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Optimization Of Delivery Routes Using The Bellman-Ford Algorithm (A Study Of A Shipping Company)

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Abstract

This study focuses on enhancing the delivery routes for a logistics firm, a courier and logistics service provider, which is undergoing rapid expansion in Indonesia. The substantial rise in delivery volume has presented numerous challenges, particularly regarding route efficiency. Inefficient routes result in time wastage, increased operational expenses, and reduced client satisfaction due to delivery delays.

This research employs the Bellman-Ford Algorithm, recognized for its capacity to handle graphs with negative weights and efficiently determine the shortest paths. This algorithm was selected for its ability to provide precise solutions in complex scenarios, such as within the vast and dynamic delivery network of the logistics firm. This method is implemented through the creation of a web-based application designed to optimize delivery routes in real-time.

The application is expected to reduce both time and delivery expenses while simultaneously enhancing customer satisfaction through the timely arrival of items. This research significantly advances the disciplines of logistics and information technology by presenting a novel strategy for resolving operational issues in the courier sector. This study provides practical insights for the logistics industry while also contributing to the scholarly literature on delivery route optimization.

Keywords : *Delivery Routes, Bellman-Ford Algorithm, Operational Efficiency, Parcel Delivery, PT. SiCepat Ekspres, Web-Based Application*

INTRODUCTION

A logistics company has observed a substantial rise in delivery volume in recent years. The increase in delivery volume poses difficulties in optimising delivery routes. Inefficient routes can result in wasted time, expenses, and fuel, as well as diminished customer satisfaction. (Harahap, R. E. P., & Husein, 2024)

Inefficient routes can lead to delivery delays and reduced client satisfaction. The expenses for fuel, vehicle maintenance, and courier compensation will increase. Couriers waste time and resources due to their inability to determine whether items can be delivered concurrently to the exact location. This leads to couriers repeatedly returning to the same places after attending to other sites, thus affecting the efficiency and efficacy of delivery.

The author will employ the Bellman-Ford Algorithm to optimise the routes. (Nair, R. R., Babu, T., Ramasamy, G., Reddy, A. S., Charan, K. S. R., Sai, N., & Yuan, 2024; Septiani, R., Joefrie, Y. Y., Ardiansyah, R., Pratama, S. A., & Laila, 2025). This technique closely resembles

Dijkstra's technique but is capable of accommodating negative weights in the search for the shortest path within a weighted graph. The Bellman-Ford Algorithm is an enhancement of Dijkstra's Algorithm and produces accurate results alone if the graph lacks a negative-weight cycle that is reachable from the source. (Adventa et al., 2023) assert that the Bellman-Ford Algorithm is a pathfinding algorithm employed to determine the shortest path. It has consistently demonstrated the ability to identify the shortest path; however, this may require a significant amount of time to accomplish.

The Bellman-Ford Algorithm is utilised to determine the shortest path in a network. Its utilisation can aid couriers in identifying optimal routes between warehouses and destination addresses. (Sholikah, 2024) Optimised routes can reduce time and shipping expenses, while prompt deliveries can improve customer satisfaction. The author has a profound interest in optimization and logistics technology and is eager to investigate a rapidly expanding logistics firm. The substantial rise in delivery volume in recent years poses considerable issues in optimising delivery routes. Inefficient routes result in wasted time, expenses, and fuel, as well as diminished customer satisfaction.

Route Optimization

Optimisation derives from the term "optimal," signifying best, highest, or most advantageous. In a specific context, optimisation denotes acts or activities directed towards enhancement and refinement. Optimization is the systematic execution of strategic programs aimed at achieving objectives and improving performance (Sahu & Tripathy, 2025; Sari & Handayani, 2024).

The Oxford English Dictionary defines a route as the distance that needs to be traversed. A route denotes the distance or direction traversed between two locations within a specified time interval.

Route optimisation involves identifying the most advantageous approach to multiple locations, considering factors such as distance, travel time, cost, and efficiency. This notion is essential in multiple domains, including logistics, transportation, and supply chain management.

Bellman-Ford Algorithm

Afivah & Meira Perma Dewi, (2025) state, "Richard Bellman and Lester Ford Jr developed this algorithm." It closely resembles Dijkstra's Algorithm, although it accommodates negative weights for determining the shortest path in a weighted graph. The Bellman-Ford Algorithm is valid only if the graph is devoid of a reachable negative-weight cycle from the source. The algorithm's fundamental steps are as follows:

1. Identify the Source Vertex and enumerate all vertices and edges.
2. Set the distance value of the source vertex to 0, while assigning infinite values to all other vertices.

3. Commence the iteration through all vertices adjacent to the source vertex, utilising the subsequent formula:

   U = Origin Vertex

   V = Destination Vertex

   UV = Edge linking U and V

   If the distance to V is less than the distance to U plus the weight of UV, then revise the distance to V to be the distance to U plus the weight of UV. Persist with this procedure until every Vertex has been examined.

Application in Shipping Goods

Utilising the Bellman-Ford Algorithm to enhance shipping routes enables logistics firms to identify optimal pathways between warehouses and destinations. This algorithm enables organisations to decrease delivery times and operational expenses while enhancing efficiency in fleet management. (Singh et al., 2024)

The Importance of Route Optimization

Route optimisation affects both cost efficiency and client satisfaction. Timely and prompt deliveries can elevate a company's reputation and cultivate client loyalty. In a competitive sector, the capacity to optimise distribution routes is crucial for success. (Timofeeva et al., 2023)

The author seeks to provide a definitive solution to the issue by employing the Bellman-Ford Algorithm, which has demonstrated efficacy in identifying the shortest path, even in the presence of negative weights in the graph. The author opted to create a web-based application that employs this algorithm to assist enterprises in controlling and optimizing shipping routes in real-time, thereby improving operational efficiency and customer satisfaction. This research advances academic knowledge in logistics and information technology, while providing practical benefits to a logistics company in overcoming its operational challenges.

METHOD

Methodology of Research

This research method employs both qualitative and quantitative approaches to evaluate the effectiveness of delivery routes for a rapidly expanding logistics firm in Indonesia. The investigation begins with the aggregation of data related to delivery volume, journey duration, and operating expenses associated with the existing delivery routes. This data will be examined to discern prevailing patterns and problems. The research subsequently employs the Bellman-Ford Algorithm to determine the shortest paths in the intricate delivery network, taking into account the possibility of negative weights that could influence the results.

System Development Methodology

The system development methodology employs an Agile approach, facilitating quick iterations and ongoing input throughout the web application development process. The initial step involves designing and developing a prototype

application that utilizes the Bellman-Ford Algorithm to optimize delivery routes in real-time. Upon completion of the prototype, testing will be performed to verify the algorithm's accuracy and efficiency in practical applications. This experiment will engage users from the logistics company to obtain essential feedback and enhance the system according to their requirements. This strategy aims to deliver effective solutions that enhance operational efficiency and customer satisfaction.

RESULT AND DISCUSSION

System Analysis and Design

a) Analysis of the running system process

This is the system process flow utilised by a shipping company. The current tuition payment business procedure:

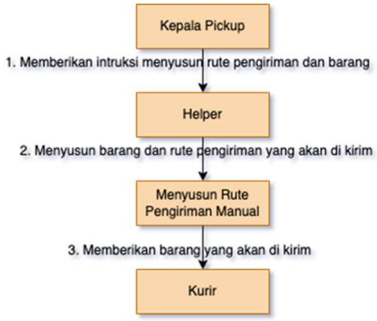

Figure 1. Analysis of the running system process

b) Analysis of the Implementation of the Bellman-Ford Algorithm

Analysis of Proposed System Process Utilising the Bellman-Ford Algorithm

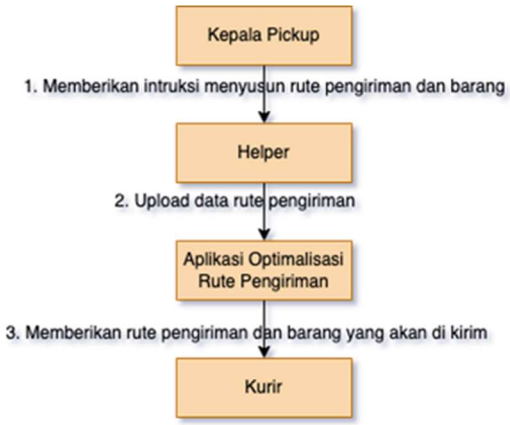

Figure 2. Analysis of the Implementation of the Bellman-Ford Algorithm

c) Use Case Diagram

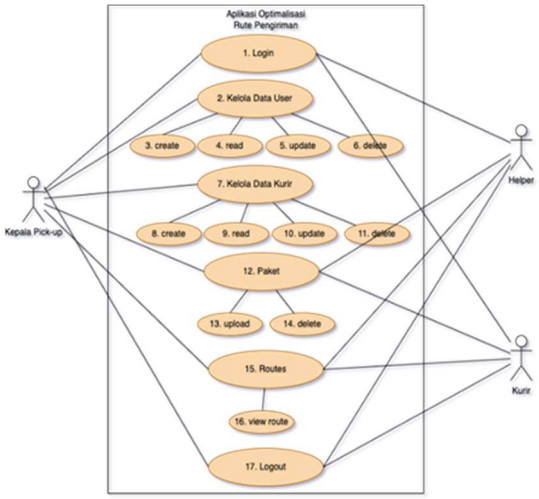

Figure 3. Use Case Diagram

d) Actor Summary

Table 1. Actor Summary

No	Actor	Description
1	Pick-up Head	Operate the application and have access to all features to optimize the delivery of goods.
2	Helper, Courier	Operate the application and have access to package and routes features.

e) Narrative Use Case Login

Table 2. Narrative Use Case Login

Use Case No. 1	
Use Case Name	Login
Description	For admin to enter the application
Actor	Pickup Head, Helper, Courier
Pre-Condition	Login page on the application
Post-Condition	Entering the main page of the application
Basic Flow	
Actor	System
1. Open the application	
	2. Display the login page
3. Enter your username and password a. Select the login button	

	4. Checking data in the database
	a. If correct, it will display the main page

f) Activity diagram

Activity diagrams encompass details regarding the procedural aspects of an activity and the resultant actions derived from it. Activity diagrams comprise:

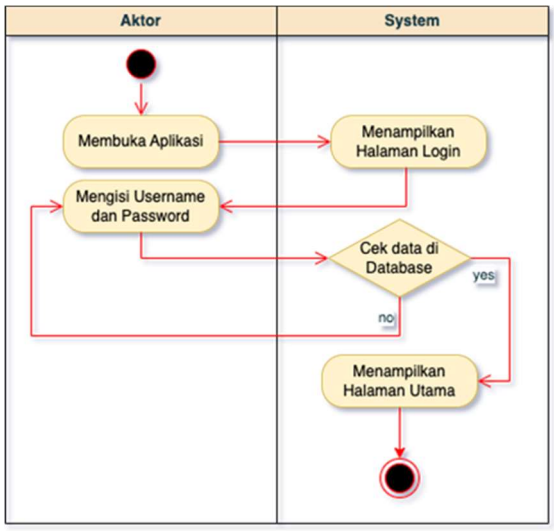

Figure 4. Activity diagram

System Design

a) Class Diagram

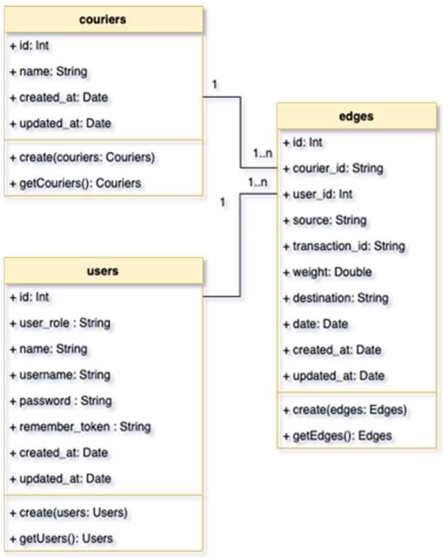

Figure 5. Class Diagram

b) Table Structure Design

Table 3. Table Structure Design

users				
No	Nama	Type	Size	Keterangan
1	id	BIGINT	25	Primary Key
2	name	VARCHAR	25	
3	user_role	VARCHAR	50	
4	username	VARCHAR	25	
6	password	VARCHAR	25	
7	remember_token	VARCHAR	50	
8	created_at	DATE	50	
9	updated_at	DATE	50	

c) Interface Design

Figure 6. Interface Design

System Implementation

The system implementation phase involves detailing an application system to ensure its readiness for operation.

Figure 7. Login Page View

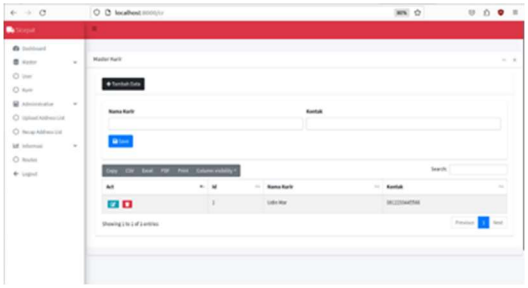

Figure 8. Home Page/Dashboard View

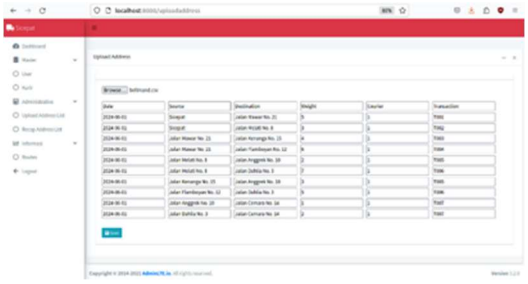

Figure 9. Address List Upload Page Display

CONCLUSION

The study reaches several conclusions. First, even when the graph has negative weights, the Bellman-Ford algorithm still determines the shortest paths. PT Sicepat Expres can find more effective routes between warehouses and delivery places by putting this algorithm into practice.

Second, PT Sicepat Expres can reduce delivery time and expenses by utilizing the Bellman-Ford algorithm. By enabling quicker, more efficient deliveries, this enhancement increases client satisfaction. By identifying packages that may be delivered to the exact location at the same time, the system helps couriers save time and money.

Additionally, this study advances our understanding of information technology and logistics while helping PT Sicepat Expres overcome its operational obstacles.

Several suggestions emerge for future scholars. To assess and optimize shipping routes, PT Sicepat Expres should continue using historical delivery route data. Continuous data analysis will help modify and enhance delivery tactics.

The business should also regularly monitor and assess the information systems and algorithms in place. These assessments will provide the information needed to implement the required modifications, ensuring the system continuously delivers the best outcomes in line with the business's demands.

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