TRAZE: A REAL-TIME ROUTING, SCHEDULING, AND MONITORING ANDROID APPLICATION FOR DELIVERY SERVICES USING DIJKSTRA ALGORITHM AND ANT COLONY OPTIMIZATION

An Undergraduate Thesis

Presented to the Faculty of the

College of Information and Communications Technology

West Visayas State University

La Paz, Iloilo City

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science in Computer Science

by

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June 2023

Approval Sheet

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Abstract

The demand for receiving goods on the same day or within a few days has become the standard in most countries all around the world. This paper proposes developing a system that can monitor, schedule, and provide real-time routing information in an attempt to improve delivery services by shortening routes, ensuring goods safety, and reducing overall operational costs that will be beneficial on the end of the seller, customer, and delivery person. The methodology for finding the optimal and alternative route includes a meta-heuristic that combines ant colony optimization (ACO) with Dijkstra’s algorithm, a search technique that uses both real-time traffic and when combined creates a greedy algorithm that is competent to satisfy the cost priority of finding routes under constraints and complex conditions by simplifying the complex situation and improving efficiency. The system is built by utilizing OSMNX for node placement in routing

along with the NetworkX and using Leaflet and folium for map visualization. The proposal of this study is only limited within the vicinity of Iloilo City.

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CHAPTER 1 INTRODUCTION TO THE STUDY

Background and Theoretical Framework of the Study

In 2020, the total number of parcels delivered globally has surpassed 131 billion. And the market is expected to grow to over 260 billion delivered packages by 2026 (Mazareanu, 2021). The demand for receiving goods on the same day or within a few days has become the standard in most countries all around the world. According to Convey (2021), Eighty-one percent (81%) of retailers ought to increase investments in more sophisticated last-mile strategies.

In lieu of this, the researchers proposed to develop a system that can monitor, schedule, and provide real-time routing information to improve delivery services by shortening routes, ensuring goods safety, and reducing overall operational costs that will be beneficial on the end of the seller, customer, and delivery person. The study utilized a combination of Dijkstra and ACO algorithms to find the optimal route to lessen the travel time of deliveries and pickups. According to Wang, et al. (2017), a combination of the Dijkstra Algorithm and Ant Colony Optimization creates a greedy algorithm that is competent to satisfy the cost priority of finding routes under constraints and complex conditions by simplifying the complex situation and improving efficiency. Hasan Basari et al. (2017) added that Dijkstra - ACO combination was able to reduce the computational time and prove its efficiency in solving large networks of nodes.

Ant colony optimization (ACO) was proposed by Dorigo et al. (2006) as a metaheuristic for solving combination optimization problems. ACO is one of the metaheuristics that imitate the group intellectual behavior of social insects, particularly ant foraging behavior (Tamura et al, 2021). The ACO algorithm is inspired by the behavior of ant colonies in finding food sources (Rahman, 2020). Ants leave pheromones in the process of activity, and following ants can choose their route based on the pheromones that were left by the prior ants. The more pheromone concentration on the trail, the ant will take that trail; the pheromone concentration would also reduce at the same time. Through ant colony behavior, ants continuously learn and optimize via the information feedback process for determining the shortest forage route (Liang et al., 2021). Route planning (Akka & Khaber, 2018), Network routing (Okdem et al., 2009), Logistics distribution (Calabro et al, 2020), Trip route planning (Liang et al., 2021), and the traveling salesman problem (Yu et al., 2019), can be implemented with ACO algorithm.

Finding the optimal route between two vertices in a weighted graph is the main objective of Dijkstra's Algorithm. Edger Wybe Dijkstra invented Dijkstra's algorithm. It is also known as the greedy algorithm, which is a problem-solving algorithm that finds the maximum value. By computing the distance from the initial vertex to the nearest vertex, then to the second vertex, and so on, Dijkstra's Algorithm finds the shortest route (Sebayang & Rosyida, 2022).

Scheduling is integrated into the system to ensure that the perishable goods will be prioritized and prevent damage. The non-perishable items will be picked up based on the nearest scheduled delivery origin on the delivery person location then after a transaction the next pick up will be from the nearest location of the first customer.

Deliveries can be monitored by the customers via a tracking number assigned to their placed ordered goods. Upon inputting a tracking number, the delivery status will appear. By providing transparency of their arriving goods, it is expected to lessen the hassle to both the delivery person and customers, including the seller. In this study, meeting the customers' demands by giving them access to monitor the actual location of their upcoming deliveries, along with the sellers setting delivery schedules based on the preferred day and time of the customers is a priority. Delivery services in the Philippines have been rapidly growing since the start of the pandemic, increasing their services and operations to meet the increased demands of customers and businesses (Mercurio, 2020). When selecting a courier service, Filipinos usually consider the delivery speed and same-day delivery option (Dones, 2020). Inefficiencies in delivery services cost delivery service providers a lot of money, whereas clients demand more flexibility in terms of alternative pickup locations or delivery timeliness (Ozarik et al., 2021). Developing an advanced delivery system that monitors and schedules to improve delivery services by shortening routes, ensuring goods safety, and overall reducing operational costs can help companies achieve competitive advantages over their competitors.

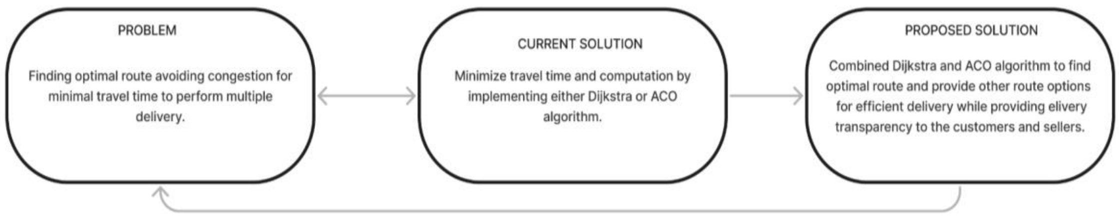


Figure 1. Conceptual Framework

Objectives of the Study

This study aimed to develop an effective and reliable logistics system capable of scheduling, and real-time monitoring deliveries.

Specifically, this research, "Traze: A Real-Time Routing, Scheduling, and Monitoring Android Application for Delivery Services using the Dijkstra Algorithm and Ant Colony Optimization" aimed to:

1. Initialize the Dijkstra algorithm to determine the optimal route and integrating Ant Colony Optimization (ACO) algorithm for alternative routes;

2. Develop a delivery services android application with real-time routing, scheduling, and monitoring; and
3. Evaluate the mobile application implementation using ISO 25010.

Significance of the Study

This study regarding the potential of Dijkstra algorithm and Ant Colony Optimization for the utilization of an intelligent delivery system will pose several benefits in increasing the number of successful first-time deliveries, optimizing delivery rounds, and reducing operational costs and its efficiency will be significant to the following:

Shipping Companies/Delivery Services. The results of the study will help the efforts to create a more reliable intelligent delivery system. The combination of Dijkstra algorithm and Ant Colony Optimization will be seen as a sustainable algorithm for tracking their delivered items.

Customers. Tracking services are essential for trust in company-customer relationships. This study will help customers track the progress of their shipped items, or items out for delivery as the system tracks the fleet or vehicles and updates the customer in real-time. Delivery services will be amplified with this study.

Business owners. The findings of this study will be beneficial for finding the optimal route possible by integrating Dijkstra algorithm and Ant colony optimization to conveniently distribute and transport goods and will less likely be susceptible to being exploited. By using this optimal route-finding algorithm business owners can avoid factors that will lead to delayed delivery of supply chains and the unbalanced relationship between the customers.

Environment. Fuels such as fossil fuels emit carbon when burned which eventually traps heat inside our planet's atmosphere. The results of the study will help the efforts of companies to reduce instances of idling which will cut carbon dioxide companies cut their fuel costs that will lead to lesser C emissions.

Future Researchers. The gathered data and formed analysis can be used by future researchers who are interested in further understanding and research of this study.

Definition of Terms

For better understanding, the following terms were defined conceptually and operationally:

Algorithm. A process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer. [Wex Definition Teams, 2022]

Algorithm. As used in the study, algorithm refers to the combination of Dijkstra algorithm and Ant colony optimization algorithm in finding the optimal route.

Ant. A very small insect that lives under the ground in large and well-organized social groups. [Cambridge Advanced Learner's Dictionary & Thesaurus, 2023]

Ant. In the study, Ant refers to as the basis of the ant colony optimization algorithm.

Environment. The surrounding conditions in which a person, animal, or plant lives or operates. [Biology Online, 2022]

Environment. In the study, environment refers to the factor considered to reduce the emission of carbon dioxide from fossil fuels used in vehicles by finding the optimal route possible.

Map. A diagrammatic representation of an area of land or sea showing physical features, cities, roads, etc. [Hamilton Lits Resource Center - Maps, 2023]

Map. In the study, map refers to a data gathering instrument in allocating point markings for the delivery of services. [Operational Definition]

Nodes. A point at which lines or pathways intersect or branch, a central connecting point. [Oxford University Press, 2018]

Nodes. In the study, nodes refers to the scope of connection or distance from the origin point to the destination.

Route. A way or course taken in getting from an origin point to a destination. [English English Dictionary, 2019]

Route. In the study, route refers to an established or estimated course that links together the origin point and the destination point.

Time. The measured or measurable period during which an action, process, or condition exists or continues. [Merriam-Webster Dictionary, 2023]

Time. In the study, time refers to the shortened amount of time consumed in delivery service by finding the optimal route.

User. A person who uses something, especially a computer or machine. [Collins COBUILD Advanced Learner's Dictionary, 2023]

User. As used in the study, the user specifically includes the customers, seller, and delivery person.

Vehicle Routing Problem (VRP). A combinatorial optimization problem that involves finding the optimal design of routes for a fleet of vehicles. [Asghari, 2021]

Vehicle Routing Problem (VRP). In the study, the Vehicle Routing Problem (VRP) refers to the problem that the proposed solution is trying to solve.

Weight. To attach importance or value to. [Macmillan Education Limited 2023]

Weight. In the study, weight refers to the distance between the scope of connection from origin to destination nodes.

Delimitation of the Study

The study will be simulated among users which are divided into three, namely: customers, sellers, and delivery persons.

Data gathering tools include Google Maps, OpenStreetMap, and an interview with various companies who work with the logistics operations.

The study is designed to monitor, schedule, and develop a routing system capable of determining the optimal route and alternative routes to the users which are classified to Customer, Seller, and Delivery Person. The Dijkstra Algorithm and Ant Colony Optimization were used to determine paths from one point to another.

In line with the proposed android application, there are limitations as to what the application can do. The user must adhere to the following guidelines when entering the data in order for the application to identify possible routes from the seller to the user: (1) the data are only limited to the 180 barangays in Iloilo City (2) users must be mindful of the correct spelling, spacing, and symbols when entering data, and more importantly, (3) users must be connected to the internet.

For demo purposes, choosing locations for assigned origin and destination routes is only limited to 174 certain areas (barangays) within the districts of Iloilo City.

CHAPTER 2 REVIEW OF RELATED STUDIES

Review of Existing and Related Studies

According to Cosmi et al. (2019), the logistic sector has always been a source of demanding problems and applications for automation and optimization. The escalation of e-commerce has had an immense impact, especially in recent years that transfigured the sector more as it reflected the proponent growth in delivery services. With this, increasing demand affiliates a huge number of works needed to be done and organized. In this, the typical context of organizing things in companies offering delivery services is the arising problem in terms of scheduling of orders so that the maximum delay with respect to the desired delivery time, or the number of late and possibly, withdraw orders are minimized.

Ky Phuc and Phuong Thao (2021) presented Vehicle Routing Problems (VRP) to address the issue of minimizing total travel distance and cost consumption while considering real-world application constraints. Ant colony optimization approach was proposed as a solution to solve large-scale transactions like multiple pick-ups and delivery problems by limiting the number of route lengths and time window constraints will not be violated. The study was able to configure the best set of solutions to output a set of routes considering conditions in every mode set and practical constraints. However, it has a low-efficiency point level as a meta-heuristic approach for a large problem size. Thus, analyzing more optimal principles in finding the best route solutions will further improve the study.

Meenakshi et al. (2021) proposed a Dijkstra – based Routing Management (DRM) algorithm to enhance the sensor network lifetime which outperforms the classic Distance-based Dijkstra Routing Management (DDRM) algorithm in terms of network lifetime and packet delivery. The study has a significant improvement in packet delivery and longevity of the network lifetime, which can be also used on intelligent sensors.

Xing et al. (2022) studied Virtual Machine Placement (VMP) problem using Energy-Efficient and Traffic-Aware ACO (ETA – ACO) which is effective in VMP problems on energy and bandwidth–aware PM selection scheme, traffic–based ordering scheme, and direct information exchange scheme. The researchers are hoping that they can combine power consumption and bandwidth resource consumption into programming.

Dijkstra Algorithm

In pursuit of analyzing vehicle scheduling problems, Li et al. (2018), utilized the Dijkstra algorithm to increase economic efficiency, stimulate energy conservation, and reduce logistics costs. The application of the algorithm in the study is to satisfy a good dispatching plan to satisfy a calculated integration of the transport functions of various enterprises, and integrate all types of logistics resources (including vehicles, personnel, warehousing, etc.), saving, high efficiency, rationalizing distribution, improving vehicle utilization rate and a best optimal driving route.

The Modified Dijkstra Shortest Path Algorithm (MDSP) used multiple parameters to find the valid shortest route instead of using a single parameter, which efficiency is analyzed in terms of the optimal route by measuring its nodes and Time complexity. Hence, the fastest route can only be determined on a real-time basis, and in some cases, it can be done in just a few seconds (Iqbal et al., 2018).

The Dijkstra algorithm will be used to find the best possible optimal route in this study.

Ant Colony Optimization

In the study by Almaalei and Razali (2019), the ACO algorithm was initially put forth by an Italian researcher named Dorigo to solve the Travelling Salesman Problem (TSP), after which, it was developed to solve additional problems like VRP, QAP, scheduling, mapping, network models, personal placement in airline companies, etc. The study's principal goal is the effective use of the ACO algorithm to identify the best optimum solution for challenging real-world issues like scheduling problems. In the paper, it was explained how ACO was used as a method of optimization in the scheduling problem of manufacturing firms with multi-objective concerns, transforming it to satisfy market demand, save production costs, improve the technology, and boost economic efficiency and management level.

ACO was utilized to find the optimal route to maximize tourists' destinations in Bangkalan – Madura which resulted in 100% optimal route determination to introduce other sites that are not available on Google Map. Thus, they recommended adding visualizations of locations for easier planning or visiting (Rachmad et al., 2021).

In this paper, ACO will be used to find the alternative routes available when the optimal routes are not and will be part of the constraints that are to be declared as the development of the logistics system continues.

Comparison of Dijkstra and Ant Colony Optimization

The Ant colony optimization is used for solving optimal routes based on behavior of ants (Rahman, 2020). It is a greedy algorithm, where the ants leave pheromones as trails, and the trail that has more pheromones after each iteration is more likely the optimal route (Calabro, 2020).

Dijkstra Algorithm is the most popularly used algorithm for finding the optimal route (Iqbal, 2018). This algorithm relies on a graph that is created from an ordered pair (V, E) made up of a set V of vertices or nodes and a set E of edges connecting the nodes. The edges in the graph must have a value for the optimal route algorithm for its correct implementation, which requires that each node's connections have their own weight. The algorithm searches for the route with the lowest weighted sum among all routes between the origin node and the destination node (Guerrero, 2019). The basis on finding the optimal route for ant colony optimization is through the pheromones left behind after iteration, while the Dijkstra algorithm uses the weighted sum of each node to conclude its optimal route.

Combination of Dijkstra and Ant colony Optimization

Wang et al. conducted a study in 2017 where they proposed a combination of the Dijkstra Algorithm and Ant Colony Optimization to create a greedy algorithm that is competent to satisfy the cost priority of finding routes under constraints and complex conditions by simplifying the complex situation and improving efficiency. The study uses the construction of network pruning, and then utilized the Dijkstra Algorithm to generate two synthesis Network Diagram with specific constraints seek the route in two synthesis network diagrams based on the Ant Colony Algorithm, and finally takes advantage of the network topology simulation to demonstrate the feasibility and validity of the scheme. The experimental results based on network topology showed that the improved algorithm can solve practical problems effectively and provide a reliable and stable scheme for bus route planning and router routing. However, the solution of the scheme is dependent on the parameters of the ACO in different network diagrams, which needs to be studied further (2022).

A study conducted by Hasan Basari et al. (2017) was compared Dijkstra's Algorithm (DA) to Dijkstra-Ant Colony Optimization Algorithm (DACO) in solving the optimal and safest route for evacuation in a building. According to them, Dijkstra's Algorithm limitations are inclined to high computation time and low efficiency for solving large networks of nodes; they solved these limitations by using DACO, a bio-inspired approach to Dijkstra's Algorithm.

Results show that both tested algorithms produced the same output for the optimal route and safest route. Researchers were able to reduce the computational time and prove its efficiency in solving large networks of nodes. The study suggests that future improvements with the safest route can be obtained with ACO.

The studies of Wang et al. (2018) and Hasan Basari et al. (2017) will be used as a basis for how to combine the Dijkstra and ACO algorithms efficiently.

In theory, combining Ant Colony Optimization and Dijkstra algorithm will reduce the computation time, and will be efficient in looking for alternative routes (Basari, 2017). Dijkstra Algorithm is used for solving for the optimal route, and is usually integrated with web applications (Kumar, 2015). Studies with regards to implementation of these algorithms on mobile apps use expensive specifications such as using CCTV cameras to monitor traffic (Nuanmeesri, 2020) and using an application programming interface (API) that requires payment for a monthly subscription (Guerrero & Tapia, 2019), (Nuanmeesri, 2020).

It is expected for the proposed system to be capable of scheduling and monitoring deliveries in real time: discovering the optimal route by using the Dijkstra algorithm initially, and then ACO algorithm will then take control and search for alternative routes. Thus, the difference of this study from other studies is that it will utilize open-source API, and will make use of the algorithm in finding the optimal and alternate routes through a mobile app.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

Description of the Proposed Study

The study will utilize a greedy algorithm called the Dijkstra Algorithm in finding the optimal route through Ant Colony Optimization (ACO) that will be implemented as an android-based application. Furthermore, Dijkstra will be initialized to provide an optimal route, and ACO will search for other alternative routes so that the delivery can arrive at its destination via the optimal route possible.

The study is expected to provide lesser travel time when delivering service with the help of the combined Dijkstra and ACO algorithm to find the optimal route. Wang et al. (2017) have proven that a combination of Dijkstra and ACO algorithms works on practical problems under complex constraints and ACO will be utilized for scheduling deliveries for easier monitoring.

Methods and Proposed Enhancement

Participants

The study was conducted to find the optimal route in a real - timed based routing. This study was conducted in Iloilo City, the 6th region in the Philippines. The participant of this study was exclusive to a certain delivery service provider that has access within the Iloilo City area. To obtain the results of the study, a simulation process of the proposed system was conducted.

Data Gathering Instrument

This study utilized the following instruments to gather the needed data:

1. OpenStreetMap

   OpenStreetMap was used as the basis of node placements, markings, and computing distance from one place to another.

2. Google Map

   The researchers have manually extracted the individual coordinates of each location.

3. Interview

Researchers conducted an interview with GrabPH, Jet Express, and LBC who are existing logistics companies within Iloilo City for validation.

In the interview conducted, the following information was gathered. The platform is open 24 hours a day, GrabPH delivery people can choose their work hours if they can meet the quota. Peak hours are at lunch and dinner, which causes delays due to the volume of orders placed. Furthermore, deliveries are based on the closest available person to the seller's pick-up location to reduce travel time to reduce travel time, deliveries are based on the closest available person to the seller pick-up location. The delivery people use the Grab app, which has a built-in map and is dependent on the internet and values efficiency by taking the shortest and best route available. Although the application includes a map, delivery personnel are free to choose alternate routes based on real-time conditions and can use third-party maps such as Waze, an interactive map. Grab Food for food, Grab Mart for groceries, and Grab Express for parcels are among the services available through the app. All transactions, including delivery person locations, are transparent to the company; however, only basic information is relayed to customers. If an issue arises, they may request confidential information about their orders.

Jet Express delivery starts at five in the morning from the warehouse, which varies in end time as they must deliver all the assigned goods on their specific route. Delays happen during the promotions due to the large volume of orders as they implement a first in first out system.

Interview at LBC Gaisano branch stated that delivery time is scheduled or set such as office hours. The LBC system is not dependent on the internet and its delivery task is lessened from the rider’s delivery schedules after being scanned from the warehouse. Riders will attempt to deliver the parcel on the scheduled date within the day. Once customers are not available, delivery attempts will proceed on the next day. If customers are not available or are not able to receive or pick up the parcel within the ten (10) days dependency on the stated branch, the parcel is subject to RTM (return to Manila). Routes are initially evaluated or areas that are subject to deliveries and secluded areas are indicated as critical areas (red zone). Riders are the ones who evaluate road conditions and adjust to avoid delays. Parcels are classified by name, consignee with a tracking number that start with a type 32 box for fragile or perishable goods, type 18 for plastics, and ABR or pouch regular for light parcels such as documents. In any case of fruit goods, a permit from the DENR should be secured before deliveries and is either transported via B Cargo care (Ruru) or via air.

Procedure

The researchers will primarily use Python as the Programming language for implementing the Dijkstra algorithm and Ant Colony Optimization in the system. The following procedures are:

a. Collect Data

The first step would be data collection where the researchers will look for or gather data that is suitable for the study. The data found or gathered will be verified by the researchers' adviser.

b. Create a system

Researchers will develop a system that can monitor, schedule deliveries as well as guide the delivery drivers on which way is appropriate and feasible to take during deliveries.

c. Combine Algorithm

This process will start by initializing the node graph through the Dijkstra algorithm to identify distances between nodes and look for the optimal route. Then, the ACO algorithm will be utilized to find alternative routes aside from the optimal route already given.

The scheduling of goods delivery will be based on perishable and non-perishable classification. Perishable goods such as foods, namely: meat, poultry, fish, dairy goods, and all cooked ones will be considered a priority in scheduling deliveries. Non – perishable goods such as canned goods, clothes, etc., will be scheduled based on entry order where the first entry by the seller becomes the next scheduled delivery after the perishable goods.

Components and Design

System Architecture

The figure presents the structural concept of the proposed system. The system architecture includes the following:

a. The system that will be used is based on android built from Python. It acts as the intermediary between the sellers, customers, and delivery person. The system functions as the location monitor for the seller and customer and a route guide to the delivery person. It is expected to handle 50 transactions initially. It works based on the nodes, delivery vehicle, and cloud database.
    - Delivery Vehicle serves as the location of delivery goods which is monitored by the customer and seller. As the delivery vehicle travels, it transmits its location to the cloud, which stores all the system's data and automatically updates the cloud of its current location.
    - Nodes are responsible for providing optimal and alternative routes which guide the delivery

person at work. Each node is assigned to specific longitude and latitude and has calculated distances that serve as a weight.

- Database is the one responsible for establishing communication between the users. It computes the weights needed during the delivery and updates the seller and customer on the real-time location of the delivery.

b. Users are the beneficiaries of the routing system based on a logistics system. They must register an account providing their personal information such as their complete name, address, and phone number and must identify themselves of what type of user they are to enjoy application services rendered. Users are classified as:

A seller is a type of user that provides goods to a customer. Upon logging in the application, they have the privilege to set schedules of their items to be picked up by the delivery person and monitor if their goods successfully reached its customer. When the delivery reaches its destination, the customer must accept it then they receive a successful delivery confirmation message sent to the seller.

The customer is the one who purchases the goods from the sellers. They have the authority to monitor the delivery location and see the set schedules by providing a delivery code given upon placing an order.

The delivery person is responsible for delivering the goods. Through the application, it can communicate with customers, sellers, and other delivery persons.

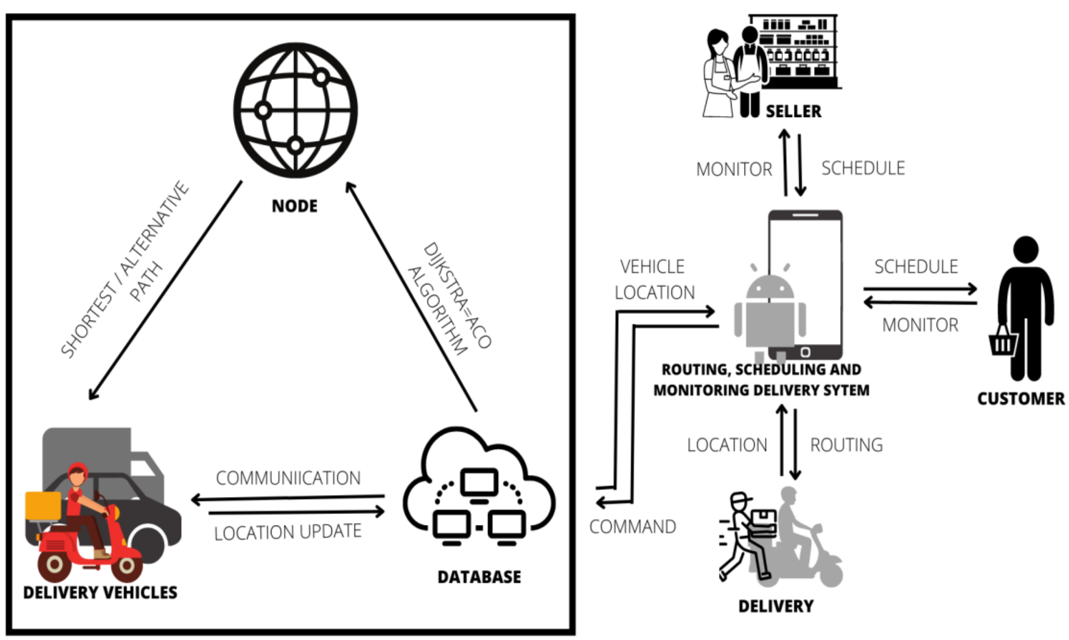


Figure 2. System Architecture Design

The database design figure of the system illustrates the normalization results of the actual database as a web-based real-time routing, scheduling, and monitoring system for delivery services. The system database design keeps a list of attributes to keep track of the distance and iterations of the initial and destination nodes. The database is up to contain information about intended users/clients that involves routing services and transactions.

Database Design

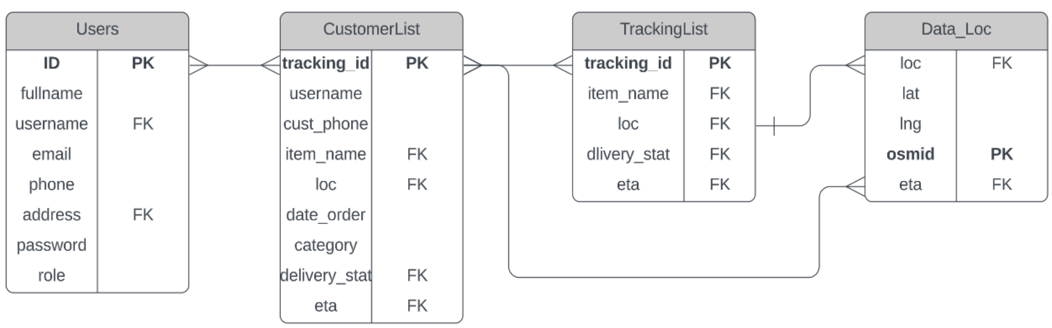


Figure 3. Entity Relationship Diagram (ERD)

This model shows the logical structure of the proposed system. The model described how the information is organized in the database used by the researchers. This logical model specified entities, attributes, and relationships between entities. It abstracts away from actual DBMS used in the implementation of the system. The model is broken into four main subject areas: Users (which is composed of the seller, customers, and delivery person), customer list, tracking list, and data loc (location). The users section includes all the information provided by users when they register or login to use the system. The relationship shown between the user entity and the customer list attribute falls for the user's role which is the seller's input when a customer purchased a good. The customer list and tracking list attributes then correlate in a mandatory many-to-many relationship when the seller then lists customers information where a tracking ID is then generated. The data loc attribute fetch data from the tracking list in a mandatory one-to-many relationship whereas the data loc attribute then based the location of users specifically the customer from the tracking list attribute from the generated data of the customer list attribute for the locations to be shown in the map.

Object-Oriented Design

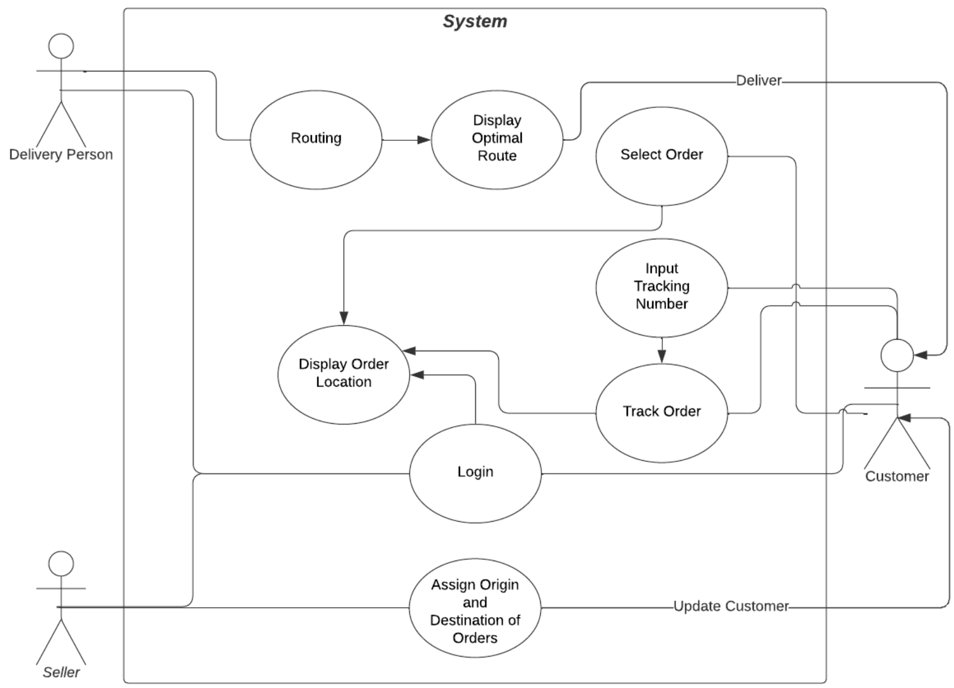


Figure 4. Use Case Diagram

Figure 4 shows the process of the implementation plan of the system. The process will comprise the three attributes: delivery person, customer, and seller. The implementation flow of the system starts with the landing page, then, with the login data. Upon logging in, the system will display scheduled route nodes for the intended delivery attempt. Within these recorded routes, the system will produce optimal routes for fast delivery. To note, this figure represents the user's perspective. Back up by being notified of the order by the seller, selecting the order, tracking order location, and monitoring process is featured in the figure. The tracking and monitoring feature of the design figure shows specific logistic information about the arrival and departure of the order at a particular time and location.

Process Design

The figures below present the data flow that will occur within the system. It will involve three users: (1) Seller, (2) Customer, and (3) Delivery person. The seller will have access to assigning the origin and destination of the order. The customer will have access to the monitoring of their order. And the delivery person will have access to scheduling the destination of the orders, in which the combined Dijkstra and ACO algorithm will optimize the route that it will take.

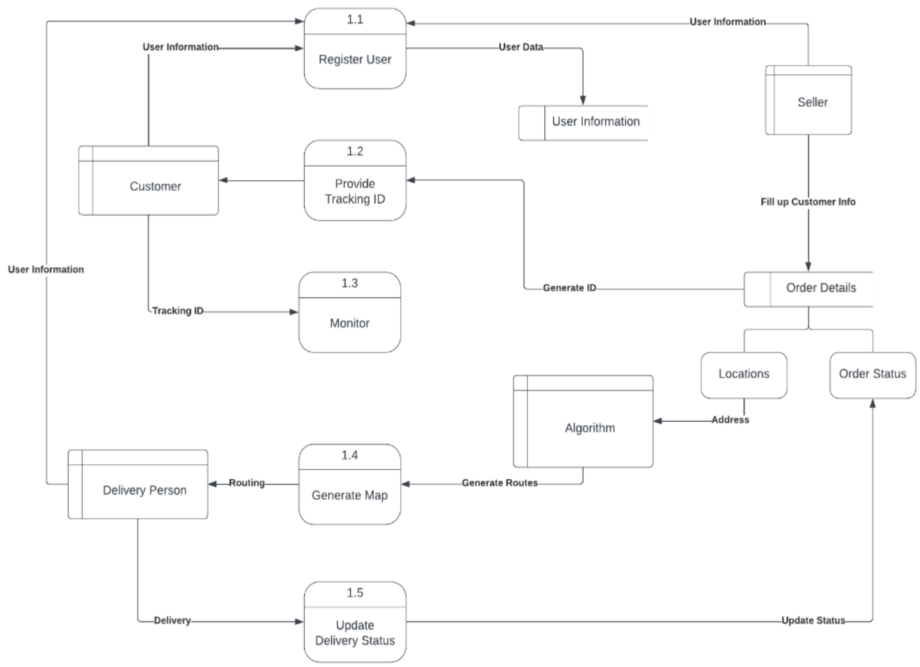


Figure 5. Customer Data Flow Diagram

Figure 5 is a detailed data flow diagram that showcases the sequential processes and information display when users interact with the system. The diagram provides an organized representation of the entire user journey within the application.

The process begins with users registering their data on the application, establishing their presence within the system. Following registration, the seller enters the customers' order details into the system, as the ordering process takes place outside the application itself. Subsequently, a tracking ID is generated for each order. This tracking ID serves as a unique identifier, enabling customers to monitor the progress of their orders by inputting the ID into the system.

Simultaneously, the delivery person gains access to the order details and is provided with an optimized route based on the seller's and customer's addresses. This route is generated using Dijkstra and ACO algorithms, ensuring an efficient and effective delivery process. As the order progresses, the system updates the order status, accordingly, allowing customers to stay informed about the status of their orders.

In summary, Figure 5 presents a comprehensive depiction of the data flow within the system, encompassing essential stages such as user registration, login, tracking ID generation, routing optimization using advanced algorithms, and automatic updates of order and delivery status. This diagram provides a clear overview of the user journey and the underlying processes that contribute to an efficient and seamless user experience within the application.

Procedural Design

The system process starts when user's login into the application with a username and password. If they do not have an existing account, they are requested to register. Upon successfully logging in, the system will identify what kind of users they are. The type of users depends on the services they can render. Customers can monitor their items to come after entering a code. Sellers can set schedules of the date of goods they sell and monitor them. The delivery person can be guided by the system by providing an optimal route upon entering the address of the customer or the seller. A map will appear if the user has inputted the address and delivery code, only if the delivery is already on the go. If the user is already done his transaction, he can log out and close the application. However, a third person is also included in the system which is the admin. Admin is the one who monitors data coming in and out of the database. He is also responsible for fixing inadequacy.

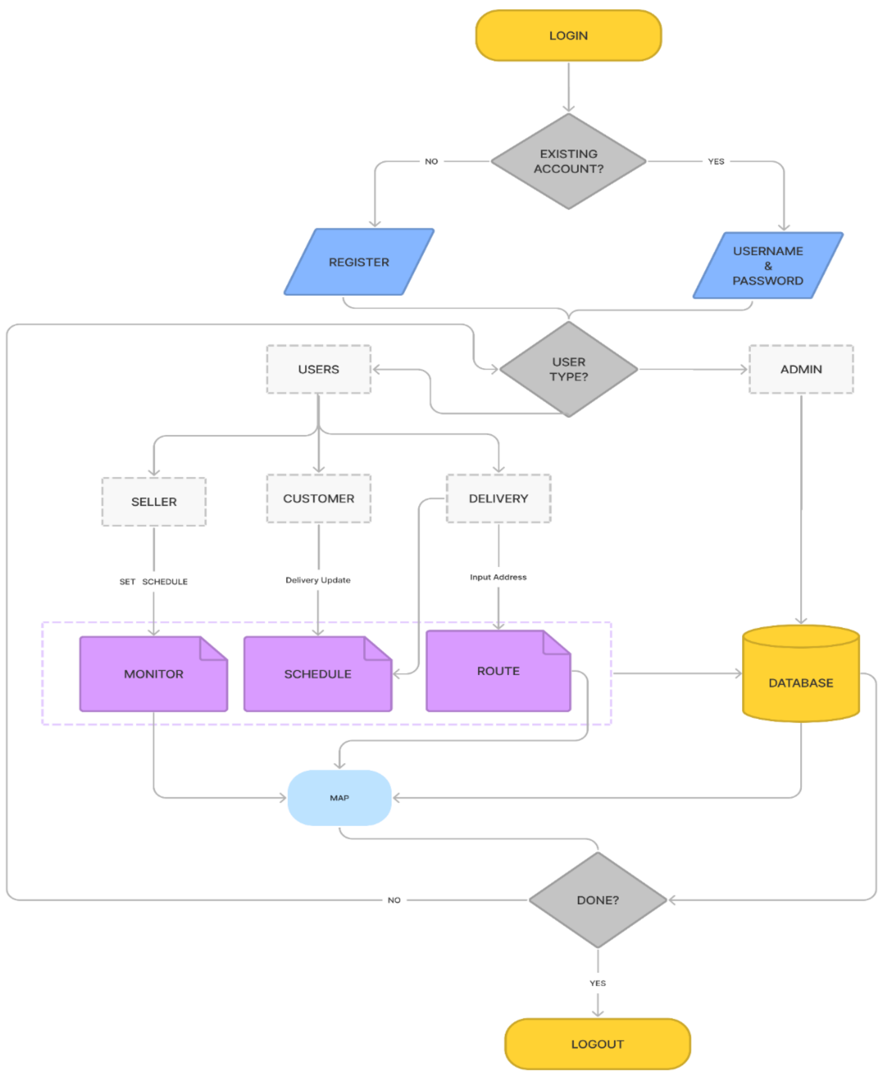


Figure 6. System Flowchart

The figure depicts the overall procedures of the proposed system. The procedures will vary depending on what type of user will login and uses the system. Customers are intended for monitoring in the system, seller for scheduling of all information regarding the purchased of goods, and delivery persons for outrounding deliveries. The proposed algorithms in the study quantified all the procedures seen in the figure.

Methodology

System Development Life Cycle

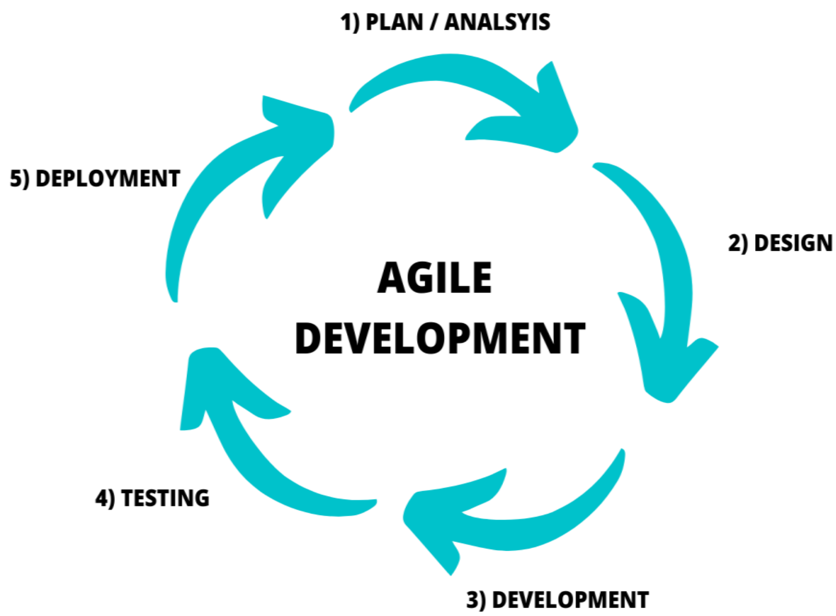


Figure 7. System Development Life Cycle

The researchers will use the Agile System Development Life Cycle for planning and defining project goals. The study goal is to reduce the travel time of delivery and to ensure its safety. This will be done by creating an android application in Python. Its system will use a combination of

Dijkstra and ACO algorithms. The following are phases in the Agile programming method:

Plan/Analysis

The researchers will combine the Dijkstra and ACO algorithms to find the optimal route and alternative routes available. Python programming language will be used to implement the system.

Design

An android-based application is expected for the implementation of the design phase of the study. The application will be composed of a system design that is going to be implemented from a customer, seller, and delivery-based perspective. The system will be built using the Python programming language. The system's design aims to provide visualization of the expected output by initializing the Dijkstra algorithm and Ant Colony Optimization (ACO) for the sole purpose of finding the optimal route in a delivery service.

Development

In the development phase, the developer will use Python as a programming language. The developer starts by graphing the location coordinates and assigning distance that will serve as a weight. Next, the developer will combine the Dijkstra and ACO algorithms and utilize them. Adding constraints then follows. The final output will be an android logistics application.

Testing

To test the quality of the application, the respondents will undergo a performance comprehensive assessment. The testing procedures will atone for the main goal which is to report, monitor, resolve and retest the application system’s components until they reach the quality standards.

Deployment

The system will be deployed in an android application using Python. The administrator will keep track of the database for occurrences of issues.

CHAPTER 4 RESULTS AND DISCUSSION

Implementation

In this section, the development of the proposed application starts with the implementation of the Dijkstra and ACO algorithm into routing integrated with scheduling and monitoring features, hardware and software specifications, results in interpretation and analysis, and system evaluation will be discussed and with the process for device identification. The final system output is an android - based mobile application.

The system was built using Python language and JavaScript was also utilized along with HTML. The Dijkstra algorithm was initialized to find the optimal path. For Iloilo City map visualization, Leaflet and folium were utilized along OSMNX and NetworkX for plotting nodes. Matplotlib was also imported to plot the route on the map.

Hardware

The system requires users to have an android mobile phone. Android phones are widely used all over the world because they are cost-efficient and have a lot of features beneficial to customers.

Input and Output

The researchers have classified the users into three, namely: seller, delivery person, and the customer. Thus, each user has different input requirements.

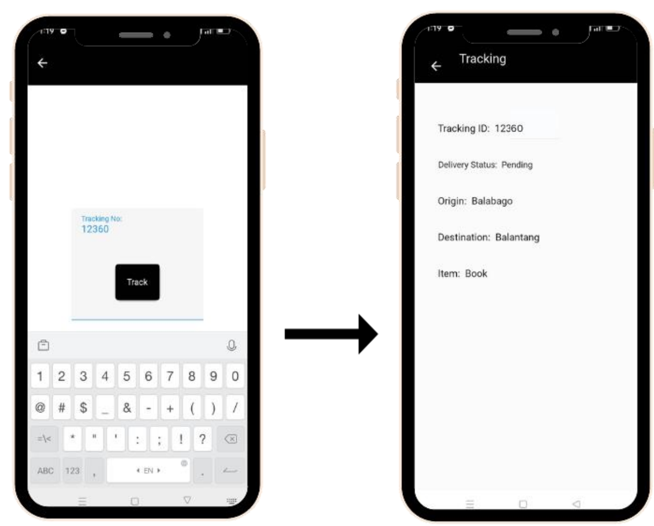


Figure 8. Customer Input and Output

The figure presents the customer user type who is required to input a tracking number to monitor his arriving parcel. Upon inputting, the tracking number, the system will check the database to see if the tracking number provided exists, then it will provide the parcels' location in a form of a map as it starts traveling on its scheduled delivery date.

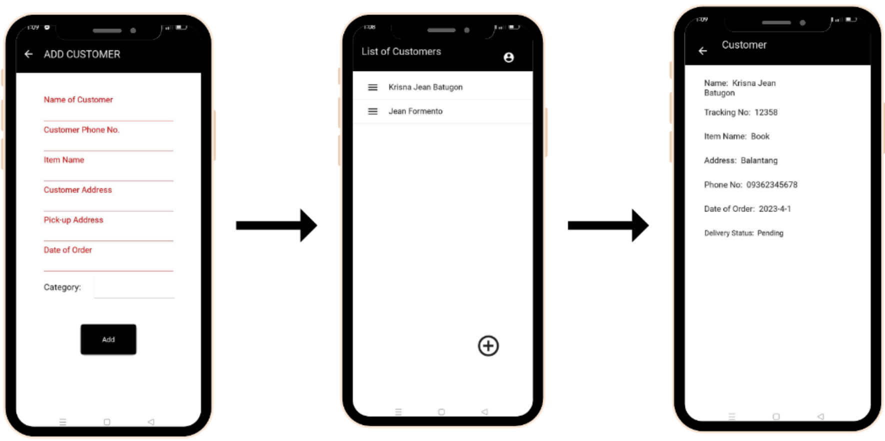


Figure 9. Seller Input and Output

The figure presents the seller user type who is required to assign the origin and destination of his goods including the delivery dates and time which will be stored to the database. Upon the pick-up of his goods, he can start monitoring its journey through the map. The monitoring will stop upon the receiving of the customer of the goods.

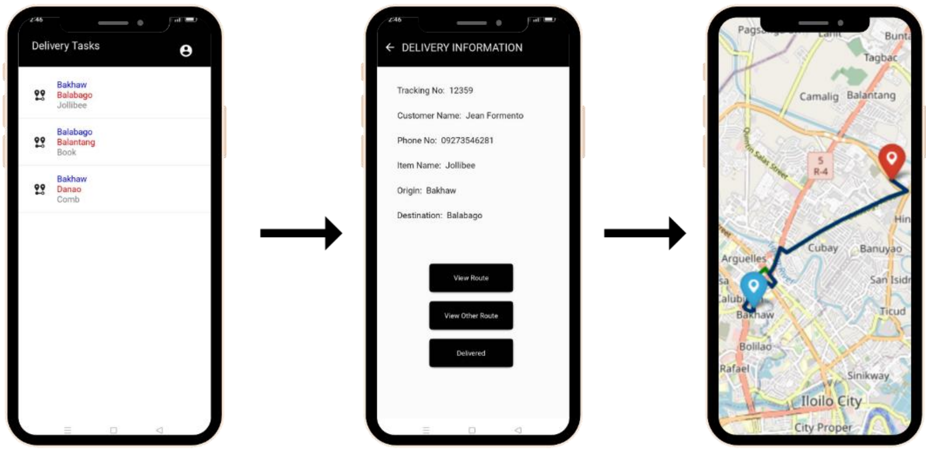


Figure 10. Delivery Person Input Output

The figure presents the delivery person user type who has access to the origin and destination of the delivery and will be provided an optimal route through the map visualization given by the system.

Results Interpretation and Analysis

The initial simulation of the proposed "Traze: A Real-Time Routing, Scheduling, and Monitoring Android Application for Delivery Services Using the Dijkstra Algorithm and Ant Colony Optimization" was performed with Python in Visual Studio Code, Windows 11 with 12GB RAM on Intel core i5-10210U processor.

The system is tested by specifying the origin location and destination manually. The system will then search for the available routes, providing the nodes it has passed, the number of nodes it utilized, distance, and finally plotting the optimal route on the OpenStreetMap. At this stage, the researchers have identified that the OpenStreetMap works on the Dijkstra algorithm but has an issue when it comes to the ACO.

The researchers also encountered some issues in finding an open-source code for the ACO. The primary packages that have been included in the code have some issues and due to unknown reasons, it cannot be installed successfully. The error appears when specifying the origin node to get the place and the nearest available nodes on the OpenStreetMap. The initial code is also dependent on the internet connection now, which is an issue for the researchers for a reason that Philippines has a slow and unstable internet connection. Thus, making it harder for the researchers to know whether the error is coming from the code or due to the unstable internet connectivity.

Initial Results

This section tackles the system evaluation based on primary data gathered during the initial simulation. It can be observed that the number of nodes being used varies on the distance of travel. Distance also affects the execution time of the system in search of the optimal route. Although the execution time of each simulation is remarkably high, it needs improvement as the study progresses. Nodes are a point where two lines or paths intersect, each node on the study was given a unique id on each corresponding coordinate.

Figure 11. Iloilo City Map Nodes

The figure above is the simulated map on a web size of Iloilo City using the Open Street Map. There are 379 streets in a 70.3 km² land area of Iloilo City. The simulated map has 7,013 nodes and 17,091 edges present.

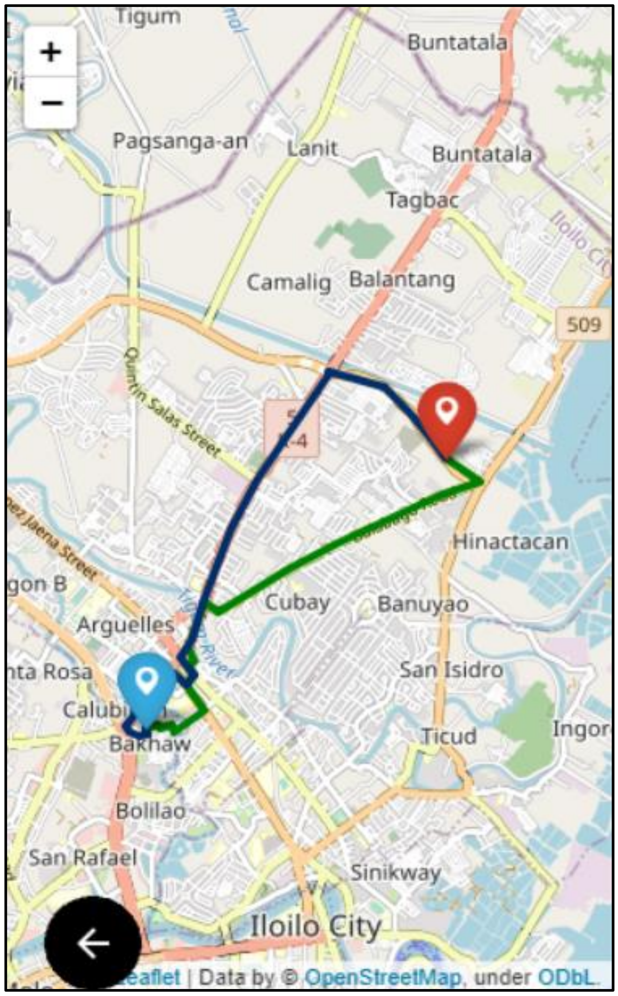


Figure 12. Bakhaw to Balabago Optimal Route

This figure is a depiction of Bakaw, Mandurriao to Balabago, Jaro optimal route based on the distance indicated in blue and travel time indicated in red. Blue tags indicate origin while the red ones are the destinations.

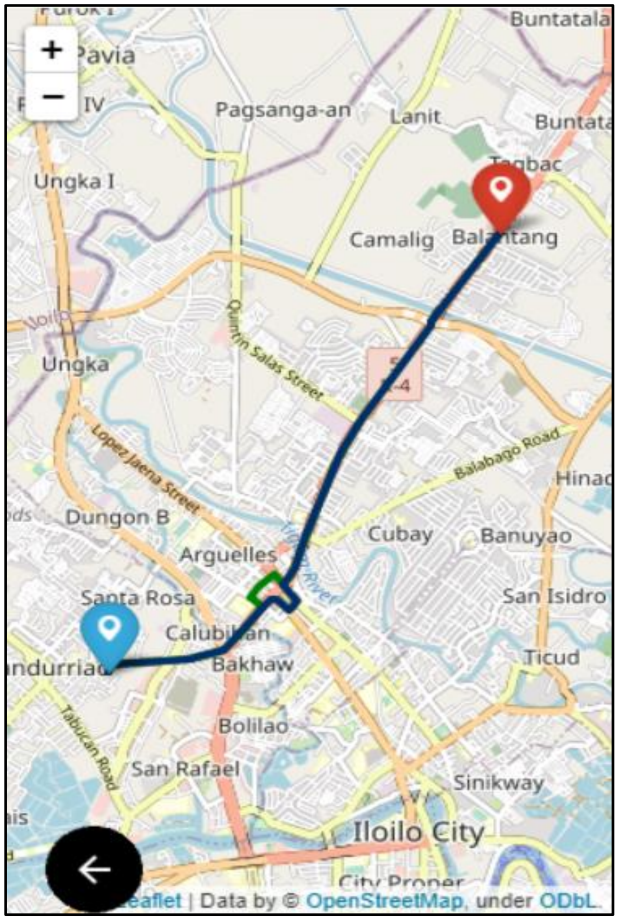


Figure 13. Abeto Mirasol to Balantang

Figure 12 shows the Abeto Mirasol Taft South, Mandurriao to Balantang, Jaro optimal routes. More than half of the blue indicated route is the same as the red one, which perceives that the two optimal routes are the same with just a little detour.

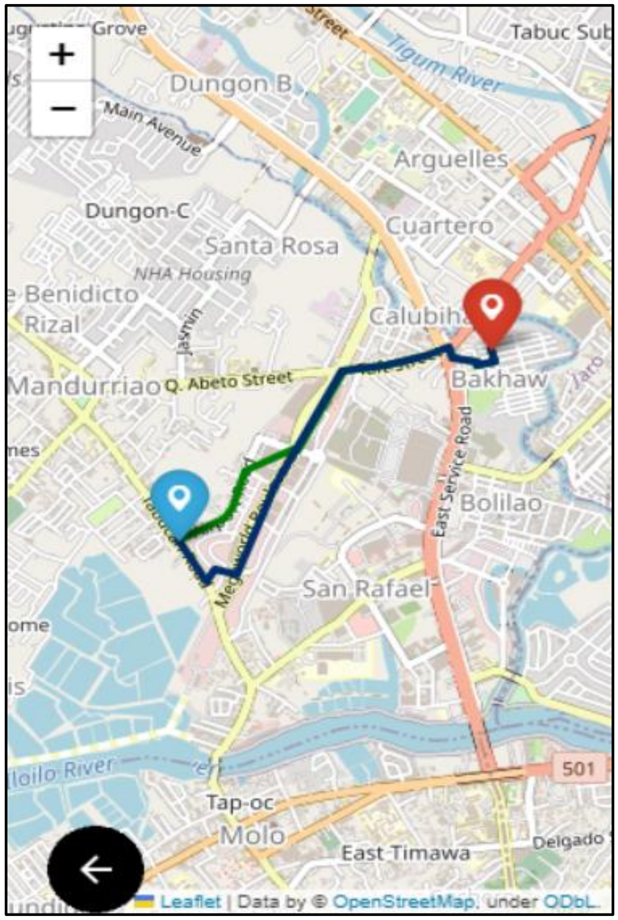


Figure 14. Bakhaw to Airport

The figure depicts the route from Bakhaw, Mandurriao to Airport, Mandurriao in which the optimal route by distance indicated in blue is the only available route. Upon checking by the researchers during the duration of the study, the route indicated in red is unavailable and restricted due to ongoing construction near the route simulated by the system.

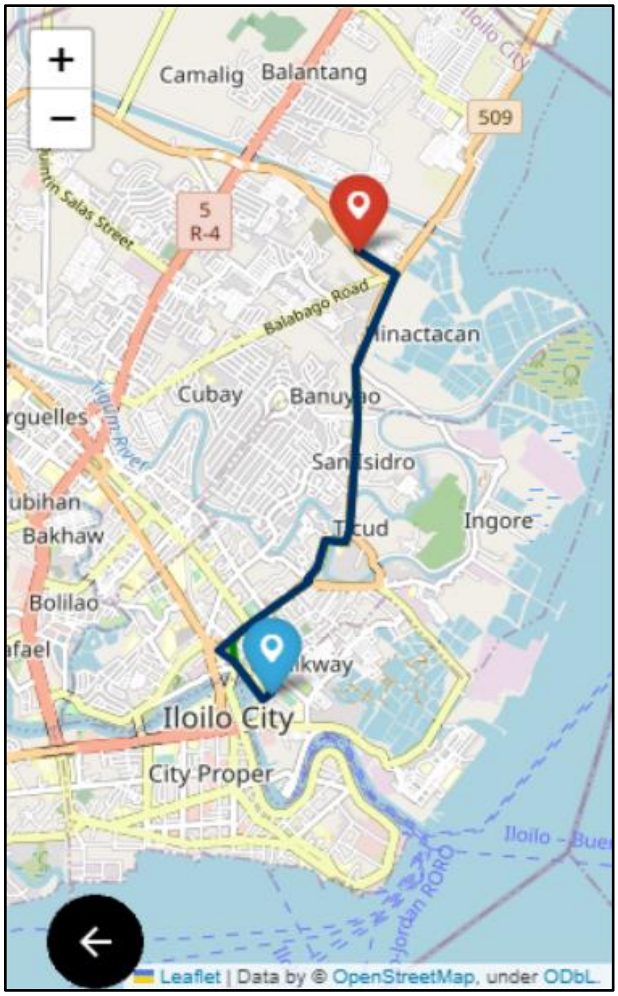


Figure 15. Aguinaldo to Balabago

Figure 15 depicts the optimal routes from Aguinaldo, Lapuz to Balabago, Jaro in terms of distance and travel time which are almost similar. However, a slight detour around Burgos and Luna Street as it is temporarily unavailable due to road construction during the duration of the study. Further route details are available in Table 2.

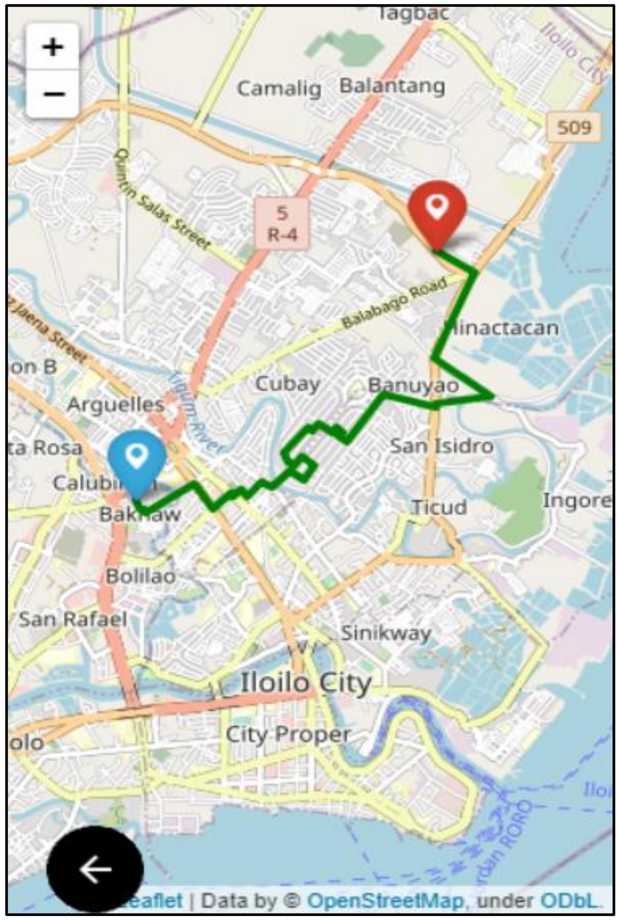


Figure 16. Bakhaw to Balabago with ACO, First Simulation

Figure 15 depicts an alternative route from Bakhaw, Mandurriao to Balabago, Jaro. The ACO algorithm generates an eastward path via Iloilo East Coast - Capiz Road, passing through E. Lopez Street and Commission Civil Street with curved sections from M.H del Pilar to Banuyao area.

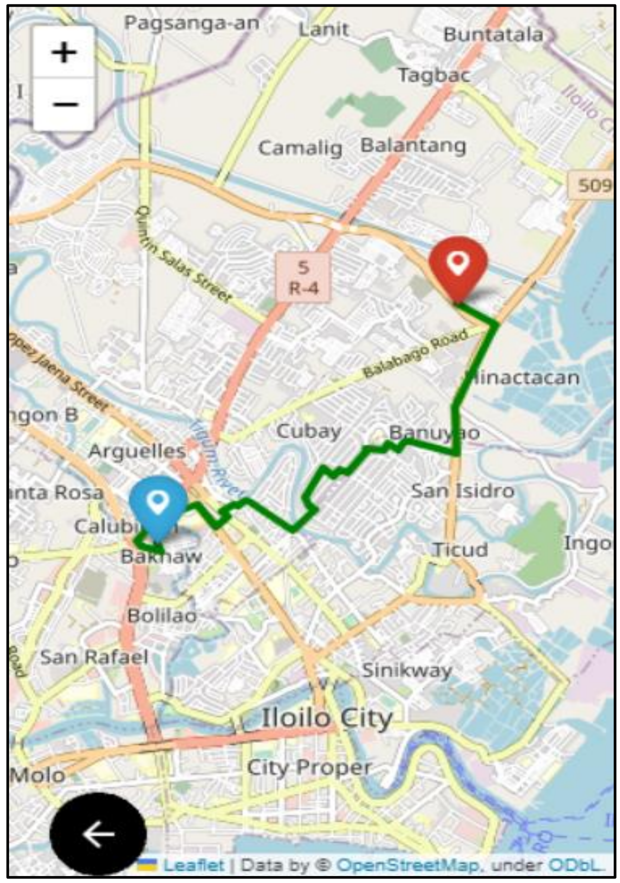


Figure 16. Bakhaw to Balabago with ACO, Second Simulation

Figure 16 depicts a second simulated alternative route from Bakhaw, Mandurriao to Balabago, Jaro using the ACO algorithm. The route includes a shift to E Lopez Street and passes through Tabuc Suba to Banuyao. Although the route differs from previous simulations, the travel time remains similar, taking approximately 13:55 minutes as validated by researchers.

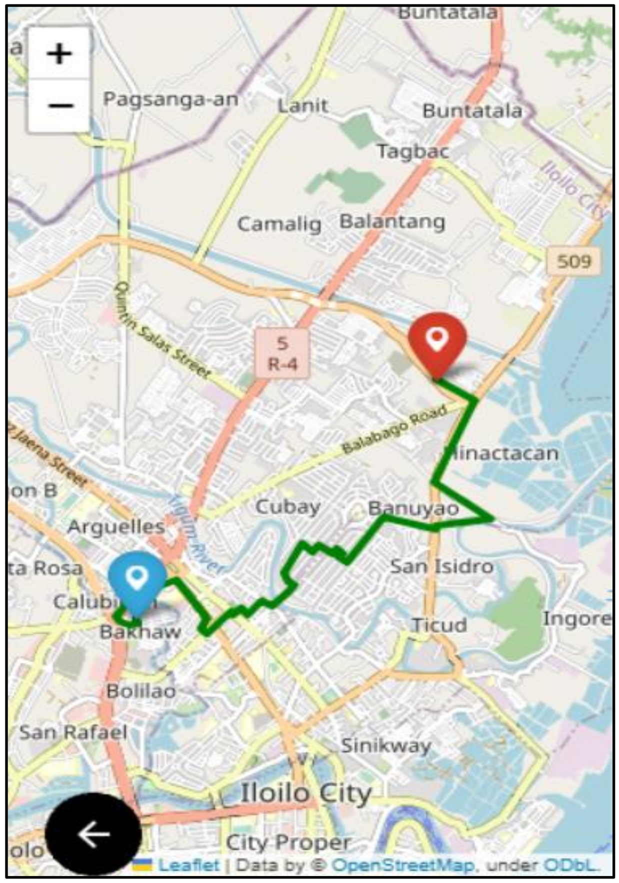


Figure 17. Bakhaw to Balabago with ACO, Third Simulation

Figure 17 displays the third simulated route from Bakhaw, Mandurriao to Balabago, Jaro. It has slight difference compared to the second simulation due to the nature of the ACO algorithm. The route includes numerous shift curves and a higher number of nodes. Notable curves are observed near E. Lopez Street and Burgos Street, with additional shifts occurring around Ledesco Avenue.

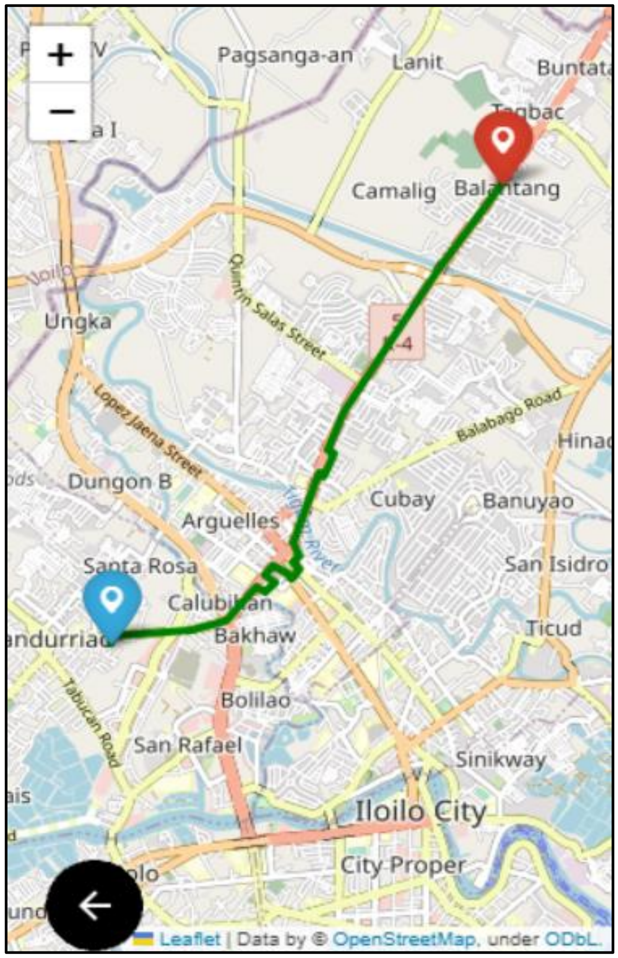


Figure 18. Abeto Mirasol to Balantang with ACO, First Simulation

Figure 18 depicts Abeto Mirasol Taft South, Mandurriao to Balantang, Jaro first ACO simulation. A route presented in a straight line with only one shift curve passing in E. Lopez Street to Commission Civil southeast of Cuartero upon validation of researchers.

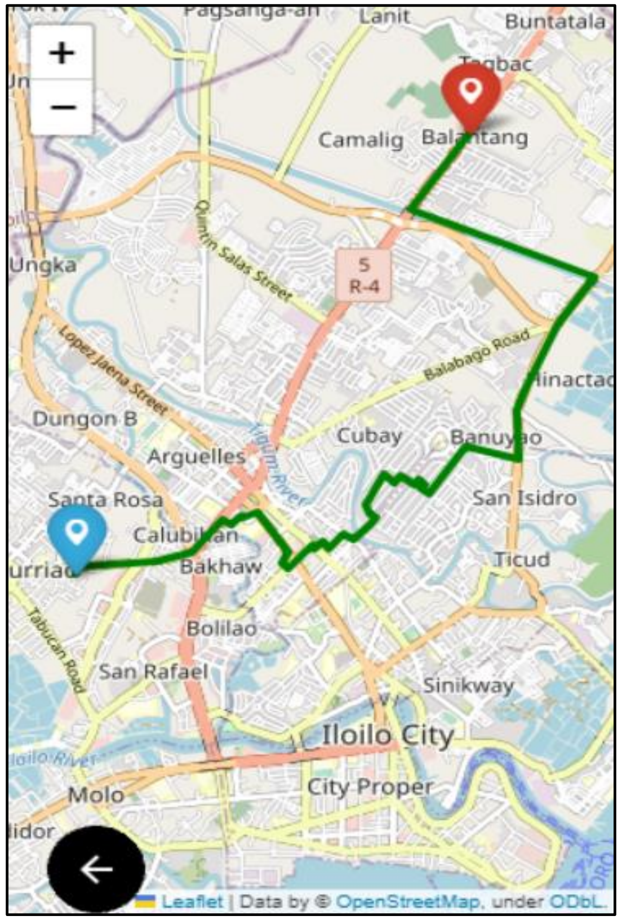


Figure 19. Abeto Mirasol to Balantang with ACO, Second Simulation

Figure 17 shows the second ACO simulation of the alternative route from Abeto Mirasol Taft South, Mandurriao to Balantang, Jaro. It differs from the first simulation by passing through Calubihan instead of Taft Street. The route contains 120 nodes, making it longer than the others.

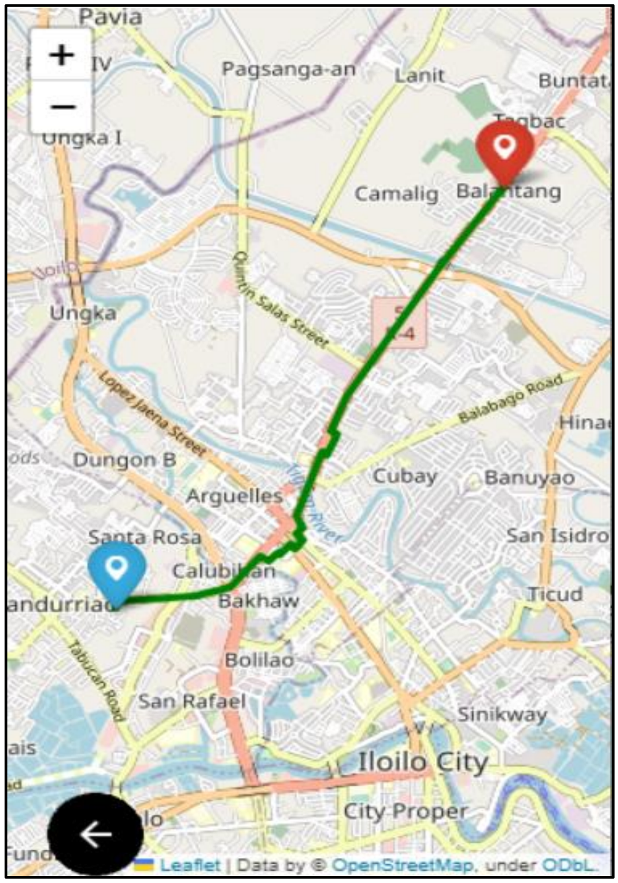


Figure 20. Abeto Mirasol to Balantang with ACO, Third Simulation

Figure 17 represents the final ACO simulation for the Abeto Mirasol to Balantang alternative route. The route differs from the previous simulation, taking a path through Cuartero and Taft Street with various shift curves. Each ACO simulation generates distinct results due to the algorithm's random route selection.

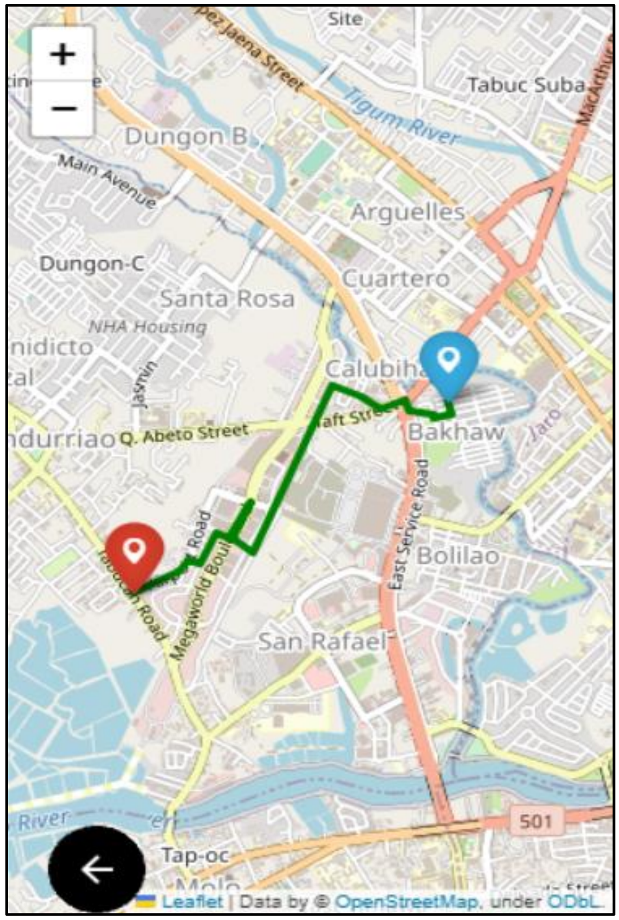


Figure 21. Bakhaw to Airport with ACO, First Simulation

Figure 21 presents the Bakhaw to Airport alternative with ACO first simulation. The route is the simulation result that runs through continuing to Iloilo City - Aleosan Road/Taft Street via Airport Road, which is the optimal route due to traffic conditions, and is validated by the researchers during the duration of the study but has restricted usage or private roads.

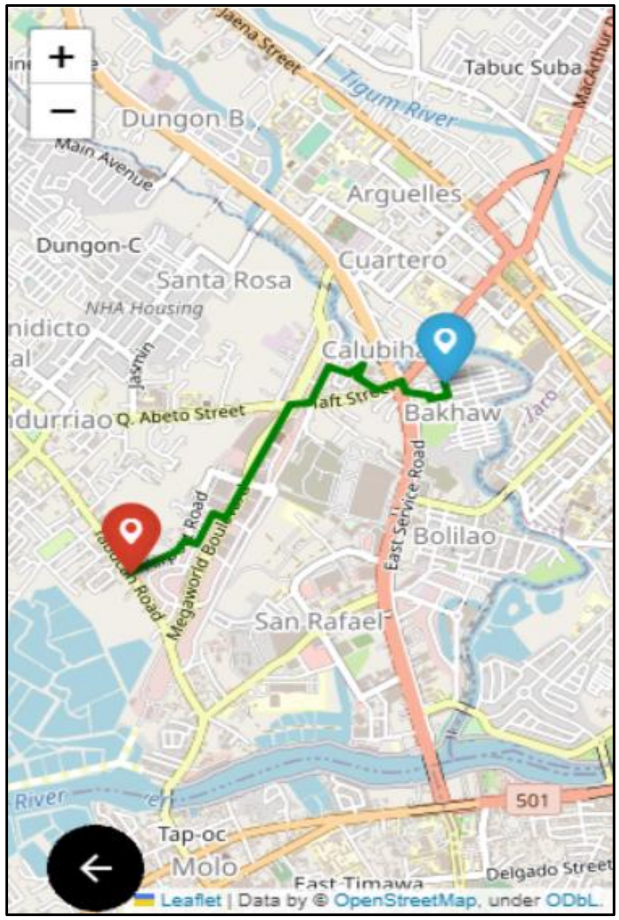


Figure 22. Bakhaw to Airport with ACO, Second Simulation

This figure depicts Bakhaw, Mandurriao to Airport alternative route with the primary data for the second ACO simulation. The generated result still passes via Airport Road but has a re-route continuing from Iloilo City - Aleosan Road/Taft Street going to Villa Alegre Road. The drafted node provided by ACO algorithm travels the optimal compared to the first and third simulation upon simulation.

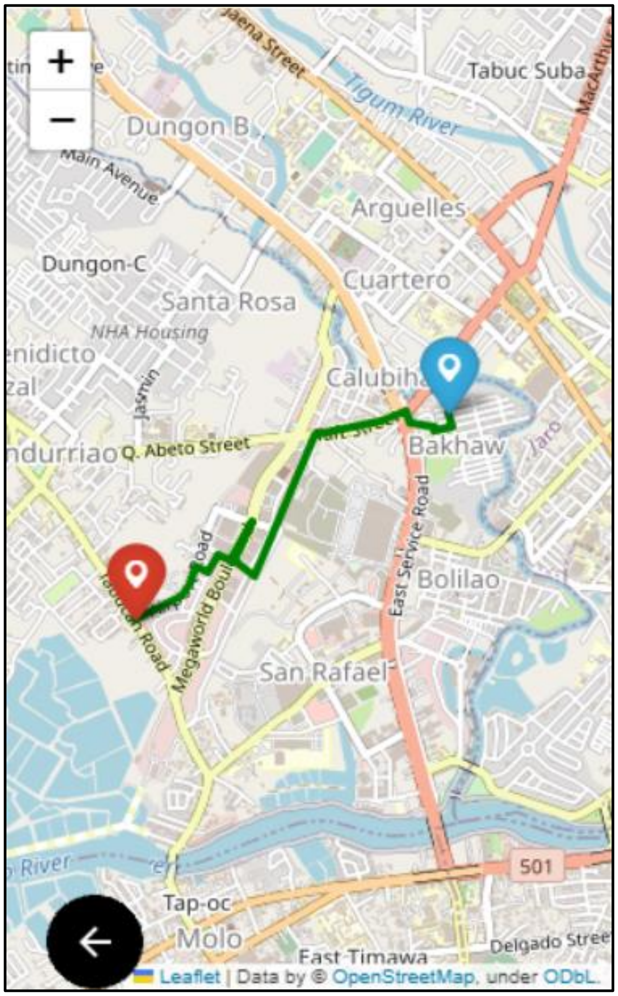


Figure 23. Bakhaw to Airport with ACO, Third Simulation

Figure 23 depicts the third ACO simulation of the alternative route. It includes re-route changes in the origin node, resulting in a different number of nodes compared to the previous simulations. However, the route still follows Iloilo City - Aleosan Road/Taft Street and passes through Megaworld Boulevard.

Figure 24. Aguinaldo to Balabago with ACO, First Simulation

The Aguinaldo, Lapuz to Balabago, Jaro alternative route first ACO simulation figure presents a simulated route that takes Divinagracia Street heading northeast toward Jereos Extension Road continuing Lopez Jaena Street. The generated alternative route travels via Coastal Road/Monfort Boulevard which is the optimal route due to traffic conditions.

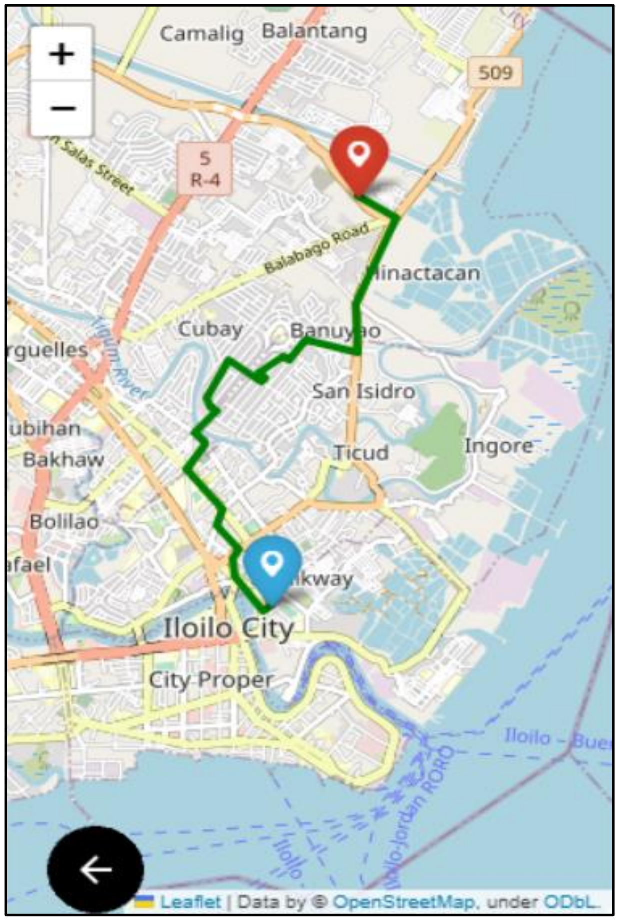


Figure 25. Aguinaldo to Balabago with ACO, Second Simulation

Figure 25, the second ACO simulation of the alternative route from Aguinaldo, Lapuz to Balabago, Jaro is presented. It differs from the first simulation due to the random route selection by the ACO algorithm. The route includes the Old Railroad Line, Huervana Street in Lapaz, and utilizes Iloilo Circumferential Road 1 in simulation.

Figure 26. Aguinaldo to Balabago with ACO, Third Simulation

Figure 26 is the third simulation of the Aguinaldo, Lapuz to Balabago, Jaro alternative route. The route still takes the Old Railroad Line traveled via Iloilo Circumferential Road 1 with a shift curve from Mabini Street to Burgos Street. Noticeable reroutes can be seen drafted past Banuyao, southwest of Hinactacan, Jaro going back to Coastal Road.

Table 2. Dijkstra Initial Results

Origin - Destination	Distance (m)	Nodes
Bakhaw - Airport	2,263	26
Bakhaw - Balabago	5,234	41
Aguinaldo - Balabago	9,085	31
Abeto Mirasol - Balantang	11,440	64

This table presents the origin and destination routes for the Dijkstra algorithm. Primary data were collected from five (5) origin- destination routes generating optimal routes for the initial simulation.

The initial results of the system using the Dijkstra algorithm, the average number of nodes is forty for an average distance of 7,005 meters.

Table 3. ACO Initial Results

Origin - Destination	Simulation	Distance (m)	Number of Nodes
Bakhaw - Balabago	1st	6621.6	44
	2nd	7748.1	59
	3rd	8733.3	55
Abeto Mirasol - Balantang	1st	10559.7	93
	2nd	10970.6	120
	3rd	12313.2	80
Bakhaw - Airport	1st	4218.2	48
	2nd	2820.8	32
	3rd	3815.8	36
Aguinaldo - Balabago	1st	7064.4	56
	2nd	8299.9	57
	3rd	8881.5	72

Data presented in the table were the initial simulation results generated by the ACO algorithm showing three different simulations from the five (5) from the previous Dijkstra algorithm simulation. The five (5) different origin-destination simulations were simulated finding the optimal alternative routes with different acquired distances and number of nodes. The simulations showed varying results with the nature of the ACO algorithm generating routes at random.

Table 5 is the summary of the ACO initial results simulated using four different origins and destinations around Iloilo City. The ACO was used to run a second simulation with the same origin and destination done on the Dijkstra. There are sixty-three average nodes on the average of 7,665 meters among four different origins and destinations which are simulated three times each. The system using ACO generates different results with each simulation since it searches for available routes at random.

Researchers have checked the routes based on the initial simulation of the optimal routes and found out that two routes were inaccessible due to rerouting for roadworks and on-going development in the area.

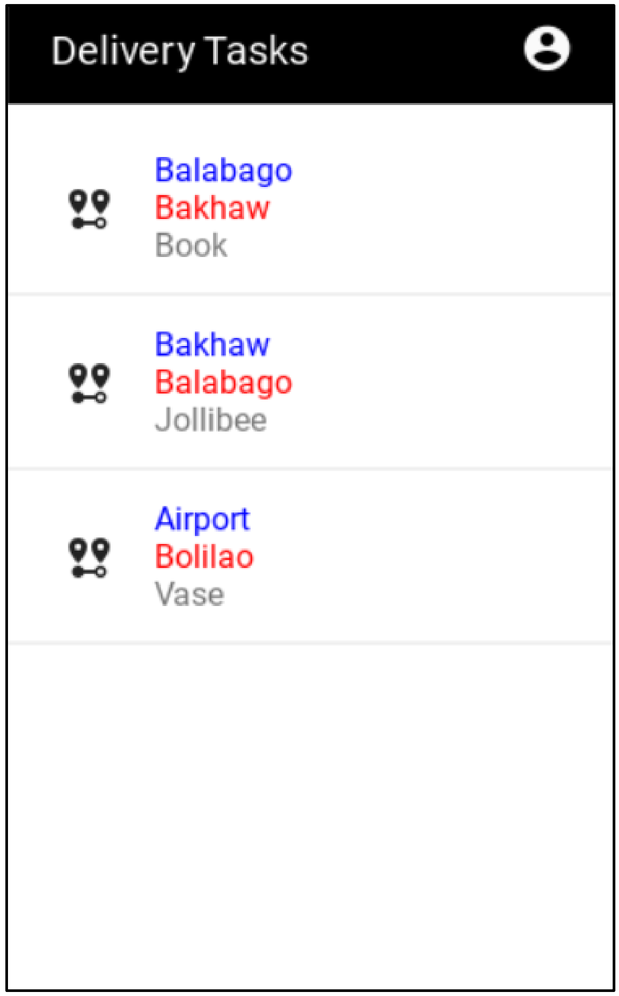


Figure 27. Scheduling

Figure 27 features scheduling where it is automated by the system. It follows specific rules where perishable goods are prioritized in the delivery schedule because they are more susceptible to damage than non-perishable goods. The items are divided into these two categories. Next, the non-perishable items were scheduled under the first-come, first-served approach. In addition, when the delivery person clicks one of the deliveries, the system will automatically calculate the estimated travel time from the origin to destination. It will also change the status of the delivery from pending to "*out for delivery*" automatically.

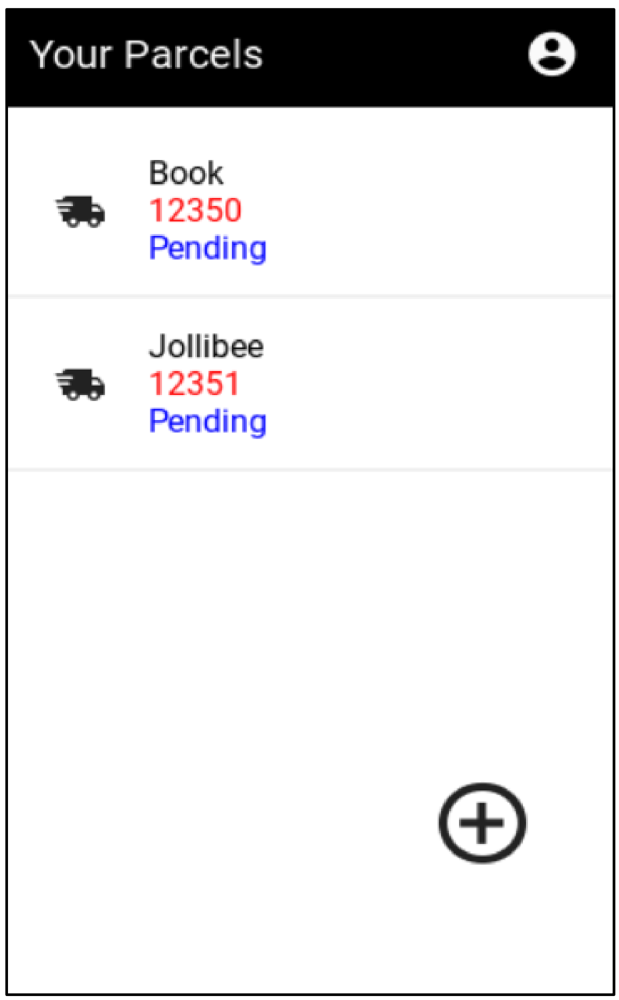


Figure 28. Monitoring

Figure 28 features monitoring, which can be seen on the end of customers for them to monitor the status of their incoming deliveries by providing a tracking number of their expected goods. The feature is designed to appear with the ordered items first, followed by the delivery status and the tracking number provided after the seller arranged the goods for delivery.

System Evaluation Results

The proposed system was evaluated by 20 randomly selected respondents to determine its quality using the eight criteria in the ISO 25010 standards: (1)functionality suitability - represents the extent to which a product or system provides functions that meet stated and implied needs when used under specific sub-conditions based on the functional completeness, functional correctness, functional appropriateness, functional suitability, functional interoperability, functional compliance, and functional security.

(2) Performance efficiency- represents the performance relative to the number of resources used under stated sub-

conditions based on time behavior, resource utilization, and capacity.

(3) Compatibility - degree to which a product, system or component can exchange information with other products, systems, or components, and/or perform its required functions while sharing the same hardware or software environment based on co-existence, interoperability, and operating system compatibility.

(4) Usability- Degree to which a product or system can be used by specified users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use based on appropriateness, recognizability, learnability, operability, user error protection, user interface aesthetics, and accessibility.

(5) Reliability - degree to which a system, product or component performs specific functions under specified conditions for a specified period of time based on maturity, availability, fault tolerance, and recoverability.

(6) Maintainability - degree of effectiveness and efficiency with which a product or system can be modified to improve it, correct it, or adapt it to changes in

environment, and in requirements based on modularity, reusability, analyzability, modifiability, and testability.

(7) Security - degree to which a product or system protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorization based on the confidentiality, integrity, non-repudiation, accountability, authenticity, modifiability, and testability.

(8) Portability - degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another based on the adaptability, installability, and replaceability. The table below shows the corresponding interpretation of likert scores that served as basis for the summary of results.

Table 4. Likert-like Scale of System Evaluation

Rating	**Mean Range**	**Descriptive Rating**
1	1.00 - 1.80	Strongly Disagree
2	1.81 - 2.60	Disagree
3	2.61 - 3.30	Agree
4	3.31 - 4.20	Strongly Agree
5	4.21 - 5.00	Very Strongly Agree

Table 4 is an overview of the instructions required to complete the evaluation for the study included in the survey questionnaire. The researchers included a list of inquiries to assess the system's or software's level of compliance with the ISO/IEC 25010 standard evaluation criteria and connected a demo video for easy reference. The respondents finished the evaluation by selecting a rating level in a column that matched their assessment, and also added comments, recommendations, and suggestions for the system's development.

Table 5. Initial Evaluation Interpreted Results

Measure	**Weighted Mean**	**Descriptive Rating**
Functionality Suitability	3.82	Strongly Agree
Performance Efficiency	3.76	Strongly Agree
Compatibility	3.79	Strongly Agree
Usability	3.72	Strongly Agree
Reliability	3.75	Strongly Agree
Maintainability	3.90	Strongly Agree
Security	3.70	Strongly Agree
Portability	3.86	Strongly Agree
Overall Mean	3.79	Strongly Agree

Table 5 presents the results of performance criteria evaluation of ISO Standard 25010 — which include functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability—were used to evaluate the system. The survey obtained preliminary findings that were scored and analyzed using a Likert-like scale and quantified by central tendency. The interpretation includes the weighted mean score as well as the ISO criterion evaluation of "Strongly Agree".

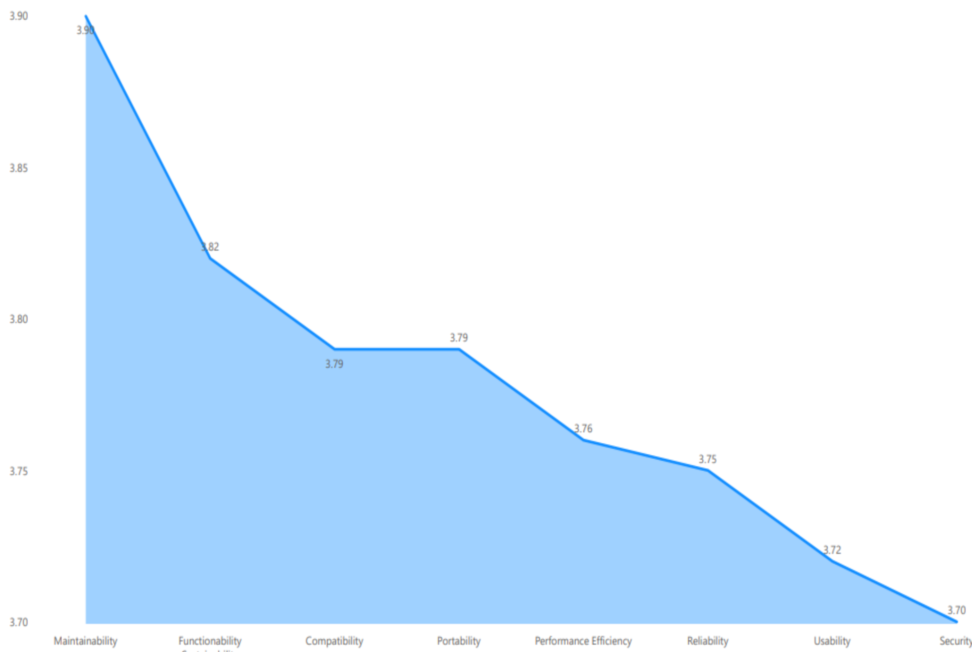


Figure 29. Standard Deviation of System Evaluation

Figure 29 is the Standard Deviation of the System Evaluation presented in a line graph to visualize the difference of the initial evaluation result. Calculations were extracted from the initial data done from the results of performance criteria evaluation of ISO Standard 25010.

Table 6. Final Evaluation Interpreted Results

Measure	**Mean**	**Descriptive Rating**
Functionality Suitability	4.03	Strongly Agree
Performance Efficiency	4.07	Strongly Agree
Compatibility	4.07	Strongly Agree
Usability	4	Strongly Agree
Reliability	4.05	Strongly Agree
Maintainability	3.92	Strongly Agree
Security	4.12	Strongly Agree
Portability	4.13	Strongly Agree
Overall Mean	4.05	Strongly Agree

Table 6 shows the final evaluation interpreted results. The final evaluation is the evaluation done by the experts who work in the logistics industry. Calculated data showed satisfactory results with an overall "strongly agree" rating. These results indicated an efficient implementation of the system that met the purpose of the study verified by experts' validation through evaluation.

Table 7. Dijkstra Simulations

Origin - Destination	Execution Time (s)	Number of Nodes	Travel Time (min)	Distance (km)
Bolilao-Bonifacio	32.97	101	20.17	10.05
MacArthur - Magdalo	2.87	10	2.26	0.8
Nonoy - Osmena	2.57	6	0.75	0.35
Ortiz - Quezon	22.47	105	14.94	8.86
Railway - Rizal	3.09	11	1.65	0.84
Roxas Village - San Agustin	4.06	16	2.81	1.5
San Antonio -San Jose	4.73	40	5.57	3.03
San Nicolas - San Pedro	8.07	72	18.58	8.45
Tacas - Taal	33.5	98	17.88	9.58
Ticud- Villa Anita	13.4	95	14.49	7.22
Yulo-Arroyo - Yulo Drive	14.32	123	17.32	9.52
Zamora Melliza - Ungka	17.7	112	19.69	10.21
Veterans village -West Timawa	4.71	52	9.66	4.91
Sambag - San Isidro	2.92	25	6.12	2.76

Nabitasan - Navais	6.1	47	10.9	4.93
Nonoy - Obrero-Lapuz	5.19	41	6.69	3.63
North Avancena - North Baluarte	4.15	33	5.99	3.48
North Fundidor - Onate de Leon	4.4	62	10.9	5.12
Maria Clara - Maria Cristina	7.29	85	13.21	7.48
Lopez Jaena - Magsaysay	6.86	68	10.95	6.59
Liberation - Kauswagan	2.8	16	2.3	1.41
Inday - Infante	2.75	16	2.66	1.41
Inggore - Jereos	2.41	38	12.56	4.93
Kasingkasing - Kahirupan	3.47	37	6.15	3.29
Hinactan - Hipodromo	8.04	79	17	8.32
Gloria - Flores	2.07	16	1.91	1.12
Fajardo - Gustilo	3.92	45	7.27	3.8
Dulonan - Dungon	19.78	115	16.41	9.5
Democracia - Desamparados	2.29	16	2.48	1.26
Camalig - Cochero	14.72	131	34.56	14.64
Average	8.79	57.03	10.461	4.98

Table 7 shows a comparison of thirty simulation results of Dijkstra algorithm, as Ugur and Ayden (2009) have performed over five simulations with intensity of the trail can be interpreted as an adaptive memory, measure of desirability and is called visibility which represents the heuristic function, number of population, and number of tours parameters. The simulations were from the remaining district areas of Iloilo city from the route samples used in initial tables above.

Table 8. ACO Simulations

Origin - Destination	Execution Time (s)	Nodes (Shortest Distance)	Time (min)	Distance (km)	Nodes (Shortest Time)	Time (min)	Distance (km)
Bolilao - Bonifacio	11.52	71	11.49	6.56	75	10.82	7.30
MacArtur - Magdalo	2.65	10	2.26	0.86	12	2.07	0.89
Nonoy - Osmena	2.48	6	0.75	0.35	6	0.75	0.35
Ortiz - Quezon	8.79	76	12.07	6.5	72	9.52	7.07
Railway - Rizal	2.72	7	0.85	0.47	7	0.85	0.47
Roxas Village - San Agustin	2.81	13	1.91	1.21	13	1.69	1.24
San Antonio -San Jose	4.91	32	4.71	2.78	32	4.71	2.78

San Nicolas - San Pedro	5.87	52	9.03	4.82	68	7.44	5.33
Tacas - Taal	7.6	68	12.95	7.93	79	10.46	9.11
Ticud-Villa Anita	4.66	39	9.17	4.74	39	8.48	4.87
Yulo-Arroyo - Yulo Drive	7.97	83	11.55	7.18	81	10.39	7.37
Zamora Melliza - Ungka	7.58	62	18.05	8.1	73	10.69	9.26
Veterans village - West Timawa	2.98	49	8.31	4.11	59	6.58	4.57
Sambag - San Isidro	2.29	25	6.7	2.67	30	4.58	2.7
Nabitasan - Navais	6.82	47	10.77	4.82	50	9.38	4.93
Nonoy - Obrero -Lapuz	6.44	34	6.27	3.44	32	6.21	
North	5.73	42	6.79	3.26	41	5.59	3.44

Avancena - North Baluarte							
North Fundidor - Onate de Leon	7.75	52	8.4	4.35	50	7.34	4.41
Maria Clara - Maria Cristina	6.38	48	7.45	5.05	57	6.93	5.17
Lopez Jaena - Magsaysay	11.77	50	5.67	4.59	50	5.67	4.59
Liberation - Kauswagan	3.19	13	2.23	1.3	14	2.23	1.3
Inday - Infante	3.08	10	1.72	0.89	10	1.72	0.89
Inggore - Jereos	6.08	37	8.22	3.87	41	8.21	4
Kasingkasing - Kahiru	4.64	27	3.58	2.19	27	3.58	2.19

pan							
Hinactan - Hipodromo	12.58	45	10.18	5.19	43	8.76	5.82
Gloria - Flores	2.64	9	1	0.5	9	1	0.5
Fajardo - Gustilo	7.64	51	6.44	2.98	49	4.92	3.03
Dulonan _ Dungon	12.61	107	15.4	7.6	95	12.63	8.59
Democracia - Desamparados	3.11	14	1.59	1.11	11	1.57	1.12
Camalig - Cochero	14.95	96	11.84	8.93	96	11.84	8.93
Average	6.34	42.50	7.25	3.95	44.03	6.22	4.21

Table 8 is the simulation of the ACO algorithm where Zhang et al. (2016) had performed twenty-four simulations to measure the performance of DA with source node, destination node, distance, speed, and traffic flow/vehicles parameters.

CHAPTER 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Proposed Study Design and Implementation

The proposed system was created for people to use their mobile phones for routing, monitoring, and scheduling purposes within the area of Iloilo City. It enables them to have shortened routes of delivery, ensured safety of goods, and reduced overall operational costs.

The system is a mobile application that incorporates monitoring, scheduling, and routing, utilizing OSMNX and NetworkX for node placement of map view using Javascript framework as the back-end of the system, Folium and Leaflet functions for the front-end, and Python as the local library. The study uses a meta-heuristic approach that combines Dijkstra Algorithm and Ant Colony Optimization creating a greedy algorithm that is competent to satisfy the cost priority of finding routes under constraints and complex conditions by simplifying the complex situation and improving efficiency.

Summary of Findings

The system using Dijkstra and Ant Colony Optimization algorithm was developed in finding the optimal and alternative routes within the system.

Python was the programming language used in creating the system. OSMNX and NetworkX were also used for node placements in the mapview using JavaScript for the backend. Leaflet and Folium, as well as the libraries in python were utilized for the backend.

The researchers conclude that the system is effective in finding the optimal and alternative routes.

The overall mean of 3.79 and an overall rating of "Strongly Agree", received in the partial evaluation of the system using the ISO Standard 25010, shows that the system was able to satisfy the software quality requirements in terms of functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

The system is still subject to further improvements.

Conclusions

The system enabled users to find the optimal route and travel with minimal time, monitor, and schedule deliveries via notification or map view on their mobile phone.

Therefore, the researchers conclude that:

1. The system was able to find the optimal route and help users to minimize the travel time and cost.
2. The implementation of the algorithm in the system was successful in finding the optimal route and alternative route.
3. According to partial evaluation results evaluated using ISO Standard 25010, the system was able to satisfy the software quality requirements of the said ISO standard.

Recommendations

Based on the observations of the respondents, thesis advisers and researchers, objectives were achieved but with certain constraints due to time restrictions and limited resources. The following are recommended:

1.) Integrate a dynamic map where the real-time location of the delivery driver can be visible on the other users during the delivery.

2.) It is recommended to make the system independent; that could work without requiring the internet.

3.) The system should try to cache a certain district of the destination route instead of searching the whole city coordinates and display nodes for origin and destination. Displaying a certain route within the specific district will enable a smaller data and shorter load time.

4.) The system should provide automated SMS notification for delivery status. Additional order status will be helpful as well.

5.) Future researchers should find a way to connect the system with road traffic systems for it to figure out which roads are inaccessible or congested in real-time.

References

Uğur, A., & Aydin, D. (2009). *An interactive simulation and analysis software for solving TSP using Ant Colony Optimization algorithms*, 40(5), 341–349. https://doi: 10.1016/j.advengsoft.2008.05.004

Calabrò, G., Torrisi, V., Inturri, G., & Ignaccolo, M. (2020). Improving inbound logistic planning for large-scale real-world routing problems: a novel ant-colony simulation-based optimization. *European Transport Research Review*, 12(1). https://doi.org/10.1186/s12544-020-00409-7

Chao, Y. (2010). A developed Dijkstra algorithm and simulation of urban path search. IEEE Education (ICCSE 2010) - Hefei, China (2010.08.24-2010.08.27)] 2010 5th International Conference on Computer Science & Education (), 1164–1167. doi:10.1109/iccse.2010.5593700

Convey Data: Retailers accelerate last mile investments. and on-time performance improves. (2021, June 29). Project44. Retrieved March 7, 2022, from https://www.getconvey.com/blog-d-carrierperformance-april-2021/

Dones, R. L. E., & Young, M. N. (2020). Demand on the of courier services during COVID-19 pandemic in the Philippines. *2020 7th International Conference on Frontiers of Industrial Engineering (ICFIE).* https://doi.org/10.1109/icfie50845.2020.9266722

Dorigo, M., Birattari, M. & Stutzle, T. (2006). Ant colony optimization. *IEEE Computational Intelligence Magazine*, 1(4), 28–39. https://doi.org/10.1109/mci.2006.329691

Guerrero, G., & Tapia, F. (2019). Mobile Application Based on Dijkstra’s Algorithm, to Improve the Inclusion of People with Motor Disabilities Within Urban Areas. *Advances in Intelligent Systems and Computing*, 219–229. https://doi.org/10.1007/978-3-030-16184-2_22

Hasan Basari, A. S. et al. (2017). Dijkstra-Ant Colony Optimization Algorithm for Shortest and Safest Evacuation in High Rise Building. *Jurnal Teknologi*,79(3).

Ingole, D., Mariotte, G., & Leclercq, L. (2020). Minimizing network-wide emissions by optimal routing through inner-city gating. *Transportation Research Part D: Transport and Environment*, 86, 102411. https://doi.org/10.1016/j.trd.2020.102411

Iqbal, M., Zhang, K., Iqbal, S., & Tariq, I. (2018). A fast and reliable Dijkstra algorithm for online shortest path. *International Journal of Computer Science and Engineering,*5(12),24-27.https://doi.org/10.14445/23488387/ijcse-v5i12p106.

Kumar, M. (2015, July 1). The famous algorithm that made navigation in Google Maps a reality. *Geoawesomeness*. Retrieved April 9, 2022, from https://geoawesomeness.com/the-famous-algorithm-that-made-navigation-in-google-maps-a-reality/

Ky Phuc, P. N., & Phuong Thao, N. L. (2021). Ant colony optimization for multiple pickup and multiple delivery vehicle routing problems with time window and heterogeneous fleets. *Logistics*, 5(2),28. https://doi.org/10.3390/logistics5020028

Liang, S., Jiao, T., Du, W., & Qu, S. (2021). An improved ant colony optimization algorithm based on context for tourism route planning. *PLOS ONE*, 16(9), e0257317. https://doi.org/10.1371/journal.pone.0257317

Mazareanu, E. (2021). Parcel traffic worldwide by sector 2015-2020. Statista. Retrieved March 7, 2022, from https://www.statista.com/statistics/737418/parcel-traffic-worldwide-by-sector/#statisticContainer.

Mercurio, R. (2020). Delivery service booming amid pandemic. Retrieved March 8, 2022, from https://www.philstar.com/business/2020/12/14/2063557/delivery-service-booming-amid-pandemic.

Nuanmeesri, S. (2020). Mobile application for the purpose of marketing, product distribution and location-based logistics for elderly farmers, Applied Computing and Informatics, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1016/j.aci.2019.11.001

Okdem, S., & Karaboga, D. (2009). Routing in Wireless Sensor Networks Using an Ant Colony Optimization (ACO) Router Chip. *Sensors*, 9(2), 909–921. https://doi.org/10.3390/s90200909

Özarık, S. S., Veelenturf, L. P., Woensel, T. V., & Laporte, G. (2021). Optimizing e-commerce last-mile vehicle routing and scheduling under uncertain customer presence. *Transportation Research Part E: Logistics and Transportation Review*, 148. https://doi.org/10.1016/j.tre.2021.102263

Rachmad, A., Syarif, M., Rochman, E. M. S. (n.d.). Application of ant colony optimization algorithm to determine optimal value in choosing tourist attractions in Bangkalan - Madura.https://simpelmas.trunojoyo.ac.id/backend/assets/uploads/lf/LF202110271635350928837.pdf?fbclid=IwAR1U3XFVT5YRhD120kuQdj8rR819gR3jQ0xJl2x2Is34DgT6Yg-Ij5lDiBo

Rahman, A. (2021). Introduction to ant colony optimization (ACO)- towards data science. *Medium*. Retrieved March 9, 2022, from https://towardsdatascience.com/the-inspiration-of-an-ant-colony-optimization-f377568ea03f/

Rahman, A. U. (2020). Introduction to Ant colony optimization(ACO). *Towards Data Science*. Retrieved March 6, 2022, from https://towardsdatascience.com/the-inspiration-of-an-antcolony-optimization-f377568ea03f

Sebayang, V. N. C. & Rosyida, I. (2022). Implementations of Dijkstra Algorithm for Searching the Shortest Route of Ojek Online and a Fuzzy Inference System for Setting the Fare Based on Distance and Difficulty of Terrain (Case Study: in Semarang City, Indonesia). *Advances in Computer Science Research*. https://doi.org/10.2991/acsr.k.220202.016

Tamura, Y. et. al., (2021). Ant Colony Optimization Using Common Social Information and Self-Memory. *Complexity*, 2021, 1–7. https://doi.org/10.1155/2021/6610670

Wang, P., Deng, H., Zhang, J., & Zhang, M. (2020). Real-time urban regional route planning model for connected vehicles based on V2X communication. *Journal of Transport and Land Use*, 13(1),517–538. https://doi.org/10.5198/jtlu.2020.1598

Wang, K., Peng, Y. F., Zhang, X. Q., & Yougar, D. (2018). Research on road finding under complicated constraints based on ant colony algorithm. DEStech Transactions on Computer Science and Engineering, cmee. https://doi.org/10.12783/dtcse/cmee2017/19981

Xing, H., et. al. (2022). An ACO for energy-efficient and traffic-aware virtual machine placement in cloud computing. *Swarm and Evolutionary Computation*, 68, 101012. https://doi.org/10.1016/j.swevo.2021.101012

Yu, L., Jiang, H., & Hua, L. (2019). Anti-congestion route planning scheme based on dijkstra algorithm for automatic valet parking system. *Applied Sciences*, 9(23), 5016. https://doi.org/10.3390/app9235016

Yu, X., Chen, W. N., Gu, T., Yuan, H., Zhang, H., & Zhang, J. (2019). ACO-A*: Ant Colony Optimization Plus A* for 3-D Traveling in Environments With Dense Obstacles. IEEE Transactions on Evolutionary Computation, 23(4), 617-631. https://doi.org/10.1109/tevc.2018.2878221

Appendices

Appendix A

Letter to the Adviser

Attachment 3

	INVITATION LETTER FOR ADVISER	Document No.	**WVSU-ICT-SOI-03-F03**
		Issue No.	**1**
		Revision No.	**0**
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	**April 27, 2018**
		Issued by:	**CICT**
		Page No.	**Page 1 of 1**

January 21, 2022

Mr. Louie F. Cervantes
MIS, Head
CICT - WVSU
Luna St. La Paz, Iloilo City 5000

Dear Mr. Cervantes,

The undersigned are BS in Computer Science Research 1/Thesis 1 students of CICT, this university. Our thesis/capstone project title is *"Traze: A Web-Based Real-Time Routing, Scheduling and Monitoring System for Delivery Services using Competitive Pulse Coupled Neural Network".*

Knowing of your expertise in research and on the subject matter, we would like to request you to be our **ADVISER**.

We are positively hoping for your acceptance. Kindly check the corresponding box and affix your signature in the space provided. Thank you very much.

Respectfully yours,

1. Batugon, Krisna Jean
2. Formento, Jean
3. Fuerte, Maria Arlyn
4. Morales, Jewel Joseph Jasper

PS:

Advisers, are task to work with the students in providing direction and assistance as needed in their thesis/capstone project. They shall meet with the students weekly or as needed to provide direction, check on progress and assist in resolving problems until such a time that the students passed their defenses and submit their final requirements, as well as, preparing their evaluations and grades.

Action Taken:

○ I Accept.

○ Sorry. I don't accept.

Signature over printed name of the Adviser

CC:

CICT Dean
Research Coordinator
Group
**To be accomplished in 4 copies*

Appendix B

Letter to the Co-Adviser

Attachment 3

	INVITATION LETTER FOR ADVISER	Document No.	**WVSU-ICT-SOI-03-F03**
		Issue No.	**1**
		Revision No.	**0**
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	**April 27, 2018**
		Issued by:	**CICT**
		Page No.	**Page 1 of 1**

January 21, 2022

Ms. Nerilou Dela Cruz
Instructor
CICT - WVSU
Luna St. La Paz, Iloilo City 5000

Dear Ms. Dela Cruz,

The undersigned are BS in Computer Science Research 1/Thesis 1 students of CICT, this university. Our thesis/capstone project title is *"Traze: A Web-Based Real-Time Routing, Scheduling and Monitoring System for Delivery Services using Competitive Pulse Coupled Neural Network".*

Knowing of your expertise in research and on the subject matter, we would like to request you to be our **ADVISER**.

We are positively hoping for your acceptance. Kindly check the corresponding box and affix your signature in the space provided. Thank you very much.

Respectfully yours,

1. Batugon, Krisna Jean
2. Formento, Jean
3. Fuerte, Maria Arlyn
4. Morales, Jewel Joseph Jasper

PS:

Advisers, are task to work with the students in providing direction and assistance as needed in their thesis/capstone project. They shall meet with the students weekly or as needed to provide direction, check on progress and assist in resolving problems until such a time that the students passed their defenses and submit their final requirements, as well as, preparing their evaluations and grades.

Action Taken:
- ◯ I Accept.
- ◯ Sorry. I don't accept.

Signature over printed name of the Adviser

CC:

CICT Dean
Research Coordinator
Group
**To be accomplished in 4 copies*

Appendix C

Recommendation Letter

	ADVISER'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F10
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **Technical Editor**, the attached manuscript of the thesis entitled:

Traze: A Real-Time Routing, Scheduling, and Monitoring Android Application for Delivery Services using Dijkstra Algorithm and Ant Colony Optimization

Said manuscript has been presented to me for preliminary evaluation and guidance, and after a series of corrections/directions given which was implemented by the proponents whose names are listed hereunder and their thorough research, we have come to its completion.

Now therefore, I hereby **ENDORSE** the said thesis manuscript to the Technical Editor for **TECHNICAL EDITING**.

Mr. Louie F. Cervantes
Adviser's Name & Signature

Date: April 24, 2023

Group Members:
1. Jean G. Formento
2. Krisna Jean D. Batugon
3. Maria Arlyn R. Fuerte
4. Jewel Josef Jasper C. Morales

Appendix D

Letter to the Technical Editor

	TECHNICAL EDITOR'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F11
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **English Editor**, the attached manuscript of the thesis entitled:

Traze: A Real-Time Routing, Scheduling, and Monitoring Android Application for Delivery Services using Dijkstra Algorithm and Ant Colony Optimization

Said manuscript was presented to me and was reviewed and edited in terms of technical specifications, correctness of diagrams and other technical matters. The corrections and suggestions was carried and implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** the said thesis manuscript to the English Editor/Grammarian for **English Grammar Editing.**

Frank I. Elijorde, DIT
Technical Editor's Name & Signature

Date: MAY 12, 2023

Group Members:
1. Krisna Jean D. Batugon
2. Jean G. Formento
3. Maria Arlyn R. Fuerte
4. Jewel Josef Jasper Morales

Appendix E

Letter the English Editor

	ENGLISH EDITOR/GRAMMARIAN'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F12
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **Thesis Format Editor**, the attached manuscript of the thesis entitled:

Traze: A Real-Time Routing, Scheduling, and Monitoring Android Application for Delivery Services using Dijkstra Algorithm and Ant Colony Optimization

Said manuscript was presented to me for English grammar editing, corrections has been made and the proponents whose names are listed hereunder implemented said corrections and changes in the revised manuscript.

Now therefore, I hereby **ENDORSE** the said thesis manuscript for **Thesis Format Editing**.

MRS. ANABELLE L. BAGA-AN
English Editor/Grammarian's Name and Signature

Date: May 26, 2023

Group Members:
1. Krisna Jean D. Batugon
2. Jean G. Formento
3. Maria Arlyn R. Fuerte
4. Jewel Josef Jasper Morales

Appendix F

Letter the Format Editor

	THESIS FORMAT EDITOR'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F13
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **Thesis Coordinator**, the attached manuscript of the thesis entitled:

Traze: A Real-Time Routing, Scheduling, and Monitoring Android Application for Deliver Services using Dijkstra Algorithm and Ant Colony Optimization

Said manuscript was presented to me and has checked the preliminaries, thesis document convention and end matters, made some corrections which was implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** said manuscript to the Thesis Coordinator for appropriate action.

DR. MA. LUCHE P. SABAYLE
Thesis Format Editor's Name and Signature

Date: 5/29/23

Group Members:
1. Krisna Jean D. Batugon
2. Jean G. Formento
3. Maria Arlyn R. Fuerte
4. Jewel Josef Jasper Morales

Note: *This form should be accomplished and signed if the corrections and changes made by the Thesis Format Editor have been implemented and the four (4) new copies have been printed ready for bookbinding.*

Appendix G
Program Source

Dijkstra Algorithm

```
ox.speed.add_edge_speeds(G, hwy_speeds=None, fallback=None,
precision=1)

ox.speed.add_edge_travel_times(G, precision=1)


def get_distance_cost(G, route):
    route = list(route)
    weight = 0
    for u,v in zip(route[:-1], route[1:]):
        leng = G[u][v][0]['length']
        weight += leng
    return weight
def get_time_cost(G, route):
    route = list(route)
    weight = 0
    for u,v in zip(route[:-1], route[1:]):
        leng = G[u][v][0]['travel_time']
        weight += leng
    return weight


def Dijkstra_fine(G,origin,destination, criteria =
'Distance'):
```

```
    # convert map nodes into index from 0 to length(nodes)
to simplify our algorithm

    n = len(G.nodes)

    map_nodes = list(G.nodes)

    # initial defination of the distance list with infinity
for all nodes and zero for source node

    dist = [math.inf] * n

    dist[map_nodes.index(origin)] = 0

    # mark all nodes as unvisited

    visited = [False] * n

    parent  = [None] * n

    while sum(visited) <= n:

        # index of the node of the minimum dist with
condition that it is not visited

        current_node = dist.index(min(dist[at] for at in
range(len(dist)) if visited[at]==False))

        # here, we will  terminate the searching after
reaching the the required destination

        if current_node == map_nodes.index(destination) :

            break

        # iterate over all neighbors of the current node

        for child in
nx.neighbors(G,map_nodes[current_node]):

            # get distance between currrent node and child
node

            distance = dist[current_node] +
func(G,map_nodes[current_node],child, criteria)

            # update minimum distance if the calculated
distnace is less than previous distance
```

```
            if distance < dist[map_nodes.index(child)]:
                dist[map_nodes.index(child)] = distance
                parent[map_nodes.index(child)] =
current_node
        visited[current_node] = True

    path = []
    path.append(map_nodes.index(destination))
    while path[-1] != None:
        path.append(parent[path[-1]])
    path.pop()
    path.reverse()
    return [map_nodes[i] for i in path]

def func(G, node1, node2, criteria):
    if criteria =='Distance':
        distance = G[node1][node2][0]['length'] # length
between the nodes
    elif criteria == 'Time':
        distance = G[node1][node2][0]['travel_time'] # time
between the nodes
    return distance
```

Ant Colony Optimization Algorithm

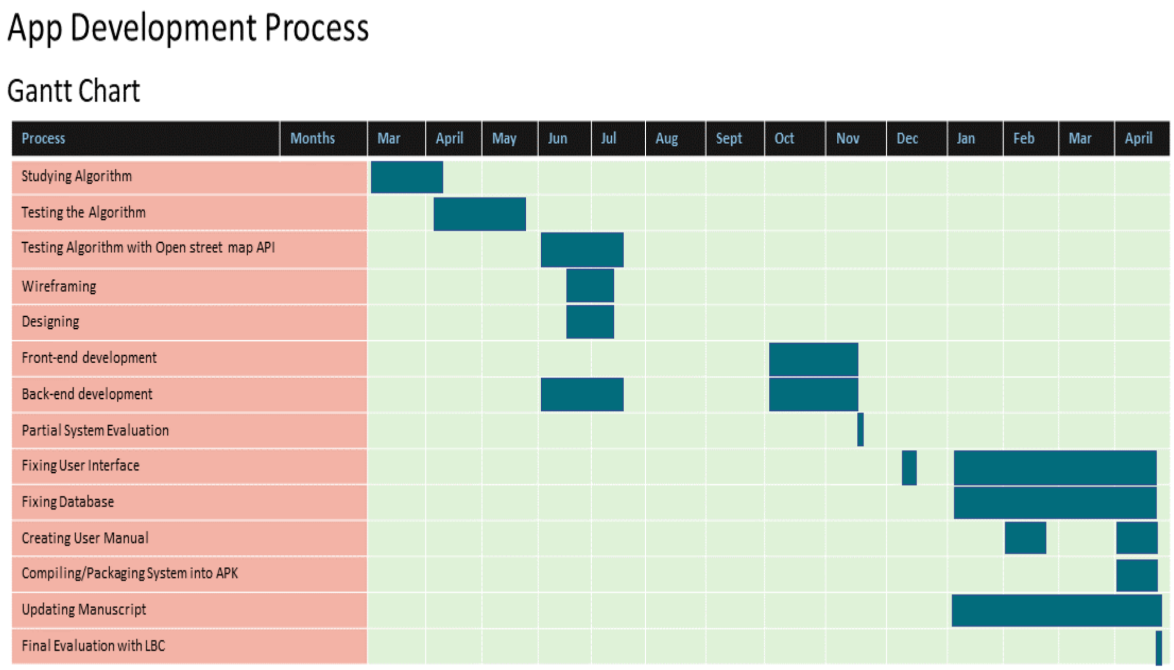
```
def pheremone(level, distance, alpha, beta):
    return level ** alpha * ((1/distance)) ** beta


for ant in tqdm(range(n)):
    # Place the ant at the colony
    frontier = [origin_node]
    explored = set()
    route = []
    found = False

    while frontier and not found:
        parent = frontier.pop(0)
        explored.add(parent)

        children = []
        children_pheremones = []
        for child in parent.expand():
            # If we see the destination, ignore all
pheremones
            if child == destination_node:
                found = True
```

```
                route = child.path()
                continue
            if child not in explored:
                children.append(child)
                children_pheremones.append(
                    pheremone(

pheremone_concentrations[(parent.osmid, child.osmid)],
                        child.distance,
                        alpha,
                        beta,
                    )
                )

        if len(children) == 0:
            continue  # The ant is stuck, go back.

        transition_probability = [
            children_pheremones[i] /
sum(children_pheremones)
            for i in range(len(children_pheremones))
        ]

        chosen = random.choices(children,
weights=transition_probability, k=1)[0]
```

```
        # Add all the non-explored children in case we need
to explore them later

        children.pop(children.index(chosen))

        frontier.extend(children)


        # Set the chosen child to be the next node to
explore

        frontier.insert(0, chosen)


    for u, v in zip(route[:-1], route[1:]):

        length_of_edge = G[u][v][0]['length']

        pheremone_concentrations[(u,v)] += Q/length_of_edge


    # If the route is newly discovered, add it to the list

    route = tuple(route)

    if route in known_routes:

        known_routes[route] += 1

    else:

        known_routes[route] = 1
```

Appendix H

Gantt Chart



Appendix I

Letter to Logistic Company

West Visayas State University
COLLEGE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Luna St., La Paz, Iloilo City 5000
Iloilo, Philippines
• Trunkline: (063) (033) 320-0870 loc 1403 • Telefax No.: (033) 320-0879
• Website: www.wvsu.edu.ph • Email Address: cict@wvsu.edu.ph

SOCOTEC ISO 9001 JAS-ANZ SCP000194Q

December 1, 2022

Nelson Gencaya
Team Head
LBC Express Gaisano Iloilo City Branch Office

To whom it may concern;

Greetings from West Visayas State University!

We are fourth-year WVSU - College of Information and Communications Technology students studying BS Computer Science. We are currently enrolled in Subject Thesis Writing 2 and are conducting a thesis study titled **"*Traze*: A Real-Time Routing, Scheduling, and Monitoring Android Application for Delivery Services Using Dijkstra Algorithm and Ant Colony Optimization."** Our group was advised to conduct interviews with companies relevant to our research. This interview will be used to compare specific information about your existing logistics system to our proposed system for rooms of improvement.

In this regard, given your expertise in the field, we would like to conduct an interview for the above-mentioned concern. We would also like to request permission to interview any of your available riders.

We look forward to your kind consideration and positive response to this invitation. Thank you very much.

Very truly yours,

Jean G. Formento
Group Leader

Group Members:
1. Maria Arlyn R. Fuerte
2. Krisna Jean D. Batugon
3. Jewel Josef Jasper C. Morales

Noted by:

Mr. Louie F. Cervantes
Thesis Adviser

Ms. Nerilou Dela Cruz
Thesis Co-Adviser

Dr. Ma Beth S. Concepcion
Dean, CICT

Appendix J

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JAS-ANZ
SOCOTEC
ISO 9001
SCP000194Q

December 1, 2022

PH Global Jet Express Inc.
Legal Affairs Department

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Dean, CICT

Appendix K

Letter to the Logistic Company

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Luna St., La Paz, Iloilo City 5000
Iloilo, Philippines
* Trunkline: (063) (033) 320-0870 loc 1403 * Telefax No.: (033) 320-0879
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SOCOTEC ISO 9001 JAS-ANZ SCP000194Q

December 1, 2022

Christian Michael Yee
City Manager
Unit 1 2nd Floor Galleria Altria,
Pasencia Pison Ave., San Rafael Mandurriao
Iloilo City, Iloilo 5000 PH

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3. Jewel Josef Jasper C. Morales

Noted by:

Mr. Louie F. Cervantes
Thesis Adviser

Ms. Nerilou Dela Cruz
Thesis Co-Adviser

Dr. Ma Beth S. Concepcion
Dean, CICT

Appendix L

Software Evaluation Form

TRAZE

TRAZE: A Real-Time Routing, Scheduling, and Monitoring Android Application using Dijkstra Algorithm and Ant Colony Optimization

krisnajean.batugon@wvsu.edu.ph Switch account

Not shared

* Indicates required question

PART II. Evaluation

After operating the capabilities of the system through viewing the demo, kindly evaluate the degree of compliance of the system/software based on ISO/IEC 25010 standard evaluation criteria. Please rate the level by choosing on the column that corresponds to your assessment. Use the scale below.

Numeric Value Equivalent Rating:

5 - Very Strongly Agree

4 - Strongly Agree

3 - Agree

2 - Disagree

1 - Strongly Disagree

A. Functional Suitability:

1. **Functional Completeness.** The system covers all the specified tasks and user objectives. *

	5	4	3	2	1
Row 1	○	○	○	○	○

2. **Functional Correctness.** The system provides the correct results with the needed degree of precision. *

	5	4	3	2	1
Row 1	○	○	○	○	○

3. **Functional Appropriateness.** The system facilitates the accomplishment of specified tasks and objectives. *

	5	4	3	2	1
Row 1	○	○	○	○	○

4. **Functional Suitability.** The system follows an appropriate set of specifications prior to the software function. *

	5	4	3	2	1
Row 1	○	○	○	○	○

5. **Functional Interoperability.** The system's software component can function to interact with other components or systems. *

	5	4	3	2	1
Row 1	○	○	○	○	○

6. **Functional Compliance.** The system addresses the compliant capability of the system. *

	5	4	3	2	1
Row 1	○	○	○	○	○

7. **Functional Security.** The system provides security to unauthorized access to the software functions. *

	5	4	3	2	1
Row 1	○	○	○	○	○

B. Performance Efficiency

1. **Time Behaviour.** The system's response and processing times and throughput rates when performing its functions, meet requirements. *

	5	4	3	2	1
Row 1	○	○	○	○	○

2. **Resource Utilization.** The system's amounts and types of resources used when performing its functions, meet requirements. *

	5	4	3	2	1
Row 1	○	○	○	○	○

3. **Capacity**. The system's maximum limits of parameters meet requirements. *

	5	4	3	2	1
Row 1	○	○	○	○	○

C. Compatibility

1. **Co-existence.** The system can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product. *

	5	4	3	2	1
Row 1	○	○	○	○	○

2. **Interoperability**. The system can exchange information and use the information that has been exchanged. *

	5	4	3	2	1
Row 1	○	○	○	○	○

3. **Operating System Compatibility.** The system can smoothly run on the operating system that it is installed to. *

	5	4	3	2	1
Row 1	○	○	○	○	○

D. Usability

1. **Appropriateness Recognizability.** The system allows users to recognize if it is appropriate for their needs. *

	5	4	3	2	1
Row 1	○	○	○	○	○

2. **Learnability.** The system can be used by specified users to achieve specified goals of learning to use the application with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use. *

	5	4	3	2	1
Row 1	○	○	○	○	○

3. **Operability**. The system has attributes that make it easy to operate and control. *

	5	4	3	2	1
Row 1	○	○	○	○	○

4. **User Error Protection.** The system protects users against making errors. *

	5	4	3	2	1
Row 1	○	○	○	○	○

5. **User Interaction Aesthetics.** The system's user interface enables pleasing and satisfying interaction for the user. *

	5	4	3	2	1
Row 1	○	○	○	○	○

6. **Accessibility.** The system can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use. *

	5	4	3	2	1
Row 1	○	○	○	○	○

E. Reliability

1. **Maturity.** The system meets the needs for reliability under normal operation. *

	5	4	3	2	1
Row 1	○	○	○	○	○

2. **Availability.** The system is operational and accessible when required for use. *

	5	4	3	2	1
Row 1	○	○	○	○	○

3. **Fault Tolerance.** The system operates as intended despite the presence of hardware or software faults. *

	5	4	3	2	1
Row 1	○	○	○	○	○

4. **Recoverability.** The system can recover the data directly affected and re-establish the desired state. *

	5	4	3	2	1
Row 1	○	○	○	○	○

F. Security

1. **Confidentiality.** The system ensures that data are accessible only to those authorized to have access. *

	5	4	3	2	1
Row 1	○	○	○	○	○

2. **Integrity**. The system prevents unauthorized access to, or modification of, computer programs or data. *

	5	4	3	2	1
Row 1	○	○	○	○	○

3. Non-repudiation. The system can be proven to have taken place, so that the events or actions cannot be repudiated later. *

	5	4	3	2	1
Row 1					

4. Accountability. The system ensures that the requirement for actions of an entity to be traced uniquely to that entity. *

	5	4	3	2	1
Row 1					

5. **Authenticity.** The system subject identity is proved to be the one claimed. *

	5	4	3	2	1
Row 1					

G. Maintainability

1. Modularity. The system is composed of discrete components such that a change to one component has minimal impact on other components. *

	5	4	3	2	1
Row 1	○	○	○	○	○

2. **Reusability.** The system assets can be used in more than one system, or in building other assets. *

	5	4	3	2	1
Row 1	○	○	○	○	○

3. **Analysability**. The system is effective and efficient with which it is possible to assess the impact of an intended change to one or more of its parts, or shows diagnosis for deficiencies or causes of failures, or provided identified parts to be modified. *

	5	4	3	2	1
Row 1	○	○	○	○	○

4. **Modifiability.** The system can be effectively and efficiently modified without introducing defects or degrading existing product quality. *

	5	4	3	2	1
Row 1	○	○	○	○	○

5. **Testability.** The system is effective and efficient with which test criteria is established for a system, and showed a tested performance determining that the criteria have been met. *

	5	4	3	2	1
Row 1	○	○	○	○	○

H. Portability

1. **Adaptability.** The system can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments *

	5	4	3	2	1
Row 1	○	○	○	○	○

2. **Installability.** The system is effective and efficient and in a successful installation and/or uninstallation in a specified environment. *

	5	4	3	2	1
Row 1	○	○	○	○	○

3. **Replaceability.** The system can serve as a replacement for another specified software product for the same purpose in the same environment. *

	5	4	3	2	1
Row 1	○	○	○	○	○

Comments, Suggestions, Recommendations

Your answer

Appendix J

Disclaimer

This Android application and its corresponding documentation entitled ***Traze: A Real-Time Routing, Scheduling, and Monitoring Android Application for Delivery Services using Dijkstra Algorithm and Ant Colony Optimization*** is submitted to the College of Information and Communications Technology, West Visayas State University, in partial fulfillment of the requirements for the degree, Bachelor of Science in Computer Science. It is the product of our own work, except where indicated text.

We hereby grant the College of Information and Communications Technology permission to freely use, publish in local or international journal/conferences, reproduce, or distribute publicly the paper and electronic copies of this android application and its corresponding documentation in whole or in part, provided that we are acknowledged.

Jean G. Formento
Krisna Jean D. Batugon
Maria Arlyn Fuerte
Jewel Josef Jasper C. Morales
June 2023