes that taken by the drivers to collect the wastes. MMC has about seven drivers that move garbage trucks daily to collect waste. Each trucks has three collectors that helps the driver to collect the waste. The selected driver had taken this route to collect waste. There are 18 nodes that the drivers have to pass through. Most of the nodes comprise of residential area.

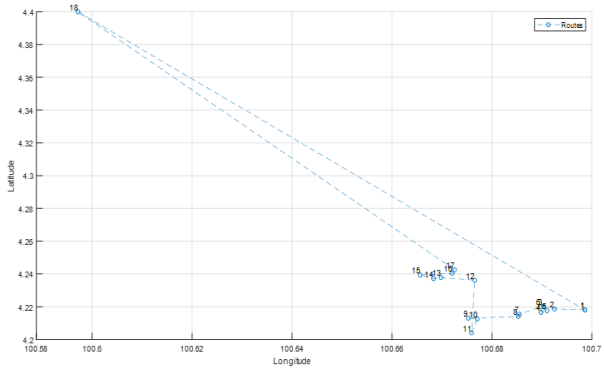

Fig. 2 Actual Routes

For the actual routes, the driver chose this route based on his own analysis and experiences. In this actual route there are several constraint such as the road is too narrow, sometimes there are an obstruction when collecting the wastes that cause the drivers to take longer routes due to this problem. Obviously, the wastes collection in the residential area needs to be collected at least three times a week. There are three major areas that to be pointed out which is the residential area, industrial areas and Segari Landfill.

In the residential area, there are seven nodes that need collection of wastes. The drivers stop at the recycle centre to exchange the recycled wastes that can be sold such as boxes, steel, newspaper and others.

Meanwhile, in the industrial areas, there are six nodes that actual routes need to cover before going to the Segari Landfill. The difference between the residential area and industrial area is the distance to collect the wastes in residential area is much closer compare to in industrial area. The time mostly consumed in the residential area even though the distance in the residential areas is closer to the next nodes because of the units of house in each node is different.

Routes Suggestion by TSP

The suggested routes are computed by TSP that simulates using MATLAB software. Figure 3 shows the graph of routes suggested TSP by distance in kilometers. The optimal path suggest by TSP started by nodes 1, nodes 3, nodes 5, nodes 7, nodes 8, nodes 10, nodes 12, nodes 14, nodes 16, nodes 18, nodes 17, nodes 15, nodes 13, nodes 11, nodes 9, nodes 6, nodes 4, nodes 2 and nodes 1. The total distance travelled suggested by TSP by distance is 91.71 km and shows about 0.33% reducing distances.

The distance calculated does not taking into account the constraint in real world application such as obstruction or narrow routes.

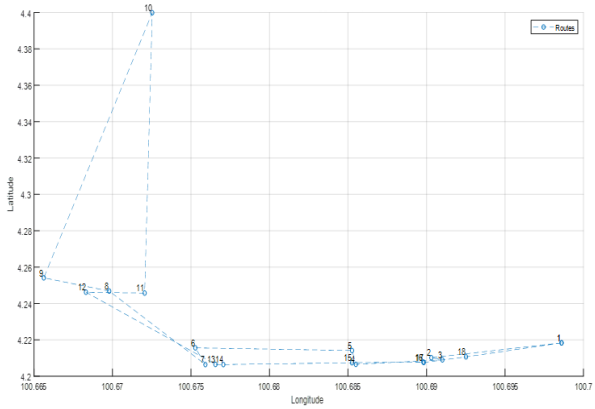

Fig. 3 Optimize the Actual Routes

Table - II below shows the routes suggested by TSP and the distances taken by TSP methods.

Table. 2 Nodes of Suggested Routes

TSP Nodes of Collection	Distances by TSP	Time (minutes)
Nodes 1-3	4.9km	20
Nodes 3-5	1.934km	34
Nodes 5-7	0.8km	32
Nodes 7-8	0km	43
Nodes 8-10	1.8km	15
Nodes 10-12	2.1km	15
Nodes 12-14	6.0km	11
Nodes 14-16	1 km	3
Nodes 16-18	28km	2
Nodes 18-17	27.5km	46
Nodes 17-15	0.1km	17
Nodes 15-13	0.6km	15
Nodes 13-11	6.676km	57
Nodes 11-9	1.9km	15
Nodes 9-6	1.5km	11
Nodes 6-4	1.457km	10
Nodes 4-2	0.450km	27
Nodes 2-1	5.0km	6

In term of comparison between actual data set and TSP data set in distance (km), it can be seen that total travelling time by TSP is lesser compare to actual routes and this will produced 7% (392 minutes) less time to complete all nodes compare with actual routes (420 minutes) Therefore, it can be shown that the TSP Route Distance suggested has higher efficiency in shorter routes. The differences can be seen in the graph above is because of the nodes of waste collection is difference. It can be differentiate in the highest distance states in the graph. In actual distance routes, the point 16, 17 and 18 is the highest because the waste collection at this point is finished and ready to be dump at Segari Landfill. The Landfill is far from the city that is why the distance at this point is at its peak. Besides that, the TSP data set graph is highest at point 9 and 10 because the optimum paths suggested dumping half of the garbage at Segari landfill and collect again after dumping. The wastes will be kept at MMC and being thrown to Segari landfill the next day of collection. This TSP data set path has its flaws where the garbage truck cannot be kept clean in the MMC. This will leads to odor pollution.

V. CONCLUSION AND RECOMENDATION

Resolving GVRP is important in this research and the elements factor of GVRP influencing the research are distance, time, routes, carbon emissions, and fuel consumption (costs). In this research only measure on the new suggested routes and time constraint. The method used is Travelling Salesman Problem (TSP) in order to solve GVRP that associates with waste collection system, that is one of main factor in green transportation and logistic. Actual routes are created from the data collected from Manjung Municipal Council and TSP also suggested optimal path by distance from the actual data set. Result analysis shows that the actual distance and TSP by distance have only slight different and that shows that the distance taken by the drivers is efficient and effective even though the routes suggested is not the same.

It is recommended that the future research should focus more towards waste management system. There is lack of good management in order to develop Segari Landfill more efficiently. Besides that, safety element when entering Segari Landfill is not enough especially to the garbage truck themselves. The truck must drive carefully because of the poor road condition will cause accidents especially during raining time.

Tt is advisable to made further development on the area of wastes system at Segari Landfill.

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