

Optimization Modelling of Parcel Delivery Problem in a Distribution Network

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DOI: <https://doi.org/10.30880/ekst.2024.04.02.009>

Article Info

Received: 27 December 2023

Accepted: 11 January 2024

Available online: 12 December 2024

Keywords

Delivery Optimization, Route Optimization, Optimization Modelling, Travelling Salesman Problem, Dynamic Programming, Genetic Algorithm

Abstract

With the rapid growth in E-commerce in Malaysia as a result of Covid-19, demands for courier services are on the rise. As such, the focus of the study will be placed on route optimization for courier services to enhance the process of parcel deliveries. Particularly in the context of the courier scene in Johor Bahru, Malaysia. The study's objective is to apply genetic algorithms and dynamic programming in finding the optimal delivery path based on distance and time spent, and to compare their performance to solve the Travelling salesman problem.. The scope of the study focuses on modeling parcel delivery paths and handling time between hubs using data collected from Google Maps and analysis conducted using Matlab. Based on the results, Dynamic Programming performs better than Genetic Algorithm as it is able to generate a more efficient route for delivery.

1. Introduction

To transport numerous products, such as goods, messages, and packages, from a sender to recipients in the lowest amount of time, couriers are essential services. Couriers respond to the demands of businesses with individualized alternatives including same-day and weekend delivery, keeping their clients updated with end-to-end tracking, and guaranteeing client satisfaction. Courier services have grown in significance in today's fast-paced economy because they provide value-added services including careful handling, temperature control, and customs clearance, which is an effective way to move goods across different locations.

Retail online shopping is growing rapidly in Southeast Asia and the e-commerce market is expected to reach over 211 billion USD dollars by 2025 [1]. Partly because of Coronavirus-19 (COVID-19) pandemic, Singapore-based e-commerce platforms such as Shopee and Lazada are rapidly getting viral and becoming one of the biggest online shopping platforms in Southeast Asia, especially in Malaysia. This situation brought about a new norm to small and medium enterprises (SME) to digitalize their business which to help them survive in this epidemic [2]. A survey shows that the COVID-19 pandemic has changed online shopping behaviors and has accelerated the shift towards a digital world which also helps world economy to recover [3].

An increase in the use of e-commerce platforms was observed and there is a 23.5% rise in Internet usage during the MCO [4]. A survey conducted by Gwendolyn Lim, a partner at Bain & Co, and shared by The Edge, revealed that 88% of Malaysians are digital consumers, surpassing Indonesia (80%) and Singapore (79%) [5]. These findings emphasize the growing importance of digital technologies and e-commerce in Johor Bahru and Malaysia as a whole. Therefore, our study focuses on Johor Bahru, the capital city of Johor, Malaysia. We aim to examine the impact of digital transformation on the local economy, consumer behavior, and businesses in the region.

Traveling Salesman Problem (TSP) is an illustration of an algorithmic problem that focuses on resource and energy efficiency [6]. The core of TSP is to find the best or shortest optimal route for salesman to pass through every node from starting point and return to stating point once passing through all the nodes [7]. The limitation of TSP is that the progression of the route may only visit every point once.

By optimizing the delivery routes, the fastest and most cost-effective routes can be found and implemented to improve both efficiency and cost, Lazada Express (LEL Express) review has up to 80% of customers that were unsatisfied with their delivery. Some of them complain that the parcel was delayed at least one week, and the parcel was distributed to a random place which is further than their resident area causing the waiting time of the parcel to be longer [8]. With an optimum delivery path, the delivery distance can be optimized, and the delivery time can also be shortened, resulting in a shorter shipment period to satisfy the consumer. Thus, this study aims to investigate the aspects of delivery path, distance travelled, and time spent between parcel hubs throughout the shipment process.

There are 3 objectives addressed in this study. First is to apply dynamic programming and genetic algorithm in finding the optimal delivery path among parcel hubs based on distance and time spent. Hence, the second objective is to optimize the delivery route pattern of TSP based on minimum distance and minimum average time spent. Lastly, the study compared the performance of genetic algorithm and dynamic programming in terms of optimal distance and time spent. This study mainly focuses on modelling of parcel delivery paths and handling time between parcel hubs, which is aimed at finding an optimal delivery path with the shortest distance and the shortest time.

2. Methods

2.1 Data Collection and Data Description

In this study, the data collected from 12 delivery parcel hubs in Johor Bahru include 2 Lazada distribution centers, 5 parcel hubs from both MBE Mail Boxes Etc and Parcel Hub. The distance between all these 12 parcel hubs were then recorded in kilometers (km) and time in minutes. The data for the distance and time travelled were collected with the help of Google Maps. The list of the selected transit hubs is shown in Table 1, and their locations are shown in Figure 1.

Table 1 List of the selected transit hubs

Hub	Name of hub
1.	Lazada Express Malaysia (Johor Bahru Hub)
2.	Lazada Logistic AUS (Mount Austin)
3.	Mail Boxes Etc. Johor Jaya
4.	Mail Boxes Etc. Mount Austin
5.	Mail Boxes Etc. Taman Abad
6.	Mail Boxes Etc.The Mall MidValley Southkey
7.	Mail Boxes Etc. Tun Aminah
8.	Parcelhub Austin Perdana
9.	Parcelhub Bandar Baru Uda
10.	Parcelhub Bandar Dato Onn
11.	Parcelhub Dataran Larkin
12.	Parcelhub Skudai Johor Bahru

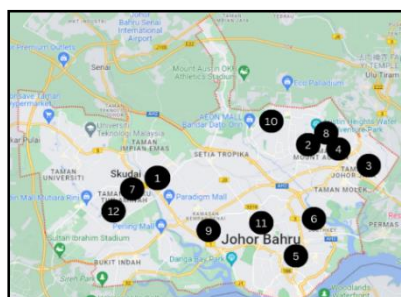


Fig. 1: Location of 12 listed hubs on Google Maps

2.1.1 Data for Delivery Based on Distance and Time

The distance between the hubs is categorized as quantitative data that is used to ascertain the best option for the shortest distance and least amount of time spent, respectively. The minimum distance among all available options was chosen to be used in analysis. As such the shortest distance for each route are considered and recorded in Table 2.

Table 2 Route selected distance between 12 parcel hubs (km)

Hub	1	2	3	4	5	6	7	8	9	10	11	12
1	0	15	18	16	16	16	7.1	16	7	13	12	9
2	15	0	6.1	3.5	13	10	17	3.5	12	6.3	11	19
3	18	6.3	0	2.3	13	10	20	2.7	15	11	12	22
4	18	3.5	4.2	0	12	9.7	20	0.6	15	8	11	21
5	16	9.4	11	9.1	0	4.3	17	9.5	11	13	5	18
6	16	9	11	9	4.6	0	19	9.4	13	13	7	21
7	2.5	17	20	18	16	19	0	18	8	15	13	2.1
8	17	3.2	4.0	2.2	12	9.5	19	0	14	7	11	21
9	8	12	15	13	10	12	8	13	0	17	6	9.6
10	12	6.0	11	9	14	12	18	9	13	0	12	20
11	12	10	12	10	5	6	13	10	6.2	14	0	15
12	4.6	18	21	19	18	21	2.4	19	9.9	18	14	0

In this study, data was collected at two different times, which are 10.00 am and 3.00 pm. to avoid timing that may have heavy traffic congestion, The above timing has been selected to allow for more precise and consistent data gathering. Traffic congestion can cause discrepancy between results. The average time spent between 12 parcel hubs at 10 am are recorded in minutes (min) in Table 3.

Table 3 Average time spent between 12 parcel hubs at 10.00 am (min)

Hub	1	2	3	4	5	6	7	8	9	10	11	12
1	0	29	34	25	23	28	15	27	14	28	24	21
2	32	0	19	10	31	20	30	9	27	13	27	38
3	34	15	0	7	26	19	33	8	27	22	25	40
4	32	10	14	0	26	18	31	3	27	17	23	40
5	29	19	22	14	0	12	23	15	22	26	13	32
6	27	16	20	12	14	0	31	13	27	23	18	36
7	8	27	32	28	27	34	0	24	16	34	23	9
8	34	10	16	9	27	19	31	0	28	23	24	39
9	20	23	33	25	21	27	15	26	0	31	14	22
10	26	14	29	21	29	20	37	19	28	0	27	42
11	26	20	26	16	17	18	17	16	16	30	0	25
12	14	34	38	31	35	41	9	31	23	40	30	0

2.2 Optimization model of TSP

Travelling Salesman Problem (TSP) is a well-known combinatorial problem that aims to determine the shortest and most efficient route to the various cities and return to back to home base. Hence, with the optimal delivery path, the delivery man will be able to follow the route given and compromise to send or pick up the parcel from hub to hub within a short period. Figure 2 shows the route pattern of TSP of this study.

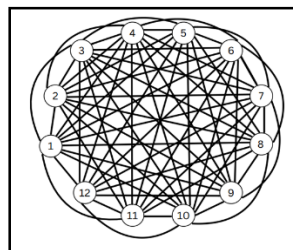


Fig. 2 Network representation of route

Define x_{ij} as the binary decision variable indicating whether the tour includes the edge from city i to city j ; u_{ij} refers to continuous variable representing the position of city i in the tour. The mathematical model and objective function based on distance is introduced below:

$$\begin{aligned} \text{Minimize } Z = & 15x_{12} + 18x_{13} + 16x_{14} + 16x_{15} + 16x_{16} + 7.1x_{17} + 16x_{18} + 7x_{19} + 13x_{110} + 12x_{111} + 9x_{112} \\ & + 15x_{21} + 6.1x_{23} + 3.5x_{24} + 13x_{25} + 10x_{26} + 17x_{27} + 3.5x_{28} + 12x_{29} + 6.3x_{210} + 11x_{211} + 19x_{212} \\ & + 18x_{31} + 6.3x_{32} + 2.3x_{34} + 13x_{35} + 10x_{36} + 20x_{37} + 2.7x_{38} + 15x_{39} + 11x_{310} + 12x_{311} + 22x_{312} \\ & + 18x_{41} + 3.5x_{42} + 4.2x_{43} + 12x_{45} + 9.7x_{46} + 20x_{47} + 0.6x_{48} + 15x_{49} + 8x_{410} + 11x_{411} + 21x_{412} \\ & + 16x_{51} + 9.4x_{52} + 11x_{53} + 9.1x_{54} + 4.3x_{56} + 17x_{57} + 9.5x_{58} + 11x_{59} + 13x_{510} + 5x_{511} + 18x_{512} \\ & + 16x_{61} + 9x_{62} + 11x_{63} + 9x_{64} + 4.6x_{65} + 19x_{67} + 9.4x_{68} + 13x_{69} + 13x_{610} + 7x_{611} + 21x_{612} \\ & + 2.5x_{71} + 17x_{72} + 20x_{73} + 18x_{74} + 16x_{75} + 19x_{76} + 18x_{78} + 8x_{79} + 15x_{710} + 13x_{711} + 2.1x_{712} \\ & + 17x_{81} + 3.2x_{82} + 4x_{83} + 2.2x_{84} + 12x_{85} + 9.5x_{86} + 19x_{87} + 14x_{89} + 7x_{810} + 11x_{811} + 21x_{812} \\ & + 8x_{91} + 12x_{92} + 15x_{93} + 13x_{94} + 10x_{95} + 12x_{96} + 8x_{97} + 13x_{98} + 17x_{910} + 6x_{911} + 9.6x_{912} \\ & + 12x_{1001} + 6x_{1002} + 11x_{1003} + 9x_{1004} + 14x_{1005} + 12x_{1006} + 18x_{1007} + 9x_{1008} + 13x_{1009} + 12x_{1011} + 20x_{1012} \\ & + 12x_{1101} + 10x_{1102} + 12x_{1103} + 10x_{1104} + 5x_{1105} + 6x_{1106} + 13x_{1107} + 10x_{1108} + 6.2x_{1109} + 14x_{1110} + 15x_{1112} \\ & + 4.6x_{1201} + 18x_{1202} + 21x_{1203} + 19x_{1204} + 18x_{1205} + 21x_{1206} + 2.4x_{1207} + 19x_{1208} + 9.9x_{1209} + 18x_{1210} + 14x_{1211} \end{aligned}$$

With reference to Figure 2, this model will be implemented to calculate the most efficient route based on distance and average time spent. The model shows how it will function with distance travelled but will also be used for average time spent based on 10:00 am and 3:00 pm and different data sets.

2.3 Dynamic Programming

In this study, dynamic programming (DP) is used to determine the optimum solution of the path based on shortest distance and shortest time by decomposing the complex problem into a sequence single-variable subproblem. With only one variable, the single task optimization process can be computed more effectively than dealing with multivariable simultaneously. The DP proceeds as follows [9]:

Step 1: Consider the shortest route in the given TSP

Step 2: Define the subproblem, let g be a set of cities, c be the minimum distance or minimum time tour that visits each city in g exactly once, starting and ending at city i .

$$\begin{aligned} g(2, \phi) &= c_{21} \\ g(3, \phi) &= c_{31} \\ g(4, \phi) &= c_{41} \end{aligned}$$

Step 3: Consider sets of 1 element, such that

$$\begin{aligned} \text{Set } \{2\}: & \quad g(3, \{2\}) = c_{32} + g(2, \phi) = c_{32} + c_{21} \\ & \quad g(4, \{2\}) = c_{42} + g(2, \phi) = c_{42} + c_{21} \\ \text{Set } \{3\}: & \quad g(4, \{3\}) = c_{43} + g(3, \phi) = c_{43} + c_{31} \\ & \quad g(2, \{3\}) = c_{23} + g(3, \phi) = c_{23} + c_{31} \\ \text{Set } \{4\}: & \quad g(2, \{4\}) = c_{24} + g(4, \phi) = c_{24} + c_{41} \\ & \quad g(3, \{4\}) = c_{34} + g(4, \phi) = c_{34} + c_{41} \end{aligned}$$

Step 4: Consider sets of 2 elements, such that

$$\begin{aligned} \text{Set } \{2,3\}: & \quad g(4, \{2,3\}) = \min\{c_{42} + g(2, \{3\}), c_{43} + g(3, \{2\})\} \\ \text{Set } \{3,4\}: & \quad g(2, \{3,4\}) = \min\{c_{23} + g(3, \{4\}), c_{24} + g(4, \{3\})\} \\ \text{Set } \{2,4\}: & \quad g(3, \{2,4\}) = \min\{c_{32} + g(2, \{4\}), c_{34} + g(4, \{2\})\} \end{aligned}$$

Step 5: Find the length of an optimal route which is refer to f , such as

$$f = g(1, \{2,3,4\}) = \min\{c_{12} + g(2, \{3,4\}), c_{13} + g(3, \{2,4\}), c_{14} + g(4, \{2,3\})\}$$

Step 6: Optimal TSP route is obtained.

To solve TSP, DP is utilized to break the problem into smaller sub problems. This involves finding the optimal routes for subsets of hub, starting from Hub1. In the TSP, this has to be done through a recurrence relation. The optimal distance route of visiting every set of hubs is the minimum distance of adding each hub to the tour while considering all the possible choices. DP uses memorization to avoid redundant computations. Once all the

problems are solved, the optimal route based on minimum distance or minimum average time spent can be obtained. This process involves backtracking through memorization table to determine the sequence of the hubs in the optimal tour.

2.3.1 Genetic Algorithm

Genetic algorithm (GA) is an adaptive heuristic search algorithm which is used to optimize which includes maximizing or minimizing in a short time. Based on the natural selection that propels biological evolution, it may resolve optimization issues that are both confined and unconstrained. In this study, GA is also one of the methods to solve TSP. Optimization, error minimization, fitness, goal function, initial population, mutation, and crossover operations are the main GA procedure components. Figure 3 shows the general flow chart of GA [10].

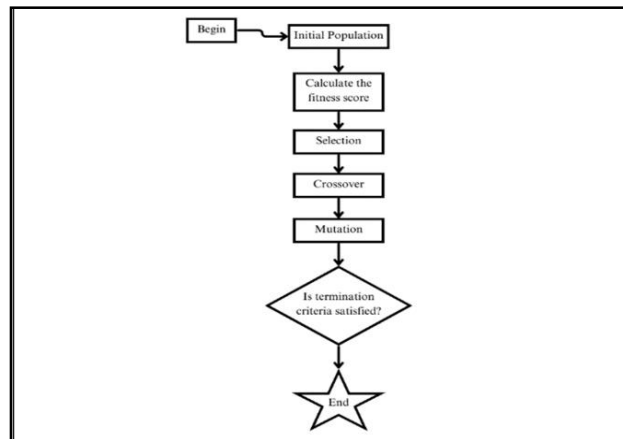


Fig. 3 Research framework

Firstly, the process will begin with a population of random routes where it represents possible routes. Then it will begin with fitness evaluation which will assess the fitness of each route by calculating the total distance travelled with shorter distances corresponding to a higher fitness. GA will then move on to its' selection process which will then choose the route from the population for the next generation with a preference to routes with higher fitness which is similar to the concept of natural selection. After selection, crossover will begin by combining pairs of selected routes to create different combinations. After creating new or different combinations, mutation will begin by introducing small random changes to some routes to maintain diversity whilst exploring different outcomes and possibilities. Replacement will commence to replace old generations whilst determining the best routes and ensuring that promising routes are retained. Termination will happen after replacement which will continue to repeat the steps above for multiple generations until a stopping criterion is met or a satisfactory solution is achieved. The route with the highest fitness in the final generation will be the optimal or closest to optimal solution to the TSP. Matlab will be used as a tool to solve TSP by GA to determine optimum delivery path with shortest distance and minimum time spent.

3. Results and Discussions

3.1 Delivery Route Based on Distance Travelled

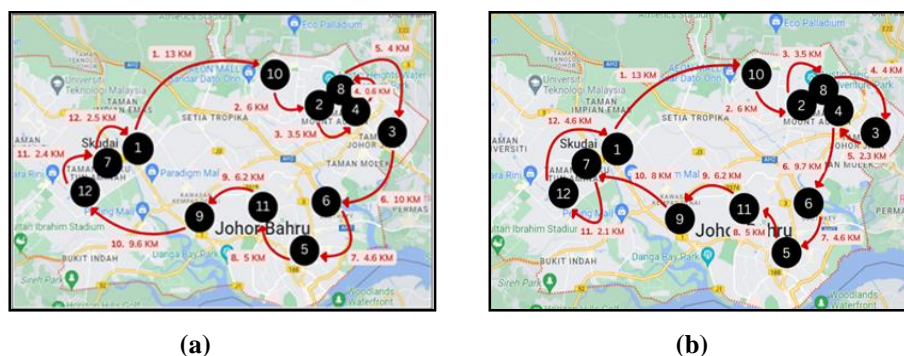


Fig. 4 Delivery Route of 12 parcel hubs based on distance travelled (a) Using DP; (b) Using GA

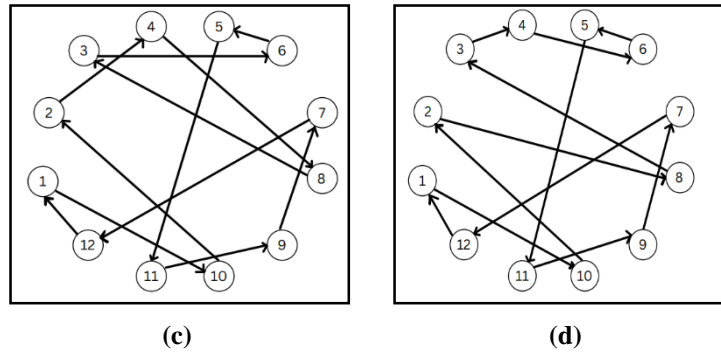


Fig. 5 Delivery Route model based on distance travelled (c) Using DP; (d) Using GA

Based on the outcome depicted in Figure 4(a), the shortest route to deliver parcels was to begin at Lazada Express Malaysia (Johor Bahru Hub) (hub 1) then travelling to Parcelhub Bandar Dato Onn (hub 10) to Lazada Logistic AUS (Mount Austin) (hub 2) to Mail Boxes Etc. Mount Austin (hub 4) to Parcelhub Austin Perdana (hub 8) to Mail Boxes Etc. Johor Jaya (hub 3) to Mail Boxes Etc. The Mall MidValley Southkey (hub 6) to Mail Boxes Etc. Taman Abad (hub 5) to Parcelhub Dataran Larkin (hub 11) to Parcelhub Bandar Baru Uda (hub 9) to Parcelhub Skudai Johor Bahru (hub 12) to Mail Boxes Etc. Tun Aminah (hub 7) and finally return to Lazada Express Malaysia (Johor Bahru Hub) (hub 1). For the delivery sequence utilizing DP, the 12 package hubs covered a total of 67.4 km.

The shortest route to deliver parcels using GA was depicted in Figure 4(b). Beginning at Lazada Express Malaysia (Johor Bahru Hub) (hub 1) then travelling to Parcelhub Bandar Dato Onn (hub 10) to Lazada Logistic AUS (Mount Austin) (hub 2) to Parcelhub Austin Perdana (hub 8) to Mail Boxes Etc. Johor Jaya (hub 3) to Mail Boxes Etc. Mount Austin (hub 4) to Mail Boxes Etc. The Mall MidValley Southkey (hub 6) to Mail Boxes Etc. Taman Abad (hub 5) to Parcelhub Dataran Larkin (hub 11) to Parcelhub Bandar Baru Uda (hub 9) to Mail Boxes Etc. Tun Aminah (hub 7) to Parcelhub Skudai Johor Bahru (hub 12) then finally returning to Lazada Express Malaysia (Johor Bahru Hub) (hub 1). The total distance traveled by the 12 parcel hubs for this delivery sequence was 69 km.

3.2 Delivery Route Based on Average Time Spent At 10:00 Am

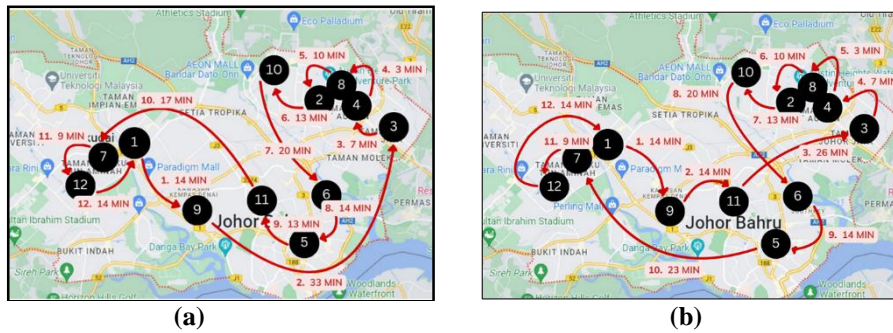


Fig.6 Delivery Route based on time spent at 10:00 am (a) Using DP; (b) Using GA

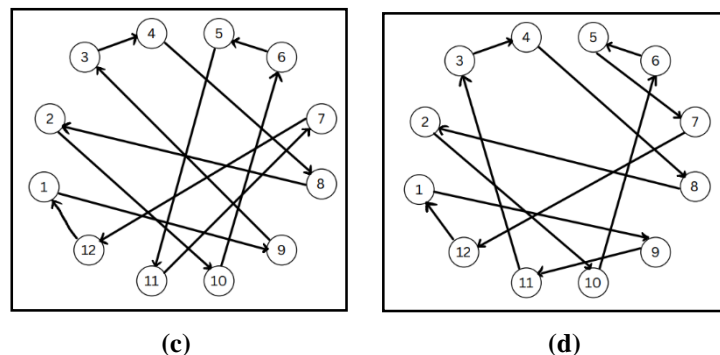


Fig. 7 Delivery Route model based on time spent at 10:00 am (c) Using DP; (d) Using GA

Based on the results, Figure 6(a) showed the quickest route provided by DP to deliver packages at 10:00 am. The shortest route begins from Lazada Express Malaysia (Johor Bahru Hub) (hub 1) to Parcelhub Bandar Baru

Uda (hub 9) to Mail Boxes Etc. Johor Jaya (hub 3) to Mail Boxes Etc. Mount Austin (hub 4) to Parcelhub Austin Perdana (hub 8) to Lazada Logistic AUS (Mount Austin) (hub 2) to Parcelhub Bandar Dato Onn (hub 10) to Mail Boxes Etc.The Mall MidValley Southkey (hub 6) to Mail Boxes Etc. Taman Abad (hub 5) to Parcelhub Dataran Larkin (hub 11) to Mail Boxes Etc. Tun Aminah (hub 7) to Parcelhub Skudai Johor Bahru (hub 12) and then return to Lazada Express Malaysia hub 1. Twelve package hubs spent an average of 167 minutes or 2 hours and 47 minutes during the delivery sequence.

The shortest route to deliver parcels at 10:00 am that was generated from GA was depicted in Figure 6(b). Based on the outcome, beginning at Lazada Express Malaysia (Johor Bahru Hub) (hub 1) to Parcelhub Bandar Baru Uda (hub 9) to Parcelhub Dataran Larkin (hub 11) to Mail Boxes Etc. Johor Jaya (hub 3) to Mail Boxes Etc. Mount Austin (hub 4) to Parcelhub Austin Perdana (hub 8) to Lazada Logistic AUS (Mount Austin) (hub 2) to Parcelhub Bandar Dato Onn (hub 10) to Mail Boxes Etc.The Mall MidValley Southkey (hub 6) to Mail Boxes Etc. Taman Abad (hub 5) to Mail Boxes Etc. Tun Aminah (hub 7) to Parcelhub Skudai Johor Bahru (hub 12) then finally returns to Lazada Express Malaysia (Johor Bahru Hub) (hub 1). The total average time spent at 12 parcel hubs for the delivery sequence was 167 minutes which was equivalent to 2 hours and 47 minutes.

3.3 Delivery Route Based on Average Time Spent At 3:00pm

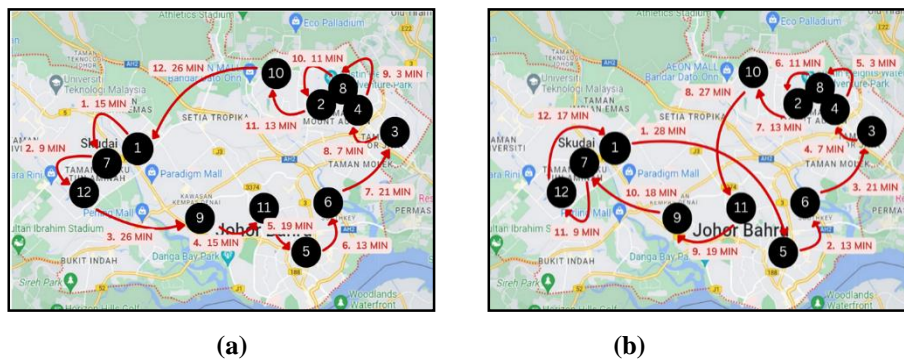


Fig. 8 Delivery Route based on time spent at 3:00 pm (a) Using DP; (b) Using GA

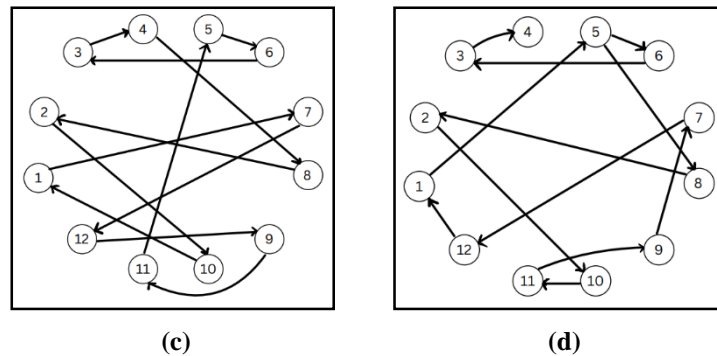


Fig. 9 Delivery Route model based on time spent at 3:00 pm (c) Using DP; (d) Using GA

According to Figure 8(a), the shortest route to deliver the parcels at 3.00 pm using DP starts from Lazada Express Malaysia (Johor Bahru Hub) (hub 1) then travelling to Mail Boxes Etc. Tun Aminah (hub 7) to Parcelhub Skudai Johor Bahru (hub 12) to Parcelhub Bandar Baru Uda (hub 9) to Parcelhub Dataran Larkin (hub 11) to Mail Boxes Etc. Taman Abad (hub 5) to Mail Boxes Etc.The Mall MidValley Southkey (hub 6) to Mail Boxes Etc. Johor Jaya (hub 3) to Mail Boxes Etc. Mount Austin (hub 4) to Parcelhub Austin Perdana (hub 8) to Lazada Logistic AUS (Mount Austin) (hub 2) to Parcelhub Bandar Dato Onn (hub 10) then finally returning to Lazada Express Malaysia (Johor Bahru Hub) (hub 1). The delivery would take an average of 178 minutes which was equivalent to 2 hours and 58 minutes.

Based on Figure 8 (b), it can be observed that the shortest route to delivery parcels at 3.00 pm using GA was illustrated according to the result, started from Lazada Express Malaysia (Johor Bahru Hub) (hub 1) then travelling to Mail Boxes Etc. Taman Abad (hub 5) to Mail Boxes Etc.The Mall MidValley Southkey (hub 6) to Mail Boxes Etc. Johor Jaya (hub 3) to Mail Boxes Etc. Mount Austin (hub 4) to Parcelhub Austin Perdana (hub 8) to Lazada Logistic AUS (Mount Austin) (hub 2) to Parcelhub Bandar Dato Onn (hub 10) to Parcelhub Dataran Larkin (hub 11) to Parcelhub Bandar Baru Uda (hub 9) to Mail Boxes Etc. Tun Aminah (hub 7) to Parcelhub Skudai Johor Bahru (hub

12) to Lazada Express Malaysia (Johor Bahru Hub) (hub 1). The total average time spent at 12 parcel hubs for the delivery sequence was 186 minutes which was equivalent to 3 hours and 6 minutes.

3.4 Comparison and Discussion for Results obtained by using DP and GA

Through the utilization of GA and DP, results were able to be obtained to evaluate the shortest distance travelled and the lowest total average time spent for the entire parcel delivery process in closed loop. Table 4 compares the delivery utilizing two methods based on the distance travelled to each of the 12 hubs. Additionally, a visual comparison based on the distance travelled is shown in Figure 10.

Table 4 Comparison of the Delivery sequence of 12 parcel hubs based on distance travelled using DP and GA

Dynamic Programming			Genetic Algorithm		
Sequence	Hub	Distance (km)	Sequence	Hub	Distance (km)
1.	1	13	1.	1	13
2.	10	6	2.	10	6
3.	2	3.5	3.	2	3.5
4.	4	0.6	4.	8	4
5.	8	4	5.	3	2.3
6.	3	10	6.	4	9.7
7.	6	4.6	7.	6	4.6
8.	5	5	8.	5	5
9.	11	6.2	9.	11	6.2
10.	9	9.6	10.	9	8
11.	12	2.4	11.	7	2.1
12.	7	2.5	12.	12	4.6
13.	1	-	13.	1	-
Total Distance Travelled		67.4	Total Distance Travelled		69

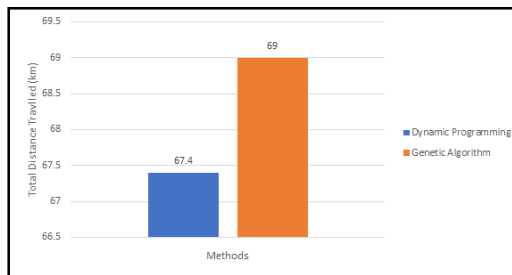


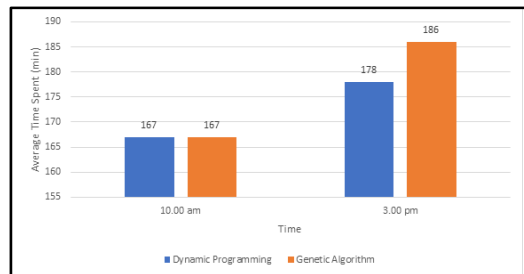
Fig. 10 Comparison on total distance travelled (in km)

The results as presented in Table 4 and Figure 10, made it evident that DP performed marginally better than GA. Specifically, DP was able to produce the result with the least total distance traveled at 67.4km whereas GA yielded a distance traveled of 69km. Thus, the outcomes demonstrated that DP is 2.33% more efficient compared to GA. The recommended route that is generated by DP begins from Lazada Express Malaysia (Johor Bahru Hub) (hub 1) to Parcelhub Bandar Baru Uda (hub 9) to Mail Boxes Etc. Johor Jaya (hub 3) to Mail Boxes Etc. Mount Austin (hub 4) to Parcelhub Austin Perdana (hub 8) to Lazada Logistic AUS (Mount Austin) (hub 2) to Parcelhub Bandar Dato Onn (hub 10) to Mail Boxes Etc. The Mall MidValley Southkey (hub 6) to Mail Boxes Etc. Taman Abad (hub 5) to Parcelhub Dataran Larkin (hub 11) to Mail Boxes Etc. Tun Aminah (hub 7) to Parcelhub Skudai Johor Bahru (hub 12) and then return to Lazada Express Malaysia hub 1.

Subsequently, comparisons of the delivery route based on different average time spent among the 12 hubs are also recorded. The two distinct times that were recorded are 10.00 am and 3.00 pm.

Table 5 Comparison of the Delivery sequence of 12 parcel hubs based on average time spent at 10.00 am and 3.00 pm using DP and GA

Sequence	Dynamic Programming				Sequence	Genetic Algorithm			
	10.00 am		3.00 pm			10.00 am		3.00 pm	
	Hub	Time (min)	Hub	Average time spent (min)		Hub	Average time spent (min)	Hub	Average time spent (min)
1.	1	14	1	15	1.	1	14	1	28
2.	9	33	7	9	2.	9	14	5	13
3.	3	7	12	26	3.	11	26	6	21
4.	4	3	9	15	4.	3	7	3	7
5.	8	10	11	19	5.	4	3	4	3
6.	2	13	5	13	6.	8	10	8	11
7.	10	20	6	21	7.	2	13	2	13
8.	6	14	3	7	8.	10	20	10	27
9.	5	13	4	3	9.	6	14	11	19
10.	11	17	8	11	10.	5	23	9	18
11.	7	9	2	13	11.	7	9	7	9
12.	12	14	10	26	12.	12	14	12	17
13.	1	-	1	-	13.	1	-	1	-
Total Average Time Spent		167		178	Total Average Time Spent		167		186

**Fig. 11** Comprison on average time spent (in minute)

With reference to Table 5 and Figure 11, the results depict that both the performance of DP and GA yielded a total average time spent of 167 minutes on the delivery process at the time frame of 10.00 am. As such, it can be deduced that the efficiency among these two methods is arguably the same or similar. This means that the shortest travel route should be chosen instead as it does not affect the time spent.

Meanwhile, for the time frame of 3.00pm, the results show that DP's performance is better than GA as it can obtain a minimum average time spent of 178 minutes whereas GA's result was 186 minutes. The percentage gap is a difference of 4.49% in favor of DP, this means that DP is much more efficient compared to GA. The shortest delivery route at 3.00pm is to start from Lazada Express Malaysia (Johor Bahru Hub) (hub 1) then travelling to Mail Boxes Etc. Tun Aminah (hub 7) to Parcelhub Skudai Johor Bahru (hub 12) to Parcelhub Bandar Baru Uda (hub 9) to Parcelhub Dataran Larkin (hub 11) to Mail Boxes Etc. Taman Abad (hub 5) to Mail Boxes Etc. The Mall MidValley Southkey (hub 6) to Mail Boxes Etc. Johor Jaya (hub 3) to Mail Boxes Etc. Mount Austin (hub 4) to Parcelhub Austin Perdana (hub 8) to Lazada Logistic AUS (Mount Austin) (hub 2) to Parcelhub Bandar Dato Onn (hub 10) then finally returning to Lazada Express Malaysia (Johor Bahru Hub) (hub 1).

The minimum distance travelled for optimal parcel delivery path was 67.4 km whereas the total average time spent for the optimal delivery route based was 167 minutes which is equivalent to 2 hours and 47 minutes. The delivery path based on time factor suggested courier companies to deliver the goods at 10.00 am as the time needed to travel to every parcel hub is the minimum at that time. This implicitly proved that the traffic congestion level at 10.00 am is Johor Bahru is the lowest.

4. Conclusion

In conclusion, this study has achieved all the research objectives by obtaining different delivery paths based on optimal distance and time spent with 2 different methods which are GA and DP. The delivery routes generated for minimum distance travelled and total average time spent were different. Courier companies can choose the most

suitable delivery path based on their needs and priorities to improve the current operation system. Hence, system failures such that causing large volume of parcel stuck in transit hub can be overcome. Delivery route based on distance travelled can reduce the transportation cost which refers to the expenses of fuel, lodging et cetera. On the other hand, customer satisfaction can also be achieved by shorter shipment period of parcel delivery. In a nutshell, this study enables courier company to optimize their routing through the usage of both GA and DP. With DP established as the superior method to derive the most optimal and efficient delivery path based on both factors of distance and time. The significance of route optimization is extremely crucial as it can not only affect delivery cost and also customer satisfaction in the long run.

Acknowledgement

The authors would thank the Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Yee Kee Man, Mahathir Bin Mohamad; **data collection:** Yee Kee Man; **analysis and interpretation of results:** Yee Kee Man, Mahathir Bin Mohamad; **draft manuscript preparation:** Yee Kee Man. All authors reviewed the results and approved the final version of the manuscript.

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