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OPTIMISING COURIER DELIVERY ROUTES AND TIME TRAVEL USING DIJKSTRA'S ALGORITHM TO FIND THE SHORTEST PATH

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Abstract

This project seeks to find the shortest path and minimum travel time courier delivery by using Dijkstra's Algorithm in Lukut, Port Dickson. Efficient route planning has become more relevant because of the rising demand for fast delivery services due to the growth of e-commerce. This research aims to enhance delivery performance by identifying the shortest path between multiple delivery locations using graph theory. The records of the distance and travel time to nine delivery points were obtained using Google Maps. Nodes are the assumed location of these places, and the edges between locations are the roads with weight in the form of time and distance. Dijkstra's Algorithm was applied in Microsoft Excel to determine the fastest route between Parcelhub, Lukut and the Tasik Villa International Resort Port Dickson. It was found out that the application of this algorithm would assist in reducing delivery time and making the route efficient. The technique cuts down on the amount of fuel used, delays in delivery and the cost of operation. Its outcomes indicate that although only a small area is studied and a set of static data is used, it shows strong potential for practical use in real-life courier services. This project proves that mathematical tools like Dijkstra's Algorithm can help solve real-world logistics problems by providing faster and more reliable delivery routes, improving service quality and customer satisfaction.

Keywords: Dijkstra's Algorithm, shortest path, courier delivery, route optimisations, graph theory

1. Introduction

In recent years, the courier delivery industry has experienced a significant transformation by adopting modern technology to enhance service efficiency. The surge in e-commerce has driven the need for faster, more reliable delivery systems. Companies such as Pos Laju, GD Express, Ninja Van, and J&T Express have responded by optimising their logistics strategies, particularly through route optimisation. Efficient delivery route planning minimises operational costs and improves customer satisfaction. This study focuses on implementing Dijkstra's Algorithm to optimise courier delivery routes in Lukut, Port Dickson, a key area affected by delivery congestion. Dijkstra's Algorithm is a reliable shortest path method in graph theory, offering accurate route decisions by analysing nodes, edges, and associated weights such as time and distance. The use of this algorithm in courier delivery services helps address delivery delays, fuel consumption, and overall logistics cost, thus demonstrating its value in real-world applications.

2. Literature Review

Route optimisation has been approached using a variety of algorithms. Genetic Algorithms (GAs) are commonly used for their ability to explore complex search spaces efficiently, particularly when hybridised with other metaheuristics (Katoch et al., 2021). Ant Colony Optimisation (ACO), inspired by the foraging behaviour of ants, has effectively solved vehicle routing problems and search and rescue scenarios (Morin et al., 2023). The A* Algorithm, combining Dijkstra's method with heuristic functions, provides efficient pathfinding in dynamic environments (Suryadibrata et al., 2019). Bellman-Ford Algorithm supports negative weights and fuzzy logic in decision-making for uncertain networks (Parimala et al., 2021). However, among all of them, Dijkstra's Algorithm stands out for its accuracy and performance in static and non-negative weighted graphs, making it ideal for fixed delivery networks (AlShaikh et al., 2019). Several studies confirm its superiority in route planning, with improvements focusing on multi-objective optimisation, energy efficiency, and dynamic rerouting.

3. Methodology

This study used a three-phase methodology to evaluate and determine the shortest route with minimal travel time in Lukut, Port Dickson. Figure 1 presents the structured process used in this research.

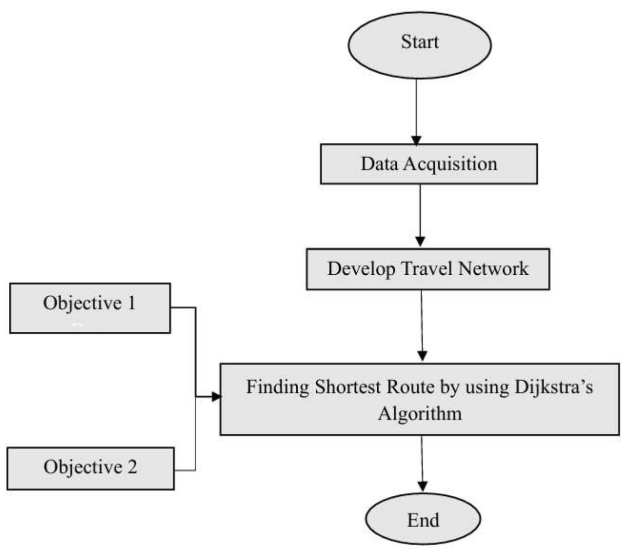

Figure 1: The structured process used in this study

The first phase involved data acquisition from Google Maps, which provided real-time data including distance and time between delivery locations. In Figure 2, the selected delivery points included Parcelhub Lukut, Tasik Villa International Resort, and seven other key sites within a 1.5 km radius of Parcelhub Lukut.

Figure 2: Nine places in Lukut for the delivery van to stop. (source: Google Maps)

In Phase Two, Figure 3 and Figure 4 show the travel network developed using nodes (delivery points) and edges (routes), with each edge assigned a weight representing time or distance.

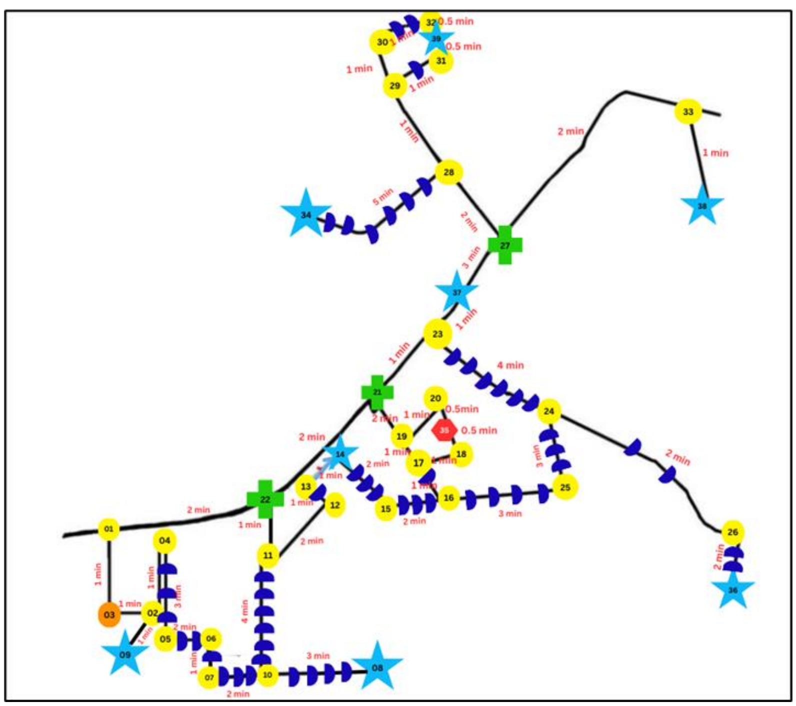

Figure 3: The complete sample travel network with time travel in minutes

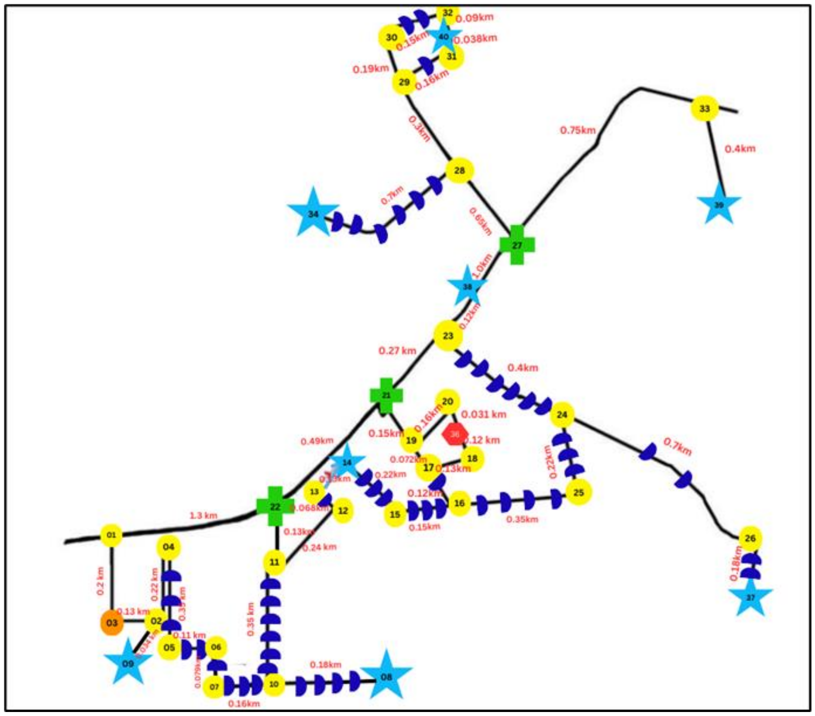

Figure 4: The complete sample travel network with distance travel in kilometres

Phase Three involved applying Dijkstra's Algorithm through Manual Calculation and Microsoft Excel, which allowed visualisation of travel networks and shortest path computation. The algorithm was manually applied in a preliminary study and later validated using Excel Solver for practical implementation. Time penalties were included for traffic lights, junctions, and road conditions to improve the realism of travel time estimation.

4. Equation

Seeta (2021) said that Dijkstra's algorithm works through a series of steps where a labelling process is carried out at each iteration. During this process, each node V is assigned a label representing the shortest path length from the starting node s to V, considering only nodes already included in a designated set. At each iteration, the algorithm selects the node with the smallest label that is not in the set and adds it to the set. This process ensures that the shortest path is obtained. Each node is assigned with Permanent Label (PL), which represents the finalised shortest path length or Temporary Label (TL), which is the neighbour of the currently selected node.

The equation to find the shortest time is:

$$(s, j) = \min(L'_j, L_j + L_{kj}) \tag{1}$$

where,

s = Initial node

L'_j = The value of time travel from the initial node to node j

L_j = Total current minimum time travel

L_{kj} = The time travel from node k to node j

5. Results and Discussion

Table 1 presents the summarised results of the whole study. The "Places" column shows the sequence of delivery points, such as starting from Parcelhub Lukut and ending at Tasik Villa International Resort Port Dickson. The "Route" column shows the specific sequence of nodes, which are identified as the shortest path by the Dijkstra Algorithm. The "Minimum Distance" and "Minimum Time" columns represent the total length and travel duration for each path, respectively. For example, the route from Parcelhub Lukut to Pejabat Pendidikan Daerah Port Dickson has a minimum distance of 2.881 km and requires 17.5 minutes of travel time by using the shortest path, which is the node sequence 35-20-19-21-23-37-27-33-38. This process is consistently applied to each delivery point, ensuring a continuous and optimised route across all delivery locations.

The cumulative result, as presented in the final row of the table, indicates that the total optimised distance for the complete delivery operation is 14.048 km, while the total estimated travel time is 109 minutes. These results show the effectiveness of Dijkstra's Algorithm in significantly reducing delivery route length and time, thus fulfilling the objectives of this study, which are to find the travel network, minimum time and minimum distance across all delivery locations to optimise courier delivery operations.

Table 1: The summarised results of the whole study

Places	Route	Minimum distance (km)	Minimum time (min)
Parcelhub Lukut to Pejabat Pendidikan Daerah Port Dickson.	35-20-19-21-23-37-27-33-38	2.881	17.5
Pejabat Pendidikan Daerah Port Dickson to Atlas Edible Ice Sdn Bhd.	38-33-27-28-29-31-39	2.298	11.5
Atlas Edible Ice Sdn Bhd to Taman Wawasan.	39-31-29-28-34	1.198	9.5
Taman Wawasan to Lukut Police Station.	34-28-27-37	2.35	12.5
Lukut Police Station to AJL Trading.	37-23-24-26-36	1.4	11
AJL Trading to CIMB Bank Lukut	36-26-24-25-16-15-14	1.82	17

CIMB Bank Lukut to SJK(C) Chung Hua.	14-13-12-11-10-08	0.968	13.5
SJK(C) Chng Hua to Tasik Villa International Resort Port Dickson.	08-10-07-06-05-04-02-09	1.133	16.5
TOTAL		14.048	109

6. Conclusion and Recommendations

This study concludes that Dijkstra's Algorithm is an effective solution for optimising courier delivery routes and minimising travel time. The implementation in Lukut, Port Dickson, demonstrates how mathematical algorithms can provide actionable insights into logistics operations. Future research should consider real-time traffic integration and dynamic route adjustments to enhance the system's adaptability. Additionally, expanding the study to cover larger geographic areas and using real-time delivery data can further validate the algorithm's scalability and effectiveness.

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