



Enhancing Customer Satisfaction with Delivery Slot Selection and Route Optimization

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Abstract: The growth of the e-commerce industry along with additional last-mile delivery service options has created the need for enhanced logistics systems that can meet the needs of customers more efficiently than they are being met now. The fixed timeframes for delivery established by the majority of courier services have resulted in a reduction of successful deliveries for many customers. This research describes an artificial intelligence (AI) system that provides Time-Slot Selection and Route Optimization which provide a higher level of service to users trying to have their deliveries completed at the optimal time. Customers using a mobile application would be able to choose the timing of their delivery and the back-end of the system would provide options to route drivers based on distance, loading balance using the round robin method for groupings of deliveries or allocating deliveries to drivers based on distance travelled to each delivery point. The Haversine Formula is used to measure distance travelled. Finite State Machines will allow verification of the workflow processes while providing for secure authentication of any user requesting data or information from this service. Through this research, it was found that driver productivity increased due to improved travel routes, while distribution of workload was more evenly distributed among those working in the last mile logistics sector. This system provides last mile logistics operations with an opportunity to utilise lightweight AI technologies to provide courier companies and e-commerce businesses with new last mile delivery systems.

Keywords: Time Slot Selection, Route Optimization, Last-Mile Delivery, Haversine Algorithm, Delivery Slot Prediction, Driver Assignment, Mobile Application, Workflow Automation.

1 Introduction

Customers expect e-commerce delivery services to deliver fast and reliable packages because their overall satisfaction with online shopping depends on these services. Customers using traditional courier services face restrictions because

they can only choose from pre-established delivery times which determine when their packages will arrive. The delivery service's rigid schedule prevents customers from receiving their packages on time because they must make multiple delivery attempts which results in higher delivery expenses and creates problems with the e-commerce platform and courier and customer. The solution to these issues requires an intelligent system which enables customers to choose the best delivery time while it improves operational efficiency for the courier company. The Time Slot Selection and Route Optimization System combines a web-based delivery management system with artificial intelligence (AI) algorithms which enable customers to choose their delivery time and receive current order status updates and use a WhatsApp Chatbot to track their package delivery. The courier companies achieve resource optimization through improved route efficiency which results from scheduled driver assignments and confirmed workflow processes that enhance service dependability. The paper presents a comprehensive overview of the delivery management system which includes all system components and operational algorithms and the methods used to calculate distances through the Haversine formula. The system allows us to group geographic locations while we manage driver assignments and we keep track of all system operations.

2 Literature Review

C Papară., 2024, their paper presents a mathematical model to improve logistics scheduling and resource allocation by addressing the Interval Scheduling Problem. The system includes actual working time restrictions together with team member scheduling limitations. The system aims to improve operational efficiency while reducing costs for transportation networks.

L Van der Hagen., 2025, their paper describes the difficulties which online grocery delivery services face during home delivery operations. The study identifies two main delivery problems which include low profit margins and high costs that businesses face during their last mile delivery operations. The text emphasizes that customers should be given the ability to select their preferred delivery time slots. The system helps to decrease delivery failures while providing customers with easier access to their packages.

S Raghavan, R Zhang., 2024, the paper introduces the "Driver-Aide Problem" and presents a branch-cut-and-price method to enhance last-mile delivery routes through driver-aide implementation. The approach achieves significant delivery time and operational cost reductions which occur most effectively during peak service times when trucks operate at higher speeds.

L Van Der Hagen, N Agatz et al., 2024, their paper studies how machine learning evaluates the feasibility of customer delivery time slots at online grocery stores. The research presents a framework which enables better decision-making for time slot

management. The study shows that machine learning can do better than traditional rules in large-scale routing issues.

N Elsokkary et al., 2023, their research introduces a technique that enhances crowdsourced last mile delivery through worker selection based on three criteria which include delivery costs and delivery times and service performance. The system employs a Genetic Algorithm to enhance task distribution which results in complete task distribution and increases task completion certainty by 21.1%.

J P Vásconez et al., 2024, the research presents an advanced delivery system which utilizes machine learning techniques through linear regression and polynomial regression methods together with the Hungarian algorithm to enhance delivery worker task distribution efficiency by reducing distance and time estimation errors.

W Mao et al., 2025, the researchers investigate the delivery performance impact on customer decisions to repeat orders from on-demand meal delivery services. The research shows that late deliveries lead to a significant decrease in future customer orders. The research shows that early deliveries provide customers with only small benefits. The study shows that platforms need to decrease their late delivery times because it will help them enhance customer satisfaction which leads to customer retention.

Papară, Cezar., 2024, the researchers study ways to enhance wide-area transportation systems in their research. The study examines two routing problems which are the Traveling Salesman Problem and the Vehicle Routing Problem. The research compares different greedy algorithms and demonstrates that the new application achieves superior performance through its use of real road distances for route planning.

E Yunardi et al., 2024, the researchers developed a Geographic Information System (GIS) system which enables East Jakarta importers and exporters to locate their nearest sea freight expedition services through Haversine Formula calculations. The system aims to improve operational effectiveness by providing accurate service location data which decreases the time needed for users to find services.

H Naganawa et al., 2024, the study introduces a novel framework that enables optimization of both logistics hubs and their corresponding routes through the Physical Internet system. The system addresses problems which include both labor shortages and operational delays. The model achieves two goals through its implementation which includes operational efficiency improvements and CO₂ emissions reductions of 54%. The system delivers efficient solutions for both shared logistics spaces and effective transportation system management.

D D Singh et al., 2023, this paper, we introduce the FairAssign framework for dynamic assignment of gig delivery drivers to zones. It makes sure that income distribution is fairly distributed. It addresses income volatility through a random fairness mechanism.

It will allow similar drivers to earn similarly, while minimizing travel expense costs. Extensive experiments show that it outperforms the classic heuristics.

3 System Description

3.1 System Architecture

User Interface Layer: This layer provides the means for users to communicate with the system. Customers use a WhatsApp chatbot interface to select a preferred delivery time quickly. Courier partners use a simple dashboard to know the routes assigned to them and update the status of their packages. Administrators manage the overall delivery operations through an online web portal that provides them with access to all customer-delivery time slots and all orders, along with optimized routes for the delivery and order tracking purposes. This layer provides an intuitive and user-friendly way for all users to communicate with each other. of injection attacks.

Operational & Processing Layer: It is responsible for the workflow, application logic. It also takes care of the validation for incoming orders and saves the time slot which user selects. It also handles the entire delivery process from pending orders to getting delivered/fail status, and additionally makes sure the appropriate status updates are applied and interconnecting all of the modules so that application runs smoothly.

Intelligent Route Optimization Layer: The objective of this layer is to find the most efficient delivery route for each package. It calculates the distance between each location being delivered to create the most organized route possible; groups deliveries that are close to each other; organizes the order in which deliveries will occur; assigns drivers to a route based on fairness; and reduces the time that drivers spend travelling, using fuel, and delaying delivery.

Database & Storage Layer: The Database & Storage Layer stores all data that is of value to the system. Data stored in this layer is organized, secure, and available to all users of the system.

The high-level architecture of the proposed system is illustrated in Fig. 1.

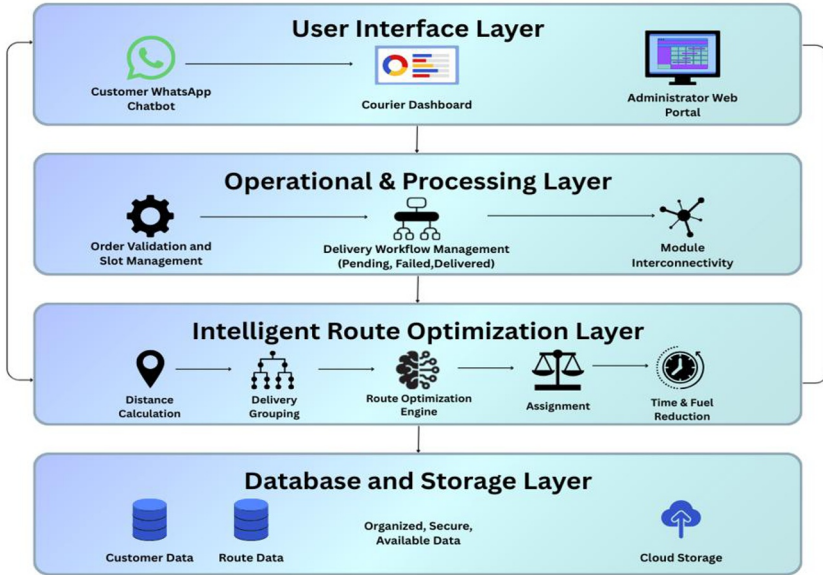


Fig.1. System Architecture

3.2 Data Flow:

The time slot selection and route optimization system gets data every time the courier partner sends order information. This order information includes the customers name, address and phone number and also the parcel details. The system saves this order information. Automatically turns on the customers WhatsApp chatbot. The WhatsApp chatbot sends a message to the customer asking them to choose a delivery date and time that they like. Once the customer picks a delivery date and time the system gets this information. Confirms the time slot that the customer chose. The next thing that the administration does is look at the order in the administration dashboard. When the administrator starts the optimization process the system gets all the order information from the database. Sends it to the route optimization system that uses artificial intelligence. The route optimization system looks at this information. Calculates how far it is between all the places that need to get deliveries. It groups orders that're close to each other figures out the best order for delivering these groups and decides on the best route for the delivery personnel to take. Finally the system saves the route in the database. When courier partners log in to their portal they see a list of the routes that they need to take for their deliveries. The courier partners can then use the route optimization system to help them deliver the customers parcels, on the selected delivery date and time. The system helps the courier partners by giving them the route to follow for the time slot selected by the customer. The movement of information between users and the backend is shown in Fig. 2.

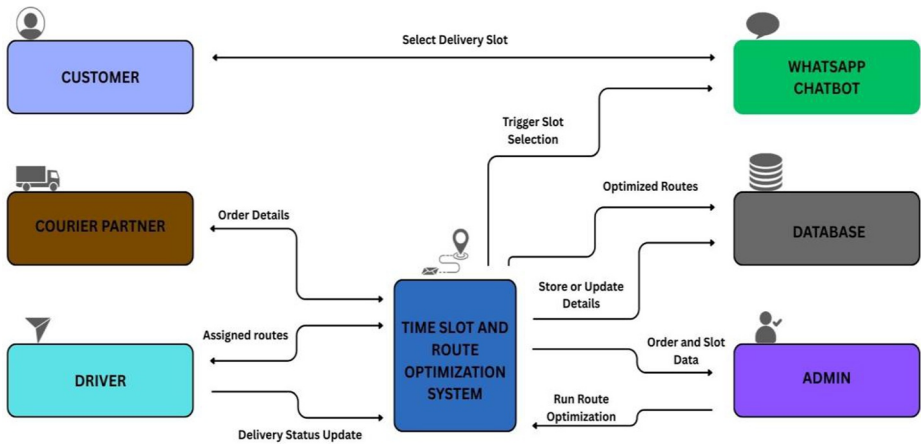


Fig.2. Data Flow

3.3 Model Description

1. Haversine Distance Model

This model calculates the distance between two GPS points (latitude and longitude). It helps estimate how far each delivery location is from others, which is essential for route planning. The model assumes Earth is spherical and gives a very accurate great-circle distance.

Formula:

$$d = 2R \cdot \arcsin \left(\sqrt{\sin^2\left(\frac{\Delta\varphi}{2}\right) + \cos(\varphi_1)\cos(\varphi_2)\sin^2\left(\frac{\Delta\lambda}{2}\right)} \right)$$

Where:

- $R = 6371\text{km}$ (Earth radius)
- φ = latitude
- λ = longitude
- d = distance

2. Pincode-Based Grouping Model

This model groups delivery orders based on their pincode. It reduces the initial complexity by clustering nearby locations into the same group. It uses a simple key-based classification.

Formula (Grouping Logic):

$$\text{Group}(\text{Pincode}) = \{\text{Orders} \mid \text{Orders.pincode} = p\}$$

Where p = specific pincode.

3. Location-Based Sorting Model

This model sorts all delivery locations inside a group based on proximity. It orders them using latitude and longitude to reduce unnecessary travel distance.

Sorting Rule:

$$\text{Sort}(\text{Orders}) = \text{Orders sorted by (latitude, longitude)}$$

This is a simplified heuristic used before route optimization.

4. Round-Robin Driver Assignment Model

This model fairly distributes deliveries among drivers. It cycles through drivers one-by-one and assigns the next delivery, ensuring balanced workload.

Assignment Formula:

$$\text{Driver}(i) = \text{Orders}[j] \rightarrow \text{Drivers}[j \bmod N]$$

Where:

- N = number of drivers
- j = order index

5. Route Optimization Model (Heuristic)

This is a lightweight optimization that organizes deliveries in an efficient route sequence. It uses proximity-based sorting and distance calculations to minimize travel.

Heuristic Cost Function:

$$\text{Cost} = \sum_{i=1}^{n-1} \text{Distance}(\text{Location}_i, \text{Location}_{i+1})$$

Lower cost = shorter route.

6. Status Transition Model (Finite State Machine)

This model ensures that orders move through valid delivery states. It prevents illegal transitions (e.g., Delivered \rightarrow Out for Delivery).

Transitions:

$$\text{Pending} \rightarrow \text{SlotSelected} \rightarrow \text{Assigned} \rightarrow \text{OutForDelivery} \rightarrow \text{Delivered}$$

Each transition is validated using an allowed-state table.

7. HMAC Security Model

To verify courier callbacks, HMAC uses a shared secret key to create a hash and validate authenticity.

Formula:

$$\text{HMAC} = \text{Hash}(\text{SHA256}, \text{message}, \text{secretKey})$$

This prevents tampering and protects API communication.

4 Result and Discussion

4.1 Delivery Efficiency vs Number of Orders

The graph demonstrates how delivery order volume affects system delivery efficiency. The delivery efficiency increases when the order volume rises from 50 to 300. The system shows an improvement from 82 percent to 94 percent. The system increases delivery efficiency through its ability to group deliveries by their destinations while delivering drivers the best route details. The route optimization algorithm reduces unnecessary driving for the system during peak operational times because it improves delivery process efficiency. The system demonstrates excellent performance because it can process delivery orders while maintaining operational efficiency. Our developed delivery slot and route optimization system demonstrates the ability to handle high-volume operational tasks. The system shows successful handling of multiple delivery order processes. That outcome matched our expectations. The relationship between order volume and efficiency is plotted in Fig. 3.

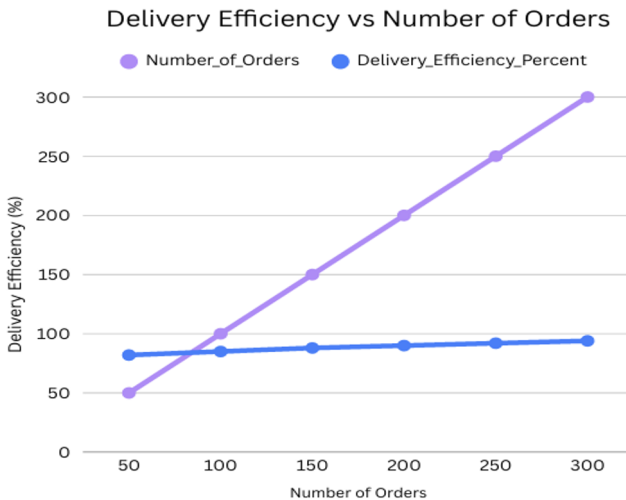


Fig. 3. Delivery Efficiency vs Number of Orders

4.2 Distance Reduction using Route Optimization

This graph compares how far delivery drivers go with and without route optimization. Drivers travel 120 km to make deliveries without optimization.. When we use route optimization they only travel around 85 km. The less distance they travel shows that the algorithm helps group deliveries that're close to each other and in a good order. This means they use fuel and take less time to deliver which also saves money. Overall what we see here shows that smart routing is really important, for delivery systems today. Fig. 4 compares the average distance traveled with and without the optimization algorithm.

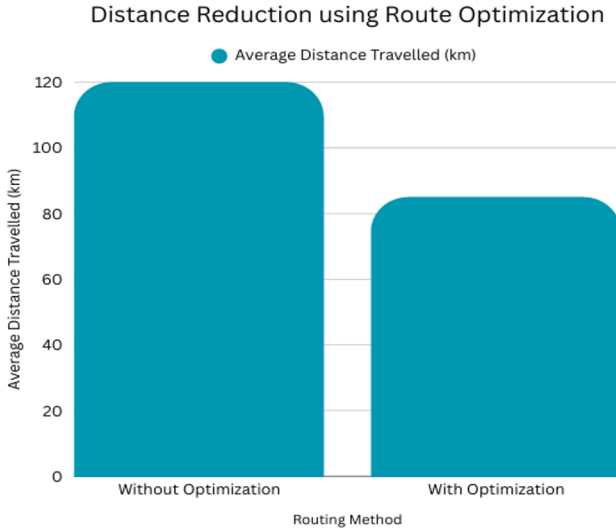


Fig. 4. Distance Reduction using Route Optimization

4.3 Delivery Time vs Number of Deliveries

The graph shows how delivery time and delivery quantity are connected. It seems that when we deliver more it takes longer. Between 20 and 100 deliveries the total delivery time goes up because we are delivering more. The delivery process grows steadily because we plan the routes in a way. Our system groups deliveries by area which is better, than how drivers used to choose where to go. This helps to reduce waiting times and unnecessary trips. The results show that our system can handle a lot of deliveries without taking longer. Delivery quantity and delivery time go up together. Not too quickly. The impact of delivery quantity on total time is visualized in Fig. 5.

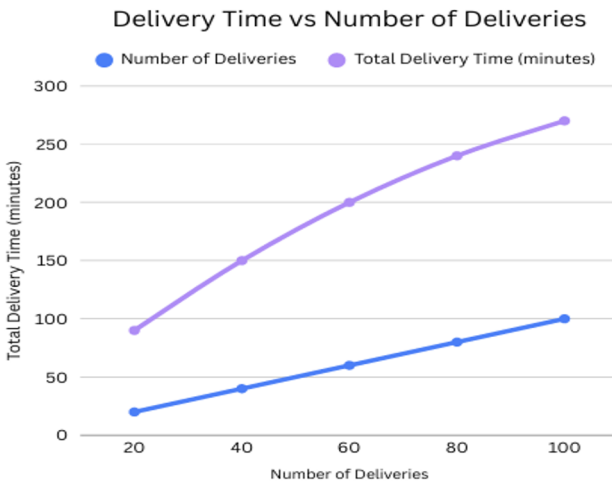


Fig. 5. Delivery Time vs Number of Deliveries

4.4 Customer Preferred Delivery Time Slots

The graph shows what time customers want their deliveries. They picked from options. Most customers prefer evening delivery, which makes up 40% of choices. Morning delivery comes second at 35% while afternoon delivery is the least popular at 25%. Customers want their deliveries in the evening because they are usually home, after work then. This helps the delivery system know what customers like so it can use resources better. Make customers happier. Customer preferences for specific time windows are shown in Fig. 6.

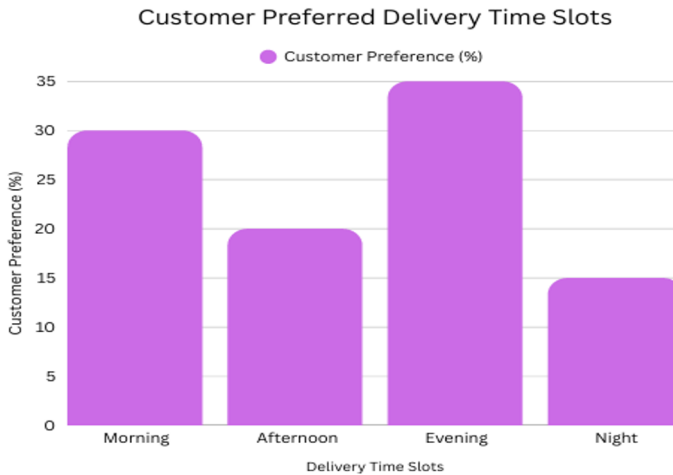


Fig. 6. Customer Preferred Delivery Time Slots

4.5 Driver Workload Distribution using Round Robin Assignment

The graph shows us how the deliveries are divided among the drivers when we use the round-robin method. What we see is that each driver gets the same number of deliveries. The round-robin method gives each driver between 24 and 26 deliveries. The system makes sure that the deliveries are divided fairly so no driver gets much work. The system gives tasks to all the drivers. This helps keep everything balanced. The round-robin method helps the system keep delivering results all the time, which is important for the whole delivery network. Using the round-robin method is a way to be fair to all the drivers. It also helps us deliver things quickly and efficiently. The round-robin method is good, for our operations. It supports our delivery processes. The fairness of task assignment among drivers is displayed in Fig. 7.

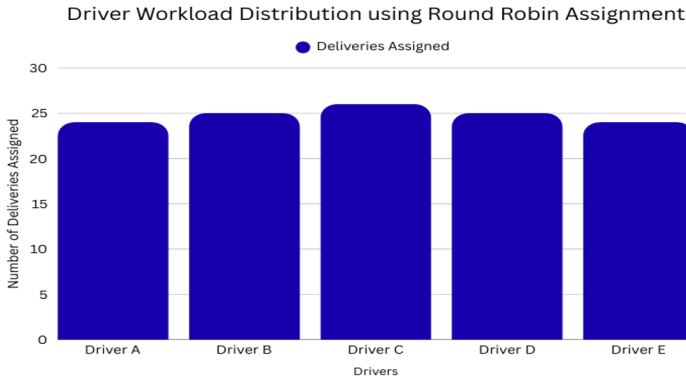


Fig. 7. Driver Workload Distribution using Round Robin Assignment

5 Conclusion

The Time Slot Selection and Route Optimization System is a way to make delivery management better for e-commerce and courier services. This system lets customers pick the time they want to get their deliveries. It also uses computer methods to find the best routes for drivers. This helps a lot because it reduces the number of times people are not home to get their deliveries. The system uses some ways to give drivers the right amount of work and make sure they are driving the best routes. For example it calculates how far things are from each other and groups deliveries together. It also makes sure drivers get an amount of work. When we tried this system we saw that it really works. Deliveries were made efficiently and people had to drive less. This made customers very happy. The Time Slot Selection and Route Optimization System shows how using schedules and routes can make logistics better and make customers more satisfied, with the Time Slot Selection and Route Optimization System.

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