GoDavao: A Ridesharing App in Davao City

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ABSTRACT

Urban transportation systems in cities like Davao face persistent challenges, including traffic congestion, inefficient route planning, and suboptimal vehicle utilization, leading to increased travel times and commuter frustration. Existing ridesharing services often operate on a rigid point-to-point model, failing to capitalize on opportunities to dynamically group passengers traveling along similar paths. This could significantly improve efficiency and reduce costs. This study addresses this gap by proposing the design and evaluation of a dynamic ridesharing platform concept specifically for the context of Davao City. Leveraging information system technologies such as Geographic Information Systems (GIS) and optimization algorithms (e.g., a Heuristic-Based Matching Algorithm and Dijkstra's Algorithm), the platform aims to dynamically group passengers based on their location and destination and optimize vehicle routes to accommodate multiple riders efficiently. While a full implementation is beyond the scope, the conceptual design incorporates features related to dynamic pricing and safety to enhance fairness, transparency, and user trust in the model. The research investigates the feasibility and potential impact of such a system in mitigating traffic issues, reducing transportation costs for commuters and drivers, and improving the overall urban mobility experience in Davao City through real-world testing and conceptual evaluation. The expected outcome is a detailed conceptual design and a limited-scope prototype demonstrating the core functionalities of dynamic passenger matching, illustrating how data-driven approaches can lead to more efficient ridesharing solutions tailored to the needs of Davao City.

Keywords: Ridesharing, Davao City, Urban Mobility, Passenger Matching, Route Optimization, Transportation Efficiency, Information Systems, GIS, Heuristic Algorithm, Dynamic Ridesharing.

Chapter 1

Introduction

This chapter presents the background of the study, outlining the context and existing landscape of ridesharing, followed by the problem statement formulated as research questions that the research aims to address. It then details the specific, measurable objectives to be achieved, discusses the significance of the study to various stakeholders, and defines the scope and limitations that set the boundaries of this research. It provides the foundation and context for the proposed dynamic ridesharing system concept focused on improving urban transportation efficiency in Davao City through optimized passenger matching for efficient pickups.

1.1 Background of the Study

Rapid urbanization and population growth in metropolitan areas worldwide, including Davao City, have put immense pressure on transportation infrastructure. This has resulted in significant challenges such as chronic traffic congestion, increased travel times, higher fuel consumption, and environmental pollution (Garcia & Santos, 2021; ResearchGate, 2025). Traditional public transportation systems and conventional taxi services often struggle to meet the dynamic demands of commuters efficiently.

The emergence of ridesharing applications has provided an alternative mode of transportation, offering convenience and flexibility. Existing literature highlights various algorithm-based ride-matching techniques to connect drivers with passengers (Makhdomi & Gillani, 2024; Sakthivelu & Jayakrishnan, 2024). Research also explores methods for analyzing ride demand and supply, aiming for better balance and resource allocation within ride-hailing networks (Makhdomi & Gillani, 2024; MDPI, 2023). Furthermore, studies on network effects discuss how the growth in users (both riders and drivers) on a platform can contribute to its scalability and reliability (ResearchGate, 2023; ResearchGate, 2025).

However, many current ridesharing models focus on one-to-one passenger-to-vehicle matching based on point-to-point requests. While this offers personalized travel, it often leads to vehicles carrying only one passenger for a significant portion of a trip, contributing to the number of cars on the road and potentially exacerbating congestion, especially during peak hours. There is a lack of widespread implementation of ridesharing systems that can dynamically adapt to real-time conditions and intelligently match passengers for efficient pickups along a driver's existing or planned route to maximize vehicle occupancy and minimize added travel time and distance, particularly in the context of urban environments like Davao City. This gap represents an opportunity to develop a more efficient and sustainable ridesharing model focused on intelligent pickup matching.

This gap is compounded by the challenge of effectively integrating and modeling localized, dynamic traffic data to accurately calculate pickup feasibility and estimated arrival times. Furthermore, research indicates a need for better methods to balance system efficiency (regarding pickup optimization) with user fairness (both driver and passenger, regarding acceptable detours or wait times) when implementing dynamic on-route matching. Additionally, there is a need to understand user acceptance and perceived value, specifically of the on-route ridesharing model within the Davao City context, and to design user-friendly and informative GIS visualizations that effectively support drivers in identifying and navigating efficient pickups. These specific challenges represent key research gaps that this study aims to investigate.

There is also research on pricing strategies in ride-hailing, including real-time dynamic pricing models that adjust fares based on demand and supply to incentivize drivers and manage passenger flow (SciELO, 2019; TRISTAN 2025, 2025). The implications of using cloud-based systems for fare calculation on transparency and fairness have also been examined (FasterCapital, n.d.; ijmrset, n.d.). Furthermore, the literature addresses safety and user trust in digital platforms (MDPI, 2024; ResearchGate, n.d.). Various theoretical frameworks, such as the Technology Acceptance Model (TAM) or theories related to perceived risk and trust, have been applied to understand the relationship between safety features and passenger trust (ResearchGate, n.d.; University of Southampton, 2024). Research on ridesharing in the Philippines highlights driver tactics and the local context (ResearchGate, n.d., Drivers' Tactics; UP NCTS, 2024).

Despite advancements in these areas, integrating these elements into a cohesive platform focused on dynamically and efficiently matching passengers for pickups along existing routes tailored to the unique traffic patterns and user needs of a city like Davao remains challenging. The existing systems often address these aspects in isolation rather than as components of a unified, efficiency-focused shared-ride model centered on intelligent pickup matching. Studies on urban transportation challenges in Davao City underscore the need for improved public transport alternatives and address accessibility disparities (Cognizance Journal of Multidisciplinary Studies, n.d.; ResearchGate, 2025).

In the context of Davao City, where urban sprawl continues and traffic volume increases, the need for innovative transportation solutions is exceptionally pressing. A ridesharing system that moves beyond the traditional point-to-point model towards a more dynamic, shared-ride approach focused on optimizing the matching of passengers for efficient on-route pickups while also conceptually incorporating robust safety and transparent pricing mechanisms holds the potential to not only offer a cheaper alternative to conventional taxis but also contribute significantly to reducing the number of vehicles on the road, lowering carbon emissions, and providing a more sustainable and less stressful commuting experience for its residents. This study anchors on the premise that a data-driven, dynamically optimized matching platform for efficient pickups can solve some of Davao City's pressing urban transportation challenges.

1.2 Problem Statement

The current urban transportation landscape in Davao City, including existing ridesharing services, faces several critical issues related to efficiency, cost, and trust. This study addresses these problems by investigating the design and potential implementation of a dynamic ridesharing platform for Davao City that employs real-time passenger matching techniques. Specifically, this study aims to answer the following research questions:

- How can a dynamic ridesharing platform be effectively designed and conceptualized for the context of Davao City?

- **Efficiency & Ride Availability:**
    - What ride-matching techniques and route optimization algorithms best influence the efficiency of an on-route pickup ridesharing service in Davao City?
    - How can the platform efficiently manage and respond to fluctuating passenger hailing requests and driver availability within a dynamic ridesharing system in Davao City?
- **Pricing & Economic Sustainability:**
    - How does real-time dynamic pricing impact user perception and market competitiveness of a ridesharing platform in Davao City?
    - What are the implications of cloud-based fare calculation systems on pricing transparency and fairness for users and drivers in Davao City?
- **Safety & User Trust:**
    - How do potential users in Davao City perceive the influence of proposed digital security measures and in-app safety features on their trust in a dynamic ridesharing application?

1.3 Objectives of the Study

The main objective of this study is to design and evaluate a dynamic ridesharing platform concept for Davao City that improves transportation efficiency, alleviates the traffic problem occuring in Davao City, lessens pollution caused by vehicle emissions, enhances fare predictability, and improves user safety through real-time passenger clustering and dynamic pricing, and integrated safety features.

Specifically, this study aims to achieve the following objectives:

- **To analyze the transportation challenges faced by commuters in Davao City** through surveys, interviews, and literature review.
- **To design a user-friendly mobile interface** that enables commuters to easily register, book rides, and offer rides using location-based services.
- **To implement core features of the ridesharing app** including user authentication, ride posting, ride matching, in-app messaging, and route tracking.
- **To integrate map-based navigation and geolocation services** using tools such as Google Maps API to assist drivers and passengers in locating pickup and drop-off points.
- **To test the functionality and usability of the prototype** through user testing sessions and gather feedback for improvements.

  To evaluate the app’s performance, usability, and effectiveness in addressing local commuting problems using a set of predefined criteria and user satisfaction surveys.

1.4 Significance of the Study

This study expects to yield significant benefits to various stakeholders in Davao City:

- **For Commuters:** The proposed system aims to provide a more affordable and potentially faster transportation option by facilitating shared rides and optimized driver finding, reducing travel time and cost. Enhanced safety features and transparent pricing will also improve the user experience.
- **For Drivers:** By optimizing route pickups and increasing passenger occupancy per trip, drivers can potentially increase their earnings and reduce fuel consumption and operational costs. Improved safety measures also benefit drivers.
- **For the Local Government:** The study's findings can provide insights into how technology-driven ridesharing solutions can help alleviate traffic congestion, reduce carbon emissions, and contribute to developing a more sustainable urban transportation system in Davao City.
- **For Future Researchers and Developers:** This study will contribute to the body of knowledge on dynamic ridesharing systems, particularly in developing urban environments, providing a foundation for future research and development in this area.

1.5 Scope and Limitations

Scope: This study focuses on designing and conceptualizing a dynamic ridesharing platform for Davao City, incorporating real-time passenger matching using a heuristic-based algorithm, dynamic route calculation with Dijkstra's, GIS visualization, and conceptually addressing dynamic pricing and key safety features. It will primarily involve:

- **Core Features:**
    - User Registration and Profiles: Basic functionality for users (passengers and drivers) to create accounts.
    - Passenger Ride Request: The passenger can input their pickup location and destination.
    - Driver Availability Status: Drivers can set their status (available/unavailable).
    - Real-time Location Tracking (GIS-based): Displaying the real-time location of available drivers and the passenger (once a ride is requested) on a map interface.
    - Dynamic On-Route Passenger Matching (Heuristic-Based): The core logic for identifying available drivers whose current route is compatible with a new passenger's request and applying heuristic rules to determine the best match.
    - Ride Offer Notification (Driver): Notifying a driver when a potential on-route match is found, including details about the passenger and detour.

    - Ride Acceptance/Rejection (Driver): The Driver can accept or reject a ride offer.
    - Dynamic Route Calculation (Dijkstra's based): Calculating the optimal route for a driver, including dynamically updating the route to incorporate accepted on-route pickups and subsequent drop-offs.
    - In-App Navigation Guidance (GIS Visualization): Displaying the calculated route on the driver's map interface with visual cues for navigation, pickup points, and drop-off points. This includes the specifically designed and qualitatively evaluated GIS visualizations.
    - Ride Progress Tracking (Passenger): Displaying the driver's location and the planned route on the passenger's map once a match is accepted.
- **Conceptual Features:**
    - Dynamic Pricing Mechanism: The logic and rules for adjusting fares in real-time based on factors like demand (observed through request volume), supply, distance, time, and potential detours for shared rides.
    - Fare Calculation and Display: Showing the calculated fare to the passenger (potentially an estimate before the ride and final after).
    - Digital Payment Integration: Mechanisms for handling payments through digital wallets (e.g., PayMongo, GCash, GrabPay) or other methods.
    - User Authentication and Security: Robust login, password management, and data protection measures.
    - Driver Verification: Processes for verifying driver identity and background.

    - In-App Emergency Button: A feature for users to quickly contact emergency services or the platform's support.
    - Ride History and Receipts: Access to past trip details and payment receipts.
    - Driver/Passenger Rating and Review System: Allowing users to rate and review each other after a trip.

Limitations: This study is subject to the following limitations:

- **Data Availability:** The availability of extensive real-time traffic, granular passenger demand, and historical pricing data for Davao City may limit the precision of the conceptual analysis for features not fully prototyped.
- **External Factors:** The study's analysis of potential impact may not fully account for all external factors influencing transportation, such as road closures, accidents, changes in local transportation regulations, or market competition from existing services.
- **Specific Vehicle Types:** The study may initially focus on a specific type of vehicle (e.g., 4-wheeled vehicles) and may not cover all potential modes of ridesharing (e.g., motorcycles) unless specified within the design.
- **Comprehensive Safety System:** While key safety features are included conceptually, developing a comprehensive, legally compliant safety and security framework for a real-world application is a complex task beyond this design-focused study's scope.
- **Handling of Cases and Exceptions:** The complexity of real-world scenarios, such as multiple simultaneous ride requests in the exact location, unexpected

road closures not reflected in traffic data, passenger cancellations after a detour has begun, or driver issues, presents operational complexities that the prototype may only address at a basic level.

Chapter 2: Review of Related Literature and Studies

This chapter reviews relevant literature and studies related to ridesharing, urban transportation, optimization algorithms, machine learning techniques, and Geographic Information Systems (GIS). Based on the scope and timeframe of this capstone project, the review concentrates on technologies and concepts deemed most critical and feasible for designing and evaluating a dynamic ridesharing platform concept for Davao City, with a primary focus on optimizing passenger matching for efficient pickups. It is structured to move from general concepts to more specific applications, highlighting problems addressed, achievements made, and recommendations for future work within these areas, ultimately focusing on how these relate to the particular context and chosen methods for this study in Davao City and addressing identified research gaps. The technologies and concepts retained for focus in this review are Heuristic-Based Matching Algorithms (with consideration of Genetic Algorithms as an advanced approach), Dijkstra's Algorithm / Search for cost calculation, Geographic Information Systems (GIS) for spatial context and visualization, and the critical aspect of User Perception and Acceptance of on-route ridesharing.

I. Ridesharing Technologies, Algorithms, and Methods

The efficiency and effectiveness of modern ridesharing platforms are heavily reliant on applying sophisticated algorithms, machine learning techniques, and spatial information systems. This section explores recent advancements and applications in the key areas relevant to this study within the general domain of ridesharing, highlighting their capabilities and limitations in the context of dynamic, on-route passenger matching.

Algorithms for Ridesharing

Various algorithms tackle core ridesharing challenges, including matching drivers with passengers and optimizing routes for multiple stops. The matching process is particularly complex for dynamic ridesharing with on-route pickups, requiring efficient algorithms that can operate in real-time.

Heuristic-Based Matching Algorithms for On-Route Pickups

- **Problems:** Efficiently pairing drivers with new passenger requests in real-time, especially when the driver is already on a trip and potential pickups are along their route, presents a complex, dynamic optimization challenge. Exact algorithms can be computationally prohibitive for large-scale, real-time systems (Masoud & Jayakrishnan, 2017; ResearchGate, n.d., A Matching Algorithm). While Genetic Algorithms offer a powerful optimization approach, heuristic methods are often favored in practice for their speed and feasibility in dynamic environments (Masoud & Jayakrishnan, 2017; CEUR-WS.org, 2025).
- **Achievements (Results):** Heuristic-based matching algorithms utilize predefined rules and criteria to evaluate potential driver-passenger pairings for on-route pickups quickly. These methods aim to find "good enough" solutions efficiently by applying rules based on factors such as the maximum acceptable detour time or distance for the driver and existing passengers, geographic proximity of the pickup point to the current route, available vehicle capacity, and compatibility of

destinations (Masoud & Jayakrishnan, 2017; Makhdomi & Gillani, 2024; ResearchGate, n.d., A Matching Algorithm). Studies explore different heuristic rules and their impact on metrics like passenger waiting time and driver idle time (ResearchGate, n.d., A Matching Algorithm; ResearchGate, 2025, Dynamic matching radius).

- **Recommendations:** Research recommends developing heuristics that effectively balance system efficiency (e.g., maximizing pickups, minimizing total travel time) with user fairness (e.g., ensuring detours are reasonable). Evaluating the performance of different heuristic rules through real-world testing is crucial. Heuristic design should consider scalability and adaptability to varying demand and supply conditions in urban settings. Despite their practical use, a research gap exists in systematically evaluating and comparing the performance of different heuristic strategies specifically for dynamic on-route pickup matching in developing urban environments with unique traffic characteristics.

Genetic Algorithm

- **Problems:** While heuristics offer speed, finding globally optimal solutions for complex dynamic ridesharing matching problems with numerous constraints (vehicle capacity, time windows, multiple pickups/drop-offs, balancing efficiency and fairness) remains a significant challenge that can be difficult for simple heuristics to fully address.
- **Achievements (Results):** Genetic Algorithms, as an evolutionary computation method, are utilized to optimize ride-matching by exploring a large search space of potential solutions (sets of driver-passenger pairings) and iteratively improving

them based on a fitness function that considers multiple objectives (Cao, Wang, & Li, 2021; Masoud & Jayakrishnan, 2017). This approach can potentially find more optimal pairings compared to simple heuristics, especially in complex, multi-passenger scenarios, and can be used for offline optimization or benchmarking real-time methods (CEUR-WS.org, 2025; FHWA, n.d.).

- **Recommendations:** Studies recommend adapting Genetic Algorithms to the specific constraints of ridesharing, incorporating real-time data, and developing efficient evaluation mechanisms for potential solutions. While potentially more computationally intensive for strict real-time applications than heuristics, they offer a powerful approach for complex optimization problems. A gap remains in the practical application and comparative analysis of Genetic Algorithms, specifically for dynamic on-route pickup matching in the context of developing urban areas, and how their potential benefits in optimality weigh against the computational demands for real-time implementation compared to efficient heuristics.

Dijkstra’s Algorithm Search for Pickup Cost Calculation

- **Problems:** Accurately estimating the time and distance costs associated with potential on-route pickups and the resulting detours is crucial for the matching algorithm to make informed decisions. This requires efficient shortest-path calculations within the dynamic urban road network (AFI, n.d.). Integrating real-time traffic data to make these cost estimations accurate is a key challenge.
- **Achievements (Results):** Dijkstra's Algorithm and its variants, like Search, are fundamental tools for finding the shortest or fastest path between two points in a

graph, making them essential for calculating travel costs in ridesharing systems (Dijkstra, 1959; Codecademy, n.d.; FarEye, n.d.). By modeling road networks as graphs, these algorithms can efficiently determine the estimated time and distance for a driver to reach a potential pickup point and continue to the destination, considering the road network structure (ResearchGate, n.d., A Matching Algorithm) and integrating real-time or time-dependent traffic data as edge weights can improve the accuracy of these cost estimations (DiVA portal, n.d.; Fu, Sun, & Rilett, 2006).

- **Recommendations:** Studies suggest enhancing the accuracy of route and cost calculations by combining Dijkstra's Algorithm with real-time traffic data. Hybrid techniques are recommended for better performance in large urban networks. A significant research gap exists in effectively integrating and modeling localized, dynamic traffic data specific to urban environments like Davao City as accurate, real-time edge weights within shortest-path algorithms for precise pickup feasibility and cost calculation in a dynamic on-route ridesharing context.

Geographic Information Systems (GIS) for Spatial Context and Visualization

Geographic Information Systems (GIS) provide the essential spatial context and tools necessary for effective data management, spatial analysis, and visualization in ridesharing, supporting both algorithm inputs and user interaction.

- **Problems:** Ridesharing operations are inherently spatial, requiring accurate mapping, real-time location tracking, and the ability to perform spatial queries (Cao, Wang, & Li, 2021). Furthermore, effectively presenting complex spatial information, such as potential pickup points and dynamic routes, to drivers and passengers through a user-friendly interface is crucial for usability and acceptance (Bac Ha Software, n.d.; Warse, 2024).

- **Achievements (Results):** GIS provides the foundational capabilities for modeling urban road networks, storing and managing spatial data (like points for locations, lines for routes), performing spatial analysis (e.g., calculating distances, identifying points within a radius), and visualizing real-time locations and routes on interactive maps (Cao, Wang, & Li, 2021; Nature.com, 2024; pmc.ncbi.nlm.nih.gov, 2020; Goong, 2023). GIS is integral to route optimization and dispatching systems (Wang & Wei, 2018; Nguyen, Le, & Tran, 2019). Local examples demonstrate the use of GIS in pooling apps (Warse, 2024).
- **Recommendations:** Recommendations include leveraging real-time GIS capabilities for dynamic route adjustments and integrating AI/ML with GIS for predictive spatial analysis. Continuous improvement of spatial data accuracy is essential. Despite the critical role of GIS, a research gap exists in systematically designing and evaluating user-friendly and informative GIS visualizations specifically tailored for drivers navigating dynamic on-route pickups in a ridesharing context, considering the need for clear, real-time information display to minimize cognitive load and support efficient decision-making.

II. User Perception and Acceptance of On-Route Ridesharing

The success and sustainability of a dynamic ridesharing platform, which relies on passengers sharing rides and potentially experiencing detours for pickups, depend significantly on user perception, trust, and acceptance. Understanding these factors within the specific local context is crucial.

- **Problems:** Users (both passengers and drivers) may have concerns about shared rides, including privacy, safety, comfort, and the fairness of detours and pricing (MDPI, 2024; ResearchGate, n.d., Trust; ResearchGate, n.d., Drivers' Tactics; University of Southampton, 2024; MDPI, 2021). Factors influencing trust in digital platforms and the sharing economy are complex and can vary across regions and cultures (ResearchGate, n.d., Trust; University of Southampton, 2024). Understanding these perceptions in Davao City and the Philippines is vital for designing an acceptable and trustworthy service (ResearchGate, n.d., Drivers' Tactics; UP NCTS, 2024; ResearchGate, 2025, Informal and Shared Mobility).
- **Achievements (Results):** Research on ride-hailing in the Philippines highlights factors influencing driver tactics and user experiences, including responses to traffic and incentives (ResearchGate, n.d., Drivers' Tactics; UP NCTS, 2024). Studies on user trust in the sharing economy emphasize the roles of digital security measures, transparency, and platform legitimacy (MDPI, 2024; ResearchGate, n.d., Trust; University of Southampton, 2024). Theoretical frameworks like the Technology Acceptance Model (TAM) and Uncertainty Reduction Theory (URT) provide lenses for understanding technology adoption and trust development (ResearchGate, n.d., Trust). Southeast Asian studies discuss the role and challenges of informal and shared mobility, including digitally-enabled ride-hailing (ResearchGate, 2025, Informal and Shared Mobility; MDPI, 2021).

- **Recommendations:** Conducting qualitative studies (e.g., interviews, focus groups) to gather in-depth insights into potential users' understanding of, concerns about, and perceived benefits and barriers to adopting an on-route ridesharing system in a specific local context like Davao City. Evaluating how proposed features (like clear communication about detours, safety measures, and transparent pricing) influence perceived trust and value is essential for design refinement. A research gap exists in specific, in-depth investigations into user acceptance and the perceived value of the on-route ridesharing model, particularly concerning the willingness to share rides and accept dynamic pickups/detours, within the specific socio-cultural and transportation context of Davao City and similar urban areas in the Philippines.

III. Application of Chosen Methods in Similar Contexts

The algorithms, machine learning techniques, and GIS chosen for this study have also been successfully applied in contexts similar to ridesharing, demonstrating their broader applicability and effectiveness in transportation and logistics.

In traffic systems, Dijkstra's Algorithm and its variants are widely used for shortest path computation within complex urban networks, essential for real-time navigation and minimizing travel time (Dijkstra, 1959; Fu, Sun, & Rilett, 2006). Integrating real-time traffic data can significantly improve route accuracy (DiVA portal, n.d.).

Grab utilizes algorithms to match passengers with various vehicle types (cars, motorcycles, taxis) and food and package delivery, all requiring efficient dispatching and combining heuristics with variants of genetic algorithms to fulfill their needs when it comes to matching.

Within ridesharing platforms themselves, AI-based ride matching algorithms, often leveraging techniques like heuristics, Genetic Algorithms, or other machine learning approaches, have shown significant improvements in pairing efficiency and reducing wait times compared to traditional methods (Kim et al., 2022; Zhang & Xie, 2023; CEUR-WS.org, 2025). Research continues handling complex scenarios and incorporating fairness and efficiency balancing (Taylor & Francis Online, 2025; MDPI, 2024, Fairness-Aware Dynamic).

IV. Relevance to the Study in Davao City

This section connects explicitly the chosen algorithms, machine learning techniques, GIS, and user perception considerations to the context of ridesharing in Davao City, emphasizing their direct relevance to this study's objectives and the identified research gaps. The urban environment of Davao City presents unique traffic patterns, infrastructure characteristics, and commuter needs that necessitate a tailored approach to ridesharing optimization focused on efficient pickups.

Applying a Heuristic-Based Matching Algorithm is central to addressing the challenge of efficiently pairing drivers with passengers for on-route pickups in real-time within Davao City's dynamic environment. This approach offers a feasible method for the prototype to evaluate numerous potential pairings and refine them to achieve efficient allocation, considering constraints such as vehicle capacity and time windows relevant to Davao City. Adapting the heuristic rules to the city's specific geographical characteristics and incorporating local considerations for balancing efficiency and fairness (e.g., setting appropriate detour limits based on typical Davao travel patterns) will be key to improving real-time performance and ensuring the matching process is perceived as equitable by local users (Masoud & Jayakrishnan, 2017; Makhdomi & Gillani, 2024; Taylor & Francis Online, 2025; MDPI, 2024, Fairness-Aware Dynamic). While genetic algorithms represent a more complex approach for potential future work, the heuristic approach provides a practical method for exploring the matching optimization problem in this context.

Dijkstra's Algorithm will be instrumental in accurately estimating the time and distance costs associated with potential passenger pickups and detours within Davao City's road network. Utilizing this for cost calculation is crucial input for the heuristic matching algorithm. Integrating it with real-time time-dependent traffic data specific to Davao City will be essential for its effectiveness in providing realistic cost estimations amidst the city's variable congestion, directly addressing the gap in localized traffic data integration for pickup feasibility calculation (Dijkstra, 1959; Codecademy, n.d.; AFI, n.d.; FarEye, n.d.; DiVA portal, n.d.).

The integration of GIS provides the essential spatial framework for implementing and visualizing the dynamic ridesharing system in Davao City. GIS tools for mapping, spatial analysis, and visualization of driver/passenger locations, potential pickup points, and recommended paths are fundamental to this study. Utilizing real-time GIS data for dynamic updates and designing user-friendly GIS visualizations specifically for drivers identifying and navigating efficient on-route pickups within Davao City are crucial for the proposed platform's usability and directly address the gap in GIS visualization design for this context (Cao, Wang, & Li, 2021; Nature.com, 2024; pmc.ncbi.nlm.nih.gov, 2020; Goong, 2023; Bac Ha Software, n.d.; Warse, 2024).

Furthermore, understanding the User Perception and Acceptance of this on-route ridesharing model within the specific socio-cultural and transportation context of Davao City is paramount. Qualitative evaluation will explore local user attitudes, concerns (e.g., about sharing rides, detours for pickups, safety), and perceived benefits to ensure the conceptual design and future implementation are well-received and address local needs, directly addressing the gap in understanding user acceptance of this specific model in the Davao context (ResearchGate, n.d., Trust; ResearchGate, n.d., Drivers' Tactics; University of Southampton, 2024; UP NCTS, 2024; ResearchGate, 2025, Informal and Shared Mobility; MDPI, 2021).

Together, these chosen methods – a Heuristic-Based Matching Algorithm and Dijkstra's for pickup cost calculation and matching optimization, GIS for spatial context and visualization, and qualitative evaluation for user perception – provide a robust foundation for designing and evaluating a dynamic ridesharing platform concept tailored to enhance urban mobility in Davao City by improving matching efficiency for pickups, leveraging data-driven insights, and considering local user needs.

Chapter 3: Methodology

This chapter outlines the research methodology employed to achieve the objectives of this study. It details the conceptual and operational frameworks guiding the research, the context area and relevant technologies, the specific methods used to address the identified problems, the approach to data collection and generation, and the data analysis and evaluation plan.

3.1 Conceptual Framework

The conceptual framework, illustrated in Figure 3.1.1, depicts the interconnected components and processes of the proposed dynamic ridesharing platform concept for Davao City, with a primary focus on optimizing passenger matching for efficient pickups. The framework highlights the relationship between the identified urban transportation problems and the technological solutions employed to address them.

Component	**Description**
Problem Addressed	Urban transportation inefficiencies in Davao City
Goal	Optimize passenger-driver matching for efficient pickups

Core Technology: GIS	Provides spatial context with road networks and real-time locations of drivers and passengers
Input: Ride Requests	Passengers submit ride requests to initiate the process
Routing Algorithm	**Dijkstra's** calculates estimated time and distance costs using GIS data
Matching Logic	**Heuristic-Based Matching Algorithm** — uses routing costs, driver availability, capacity, and detour tolerance to match passengers to drivers
Dynamic Pricing (Conceptual)	Adjusts fare based on real-time demand, supply, distance, and pickup efficiency using backend data (e.g., Supabase/PostGIS)
Safety Features (Conceptual)	GPS tracking, reviews, emergency button, and digital payments to enhance trust and security
Target Outcomes	- Increased transportation efficiency (less wait time, fewer detours) - More accurate and predictable fares (conceptually) - Improved user safety

The system relies on Geographic Information Systems (GIS) to provide the foundational spatial context, including the road network representation and real-timelocation data of drivers and passengers. Incoming passenger Ride Requests initiate the process. The system utilizes Dijkstra’s Algorithm to calculate the estimated time and distance costs associated with potential pickups along a driver's route, using the spatial data from the GIS. These cost calculations and other relevant factors (like driver availability, vehicle capacity, detour tolerance) serve as inputs for the Heuristic-Based Matching Algorithm. This algorithm processes the available drivers and incoming requests to identify and propose optimal passenger-driver pairings for efficient on-route pickups.

While not fully implemented in the prototype, the conceptual design integrates Dynamic Pricing mechanisms, utilizing real-time factors (demand, supply, distance, pickup efficiency) and potentially cloud-based backend data (Supabase/PostGIS) for transparent fare calculation. Similarly, Safety Features (GPS tracking, reviews, emergency buttons, digital payments) are conceptually integrated into the framework, contributing to user trust and security.

The ultimate aim of this integrated system is to improve Transportation Efficiency (reduced wait times, minimized detours, increased vehicle occupancy), enhance Fare Predictability & Accuracy (conceptually), and improve User Safety & Security (conceptually), thereby contributing to a better Urban Mobility Experience in Davao City.

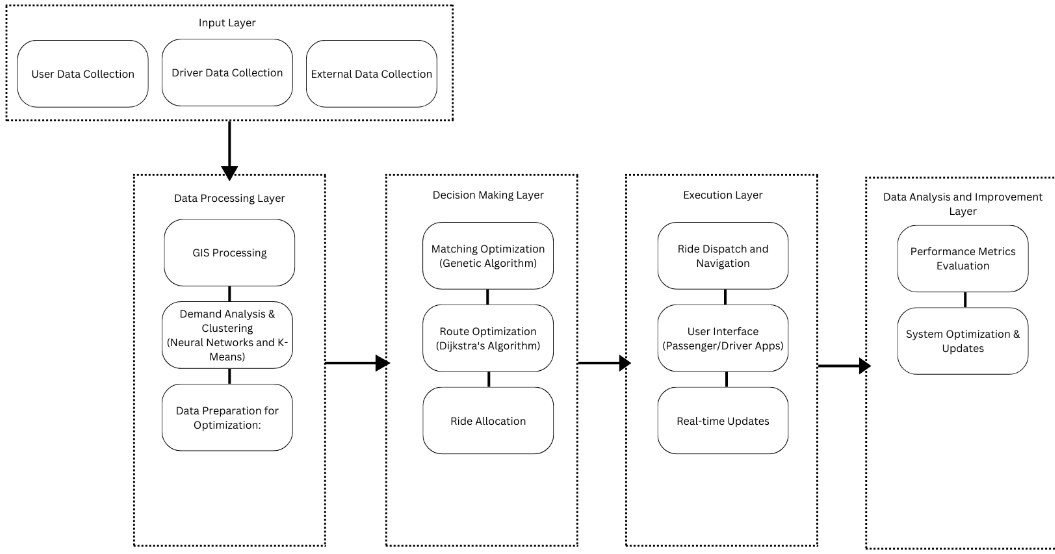

Figure 3.1.1

3.2 Research Design

This study employs a Design Science Research (DSR) approach, real-world-based evaluation, and qualitative investigation. DSR is appropriate as the project aims to design and evaluate an innovative Information System artifact – the dynamic ridesharing platform concept and its limited-scope prototype – to address a real-world problem in urban transportation. The evaluation allows for controlled testing of the core matching and routing algorithms' performance metrics (like wait time and detour) under various scenarios, mitigating the limitations of full-scale real-world deployment. The qualitative investigation complements the technical evaluation by exploring the crucial human factors of user perception, acceptance, and interface usability, which are critical for successfully adopting such a system in the Davao City context. This mixed-methods approach comprehensively explains the proposed solution's technical feasibility and potential user acceptance.

3.3 Data Collection or Generation

Given the limitations on accessing extensive real-time and historical ridesharing data for Davao City, the primary approach for technical evaluation will involve real-world data.

- **Ride Request Data:** Passenger ride requests will be generated based on assumptions about origin-destination pairs, request times, and passenger counts.
- **Driver Data:** Driver data will be collected, including starting locations, availability times, and initial routes (which can be random or follow predefined patterns). The number of available drivers will be varied to test performance under different supply conditions.
- **Road Network Data:** A digital representation of the Davao City road network will be obtained from publicly available sources such as OpenStreetMap (OSM). This data will be processed and converted into a graph structure where intersections are nodes and road segments are edges, suitable for shortest-path algorithms.
- **Traffic Data:** To test dynamic traffic conditions, edge weights in the road network graph (representing travel time) will be varied over time based on predefined patterns (e.g., slower speeds during peak hours in certain areas) or a simplified random variation model. Accessing and integrating actual real-time traffic data from sources like the Davao City Traffic Management Center is acknowledged as a limitation and is outside the scope of this study.

- **Qualitative Data:** User perception and usability evaluation data will be collected through audio recordings and notes from semi-structured interviews, focus group discussions, and usability testing sessions. Consent will be obtained from all participants for data collection and use.

3.4 Data Analysis

The data collected and generated will be analyzed using both quantitative and qualitative methods.

- **Data Analysis:** The output of the test runs will be analyzed quantitatively to evaluate the performance of the heuristic matching algorithm. Key metrics to be calculated and compared against a simple baseline (e.g., first-come, first-served matching without on-route pickups) include:
    - Average Passenger Wait Time (time from pickup request).
    - Average Driver Detour (additional time/distance added to a driver's trip due to pickups).
    - Vehicle Utilization Rate (percentage of time vehicles are carrying passengers).
    - Number of Successful Matches/Completed Shared Rides.
    - These metrics will be compared under varying conditions (e.g., different demand levels and numbers of available drivers).
- **Qualitative Data Analysis:** Audio recordings and notes from interviews and focus groups will be transcribed and analyzed using thematic analysis. This involves reading through the data, identifying recurring themes, patterns, and key insights related to user perceptions, concerns, and acceptance factors of the

on-route ridesharing model in Davao City. Usability testing data, including SUS scores and qualitative feedback, will be analyzed to identify usability issues and assess the perceived clarity and effectiveness of the GIS visualizations for driver navigation.

3.5 Ethical Considerations

The design and implementation of GoDavao ridesharing app need careful consideration of several ethical variables to ensure the appropriate development of the app. These considerations are vital for building community trust, promoting fairness, and mitigating potential problems and issues.

3.5.1 Data Privacy and Security

A dynamic ridesharing platform collects sensitive user data, including real-time location information, pickup and drop-off locations, personal details (names, contact information), payment details, and ride history. Ethical considerations in this area include:

- Informing the passengers and the drivers about how their data will be used.
- Only collecting necessary information and discarding when no longer needed
- Implementing strong technical and organizational security measures to protect data against cyber threats.

3.5.2 Fairness and Algorithmic Bias

The platform relies on algorithms for passenger matching and dynamic pricing. There is an ethical responsibility to ensure these algorithms operate fairly and do not perpetuate or create biases based on factors such as location, socio-economic status, or time of day in a way that unfairly disadvantages certain users or drivers. Considerations include:

- Ensuring the heuristic matching algorithm does not systematically prioritize or deprioritize the way they match passengers to drivers.
- While dynamic pricing is intended to balance supply and demand, the mechanisms should be transparent to users, and efforts should be made to prevent price gouging by drivers, especially during peak demand or in underserved areas.

3.5.3 Safety, Security, and Trust

Beyond the integrated safety features (GPS tracking, emergency buttons, etc.) discussed in the scope, the platform has an ethical obligation to contribute to the safety and security of its users during rides. This involves:

- Implementing thorough processes for verifying the identity and background of both drivers and passengers to enhance safety.
- Establishing clear protocols for responding to safety incidents or emergencies reported through the platform.
- Recognizing that user trust is built not only on features but also on the ethical operation of the platform, including reliable safety measures and fair practices.

3.5.4 Transparency and Accountability

Operating the platform with transparency and establishing clear lines of accountability are crucial ethical considerations.

- Clear Terms of Service: Users should clearly understand the terms and conditions of using the service, including their rights and responsibilities.
- Establishing processes for users to report issues, provide feedback, and seek recourse in case of problems.

3.6 Operational Framework

The operational framework describes the step-by-step processes from the perspective of both the passenger and the driver interacting with the dynamic ridesharing platform. Figures 3.2.1 (Passenger-side) and 3.2.2 (Driver-side) illustrate these workflows.

3.6.1 Passenger-Side Operational Flow

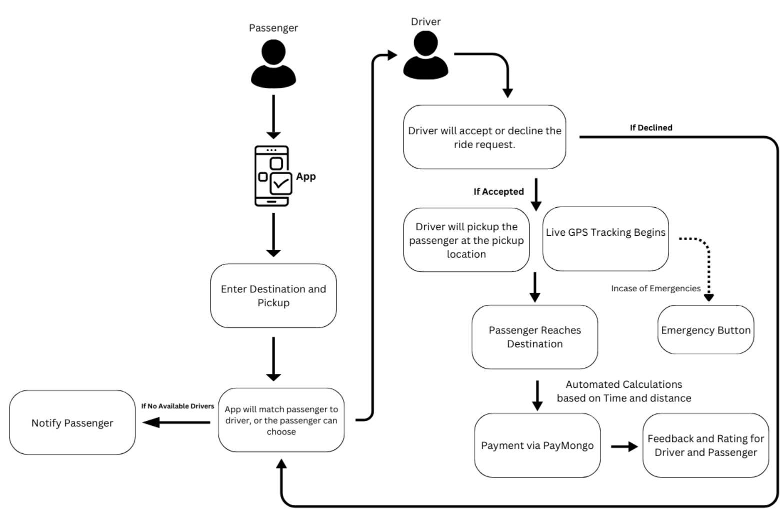

Figure 3.6.1

The passenger-side flow begins with the passenger opening the application and potentially viewing nearby available drivers on a map (utilizing GIS). The passenger initiates a ride request by entering their pickup location and destination. This request is sent to the system backend. The system processes the request using the matching algorithm. If a suitable on-route match is found, the passenger receives a notification with details about the matched driver, estimated pickup time, and estimated fare. The passenger confirms the booking. The app then displays the driver's real-time location and the planned route (GIS visualization). During the trip, the passenger can track progress. Upon arrival at the destination, the trip is completed, and the fare is processed (conceptually, via digital payment integration). The passenger may then have the option to rate the driver.

3.6.2 Driver-Side Operational Flow

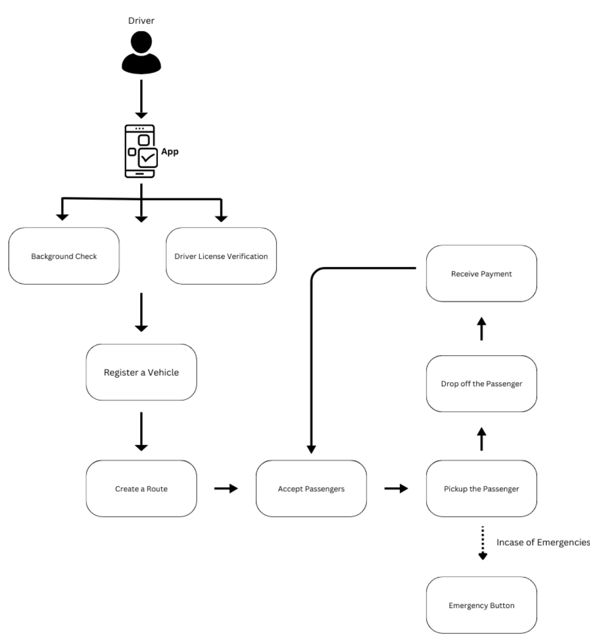

Figure 3.2.2

The driver-side flow begins with the driver logging into the app and setting their availability status. The driver's real-time location is tracked via GPS and displayed on their map interface (GIS). As the driver proceeds along their route, the system continuously evaluates potential new passenger requests for on-route pickups using the heuristic matching algorithm. If a possible match is identified, the driver receives a ride offer notification, including the passenger's location, destination, and the estimated impact (detour time/distance) of the pickup on their current trip. The driver can choose to accept or reject the offer. If accepted, the system updates the driver's route to include the new pickup point (utilizing Dijkstra's for cost calculation and route update). The driver's GIS visualization updates will guide them to the pickup location and subsequent drop-offs. During the trip, the driver follows the guided route. Upon completing all drop-offs, the trip concludes, and the fare is finalized (conceptually). The driver may then rate the passenger.

References

- AFI. (n.d.). *Using Route Optimization to Build a Ride Share Dispatch Algorithm*. Retrieved from https://blog.afi.io/using-route-optimization-to-build-a-ride-share-dispatch-algorithm
- Alisoltani, N., Zargayouna, M., & Leclercq, L. (2022). *A Shareability Clustering Method to Solve the Dynamic Ride-Sharing Problem*. HAL Archives. Retrieved from https://hal.science/hal-03637134/document
- Cao, Y., Wang, S., & Li, J. (2021). The Optimization Model of Ride-Sharing Route for Ride Hailing Considering Both System Optimization and User Fairness. *Sustainability, 13*(2), 902. https://doi.org/10.3390/su13020902
- Chen, L., Thakuriah, P., & Ampountolas, K. (2021). Short-Term Prediction of Demand for Ride-Hailing Services: A Deep Learning Approach. *Journal of Big Data Analytics in Transportation, 3*, 175–195. https://link.springer.com/article/10.1007/s42421-021-00041-4
- Codecademy. (n.d.). *Ridesharing Algorithms: Optimization and Iteration*. Retrieved from https://www.codecademy.com/article/ridesharing-algorithms
- Delling, D., Pajor, T., & Werneck, R. F. (2011). Round-based public transit routing. *Transportation Science, 45*(3), 432-449. https://doi.org/10.1287/trsc.1110.0370
- Dijkstra, E. W. (1959). A note on two problems in connexion with graphs. *Numerische Mathematik, 1*(1), 269-271.
- Econstor. (n.d.). *Passenger Demand Forecasting for Urban Bus Systems Using Machine Learning*. Retrieved from

https://www.econstor.eu/bitstream/10419/272424/1/Passenger-Demand-Forecasting-For-Urban-Bus-Systems-Using-Machine-Learning.pdf

- FarEye. (n.d.). *What is Route Optimization Algorithm? How Does it Work?* Retrieved from https://fareye.com/blog/route-optimization-algorithm/
- Fu, L., Sun, D., & Rilett, L. R. (2006). Simulation for dynamic traffic assignment with real-time information. *Transportation Research Record, 1964*(1), 100-108.
- IEEE. (n.d.). *Real-Time Bus Arrival Prediction Using Machine Learning Models*. Retrieved from https://ieeexplore.ieee.org/document/9648921
- Javidi, H., Simon, D., Zhu, L., & Wang, Y. (2020). *A Multi-Objective Optimization Framework for On-Line Ridesharing Systems*. arXiv preprint arXiv:2012.05046. https://arxiv.org/abs/2012.05046
- Kim, S., et al. (2022). Predictive Analytics in Ridesharing: Enhancing Efficiency with Machine Learning. *Transportation Research Part C: Emerging Technologies*. https://www.sciencedirect.com/journal/transportation-research-part-c-emerging-technologies/vol/156/suppl/C
- Makhdomi, A. A., & Gillani, I. A. (2024). Fair and Efficient Ridesharing: A Dynamic Programming-based Relocation Approach. arXiv. Retrieved from https://arxiv.org/abs/2401.15363
- Masoud, N., & Jayakrishnan, R. (2017). A Real-Time Algorithm to Solve the Peer-to-Peer Ride-Matching Problem in a Flexible Ridesharing System. *Transportation Research Part B: Methodological, 106*, 218-236.

- MDPI. (2023). Predicting Ride-Hailing Demand with Consideration of Social Equity: A Case Study of Chengdu. Retrieved from https://www.mdpi.com/2071-1050/16/22/9772
- MDPI. (2024). Decoupling Online Ride-Hailing Services: A Privacy Protection Scheme Based on Decentralized Identity. Retrieved from https://www.mdpi.com/2079-9292/13/20/4060
- Nature.com. (2024). *Nature.com article on GIS-based Ridesharing Optimization*. (Note: Full citation details needed)
- Nguyen, T. T., Le, M. H., & Tran, P. N. (2019). The integration of GIS and demand forecasting in supply chain management. *International Journal of Logistics Systems and Management, 34*(2), 215-233. https://doi.org/10.1504/IJLSM.2019.098765
- ResearchGate. (2023). Matching and Network Effects in Ride-Hailing. Retrieved from https://www.researchgate.net/publication/370996073_Matching_and_Network_Effects_in_Ride-Hailing
- ResearchGate. (2025). ASSESSING THE URBANIZATION-DRIVEN CHALLENGES OF TRANSPORTATION SCARCITY AND COMMUTER ACCESSIBILITY IN DAVAO CITY: A SYSTEMATIC REVIEW. Retrieved from https://www.researchgate.net/publication/387525353_ASSESSING_THE_URBANIZATION-DRIVEN_CHALLENGES_OF_TRANSPORTATION_SCARCITY_AND_COMMUTER_ACCESSIBILITY_IN_DAVAO_CITY_A_SYSTEMATIC_REVIEW

- ResearchGate. (n.d.). (PDF) Drivers' Tactics in Ridesharing Economy in the Philippines. Retrieved from https://www.researchgate.net/publication/336599982_Drivers'_Tactics_in_Ridesharing_Economy_in_the_Philippines
- ResearchGate. (n.d.). (PDF) Trust in the Ride Hailing Service of the Sharing Economy: The Roles of Legitimacy and Process Transparency. Retrieved from https://www.researchgate.net/publication/353142980_Trust_in_the_Ride_Hailing_Service_of_the_Sharing_Economy_The_Roles_of_Legitimacy_and_Process_Transparency
- Sakthivelu, A., & Jayakrishnan, S. (2024). An Energy-Efficient Ride-Sharing Algorithm Using Distributed Convex Optimization. Stanford Digital Repository. Retrieved from https://purl.stanford.edu/ss423gm7371
- SciELO. (2019). DYNAMIC PRICING AND PRICE FAIRNESS PERCEPTIONS: A STUDY OF THE USE OF THE UBER APP IN TRAVELS PRECIFICAÇÃO DINÂMICA E PREÇO. Retrieved from https://www.scielo.br/j/tva/a/Y6XjBk7z9N8f7mvTWnMygzP/?format=pdf&lang=en
- Soria, J., Chen, Y., & Stathopoulos, A. (2020). *K-Prototype Segmentation Analysis on Large-scale Ridesourcing Trip Data*. arXiv preprint arXiv:2006.13924.
- Subramanian, D. (2020). *Clustering Uber Rideshare Data*. KDnuggets. Retrieved from https://kdnuggets.com/2020/05/clustering-uber-rideshare-data.html
- TRISTAN 2025. (2025). Privacy-Preserving Contextual Personalized Dynamic Pricing for Ride-Hailing Platforms 1 INTRODUCTION. Retrieved from https://tristan2025.org/proceedings/TRISTAN2025_ExtendedAbstract_320.pdf

- University of Southampton. (2024). Passengers as defenders. Retrieved from https://eprints.soton.ac.uk/496349/1/Passengers_as_defenders_1-s2.0-S026151772400205X-main_Alex_Zarifis.pdf
- UP NCTS. (2024). An Analysis of Ride-Hailing Services as Mode of Public Transportation in Olongapo City. Retrieved from https://ncts.upd.edu.ph/tssp/wp-content/uploads/2024/12/TSSP2024-12-Revised-Paper.pdf
- Wang, X., & Wei, H. (2018). GIS-based warehouse location planning for supply chain optimization. *Journal of Transportation Research, 56*(4), 102-118. https://doi.org/10.1016/j.jtr.2018.06.004
- Zhang, Y., & Xie, L. (2023). Real-Time Ride Matching Using Reinforcement Learning: A Case Study on Urban Transportation. *IEEE Transactions on Intelligent Transportation Systems*.https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10352976
- Zheng, Y., Wang, Q., Zhuang, D., Wang, S., & Zhao, J. (2023). Fairness-Enhancing Deep Learning for Ride-Hailing Demand Prediction. *IEEE Transactions on Knowledge and Data Engineering*. https://doi.org/10.1109/TKDE.2023.3298960