

# **Para Mobile: A Smart Transport Route with Traffic Monitoring Application for Commuters in Imus City, Cavite.**

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## INTRODUCTION

### I. Project Context

The technological development of public transit solutions in areas like Imus City, Cavite, is necessitated by prevailing systemic inefficiencies that impose significant stress (Galvez et al., 2025; Morales et al., 2024), uncertainty (Fillone et al., 2024),, and financial cost (Galvez et al., 2025) upon commuters. A primary issue defining the current commuting experience is the fundamental lack of a reliable, verified, and complete digital database detailing public utility vehicle (PUV) routes, stops, and corresponding official fare matrices in provincial areas (Bolivar et al., 2024; Santiago et al., 2024). Commuters face acute uncertainty regarding which bus or jeepney to ride and difficulty in locating designated drop-off and pick-up points (Fillone et al., 2024).

These challenges are compounded by systemic failures in information delivery, including a lack of accurate, dynamic real-time traffic updates. Traffic congestion and subsequent delays are reported as the primary cause of stress and late arrival times Lara et al., 2024). Furthermore, without officially verified fare matrices sourced directly from the Land Transportation Franchising and Regulatory Board (LTFRB) and Local Government Unit (LGU), commuters lack the data needed to accurately budget, which can lead to overcharging and financial anxiety. The unpredictable nature of travel contributes to negative psychological impacts, turning the commute into a source of frustration and helplessness (Morales et al., 2024).

The desire and concern to improve this system are directly addressed by transforming the solution's core value proposition from generic features to data validity. Para Mobile is a top-of-the-line intervention because it establishes a 100% manually verified, ground-truth data service for all routes and fares within Imus, Cavite, sourced from the LTFRB and LGU. To

ensure the project is budgeted, feasible and scalable, it pivots from expensive, unfeasible in-vehicle hardware tracking to a software-only model that crowdsources real-time location and traffic data directly from anonymous, opted-in users. This approach is backed by evidence supporting the use of a cost-effective, unified technical stacks and the use of OpenStreetMap (OSM) to avoid commercial licensing fees.

The development and implementation of Para Mobile aims to bridge this gap by offering a user-friendly platform with constantly maintained database of all jeepney routes, stops, and designated fare matrices. A granular step-by-step guidance, integration of gamification such as the route timing feature and achievement scores. Finally, the research incorporates modern technological standards, utilizing an Agile methodology and adopting a "Privacy by Design" ethical framework to establish a safe, legally compliant model for mass location tracking. By leveraging digital tools and real-time data, the app empowers users to make informed decisions about their travel routes, avoid congested areas, and save time.

Furthermore, it contributes to the modernization of public transportation systems in Imus by promoting the use of technology to improve urban planning. Finally, the resulting application is designed to be highly useful and contributable.

## II. Objectives of the Study

This study aims to design, develop, test, and evaluate "Para Mobile," an innovative mobile application intended to alleviate the daily commuting challenges for residents in Imus City, Cavite. To design, develop, and deploy a smart transport mobile application, highly efficient, user-centric, and economically feasible mobile transit navigation system, that leverages a database of public utility vehicle (PUV) routes, real-time commuter crowdsourcing, and gamification to fundamentally enhance transportation predictability, cost-effectiveness, and overall commuter experience that provides commuters in Imus City with efficient routing, clear public transport maps, and real-time traffic monitoring to reduce travel time, frustration, and inefficiency. Specifically, it aims to:

1. To design the comprehensive system architecture and the highly granular User Interface (UI) for "Para Mobile," which must prioritize data veracity and navigational clarity by:
  - a. Integrating official, verified fare matrices sourced directly from the Land Transportation Franchising and Regulatory Board (LTFRB) and Local Government Unit (LGU).
  - b. Providing granular, step-by-step guidance that explicitly includes specific vehicle signboard text (e.g., "signboard Baclaran") and precise hub mapping.
  - c. Structuring the database to manage the only 100% manually verified, complete public transportation route data set for the locality.
2. To develop the "Para Mobile" application using a coherent, cost-effective, and cross-platform technical stack, ensuring budgeted feasibility and maximizing development efficiency:
  - a. Software: Utilize the MERN stack (MongoDB, Express.js, Node.js) for the core backend and data management. Deploy React Native as the frontend development

methodology to allow for a single codebase that targets both iOS and Android platforms.

- b.** Mapping & Services: Integrate OpenStreetMap (OSM) for free, open-source geospatial data. Implement Firebase (or equivalent services) as a mandatory component for secure user authentication and essential real-time push notifications.
    - c.** Methodology: Execute the development process using the Agile methodology (e.g., Scrum) to effectively manage dynamic requirements, facilitate continuous testing, and embrace necessary feedback and change throughout the lifecycle.
- 3. To systematically test the foundational functional capabilities of the "Para Mobile" system to confirm operational reliability and data integrity:
  - a.** Validate the accuracy and completeness of the end-to-end route planning capabilities, including necessary transfers, based on the verified data set.
    - b.** Verify the reliable ingestion and use of real-time traffic data crowdsourced exclusively from active user location inputs.
    - c.** Confirm the successful functionality of the achievement score system and the route timing (stopwatch) feature for generating measurable route efficiency data.
- 4. To rigorously evaluate the system's effectiveness, utility, and modern compliance, establishing its standing as a top-of-the-line innovation:
  - a.** Quantify the system's ability to solve commuter challenges by measuring the efficiency gains derived from comparing fastest routes using the crowdsourced timing feature.
    - b.** Assess the utility of the verified fare matrix system in empowering users to make informed, cost-saving decisions and prevent instances of overcharging.
    - c.** Critically evaluate the system's adherence to the Philippine Data Privacy Act by confirming that all location sharing is opt-in, anonymized, and aggregated at the server level, proving a model for privacy-by-design in transit technology.

5. To establish a clear path for the sustained deployment, maintenance, and distribution of the "Para Mobile" platform, ensuring maximum contribution potential for stakeholders:
  - a. Develop a structured implementation strategy for rolling out the mobile application across major platforms (iOS/Android).
  - b. Formulate a data governance strategy detailing how the core verified route database will be maintained and updated in collaboration with key governmental stakeholders, specifically the City Planning and Development Office (CPDO) of Imus and the LTFRB.
  - c. Outline the strategy for distributing the foundational, high-quality public transport data set to allow future researchers and urban planners to contribute to and leverage this valuable resource and local stakeholders.

### **III. Purpose and Description**

The primary purpose of the project is to deploy a top-of-the-line, budgeted feasible, and highly useful mobile application designed to resolve the pervasive challenges of by commuters navigating public transportation.

The purpose of developing the "Para Mobile" project is to establish a top-of-the-line, highly useful, and budgeted feasible solution addressing the core challenges of stress, inefficiency, and uncertainty reported by commuters navigating complex provincial public transportation systems. This research must be undertaken because it fills a critical market deficit: the lack of a reliable, verified, and complete digital database of provincial Public Utility Jeepney (PUJ) routes. The project's primary contribution to the body of knowledge is its pivot from a "feature-bloated app" to a "high-quality data service," achieved by becoming the only application with a 100% manually verified, ground-truthed, and constantly maintained database of all public transportation routes, stops, and fare matrices in Imus, Cavite.

This foundational data is derived from the manual acquisition and digitization of the Local Public Transport Route Plan (LPTRP) from the Land Transportation Franchising and Regulatory Board (LTFRB) and the Local Government Unit (LGU), a crucial input that ensures accuracy and supports decision-making for stakeholders like the City Planning and Development Office (CPDO) of Imus.

The project's description details its innovative architectural approach designed specifically for feasibility and scalability. To provide accurate, real-time traffic updates without the unfeasible and high-cost requirement of installing physical, in-vehicle GPS hardware, the application adopts a 100% software-based, "Waze-like" commuter crowdsourcing model. This dynamic approach generates traffic data directly from active users, addressing delayed arrival times and congestion. Furthermore, to meet the "budgeted feasible" and cross-platform criteria, the architecture leverages the MERN stack with React Native for the frontend, allowing a single codebase to deploy efficiently across both iOS and Android. This architecture utilizes the OpenStreetMap (OSM) for free geodata integration, thus avoiding costly licensing fees associated with commercial map providers.

For practical application, "Para Mobile" provides comprehensive, end-to-end route planning for all registered modes of public transportation, including Jeepneys, buses, taxis, and tricycles. The application functions by providing granular, step-by-step instructions that include the specific vehicle signboard text (e.g., "signboard Baclaran"), eliminating commuter uncertainty at busy terminals. It also clearly maps designated drop-off and pick-up points. To support cost-conscious users, verified fare matrices sourced from the LTFRB and LGU are integrated directly into the route instructions, displaying the precise fare per step of the journey, thereby preventing overcharging and aiding informed budgeting. Finally, the platform incorporates a gamification structure, including a "stopwatch" feature for users to empirically compare routes for speed and an "achievement score" system that rewards users for completing trips, transforming the commute into a goal-oriented activity and incentivizing

valuable data contribution. Crucially, the system integrates "Privacy by Design," ensuring all location sharing is opt-in, anonymized, and aggregated in compliance with the Data Privacy Act, making the application both the most accurate and the safest, thereby significantly enhancing its significance and legal disreputability.

## **IV. Scope and Limitation of the Study**

This section identifies the boundaries and coverage of the "Para Mobile" research project, as well as the specific constraints and factors not covered by the study.

The "Para Mobile" project is engineered as a top-of-the-line mobile application solution, focusing rigorously on achieving budgeted feasibility, high utility, and verifiable data integrity, making it distributable and easily adoptable by researchers and stakeholders.

The project's scope is meticulously defined by its geographic coverage, technological capabilities, and functional deliverables:

- 1 **Geographic and Data Coverage:** The study's coverage is strictly focused on public transportation within Imus, Cavite. The project's core deliverable is a 100% manually

verified, ground-truthed, and constantly maintained digital database of all public transportation routes, stops, and official fare matrices specific to Imus. This data is acquired from official stakeholders, specifically the Land Transportation Franchising and Regulatory Board (LTFRB) and the Local Government Unit (LGU).

- 2 **Vehicle and Platform Support:** The application is exclusively a mobile-only service. It is designed to provide comprehensive, end-to-end route planning for all registered modes of public transportation, including Jeepneys (PUJs), buses, taxis (cabs), and tricycles.
- 3 **Core Functionality (Route Planning and Guidance):**
  - a **Real-Time, Smart Routing:** The app provides dynamic, traffic-aware routing using crowdsourced data generated directly from active users, identifying congestion and proposing the most efficient path.
  - b **Granular Step-by-Step Instructions:** The user interface (UI) delivers highly detailed, turn-by-turn guidance, including the explicit vehicle signboard text (e.g., "signboard Baclaran") and the specific locations of designated drop-off and pick-up points.
  - c **Verified Financial Planning:** The UI integrates the official LTFRB/LGU fare data, displaying the precise fare for each step of the journey to aid in budgeting and prevent overcharging.
- 4 **Technological Architecture and Feasibility:** The project utilizes the MERN stack (Node.js, Express.js, MongoDB) and leverages React Native for the frontend, allowing a single codebase to achieve cross-platform deployment on both iOS and Android. Map integration is managed through OpenStreetMap (OSM) to ensure free geodata use and avoid commercial licensing fees.
- 5 **Ethical and Stakeholder Alignment:** The framework incorporates "Privacy by Design," ensuring all location sharing is strictly opt-in, anonymized, and aggregated in compliance with the Data Privacy Act. The study's data is intended to support bodies such as the City Planning and Development Office (CPDO) of Imus.

- 6 **User Engagement Deliverable:** Gamification features, including a stopwatch for route timing/comparison and an achievement score system, are implemented to motivate user contribution and transform commuting into a goal-oriented activity.

To ensure the project remains focused, budgeted feasible, and aligned with modern development standards, the following boundaries and limitations are established:

- 1 **Geographic Boundary:** The application and its verified data coverage are strictly limited to the public transportation routes within Imus, Cavite.
- 2 **Transportation Limitation:** The system will not provide routing for private vehicles, taxis, or ride-hailing services (e.g., Grab).
- 3 **Exclusion of Hardware:** The project will *not* track individual public utility vehicles (PUVs) through physical, in-vehicle GPS hardware, as this is deemed unfeasible and excessively costly. Real-time data is derived solely from the crowdsourcing of commuter locations (a software-only model).
- 4 **Feature Exclusion:** The scope explicitly removes extraneous features, specifically the "Community with Event Tracker," ensuring the project remains lean and focused on core routing and traffic solutions.
- 5 **Technological Scope:** The project does not include components related to Artificial Intelligence (AI) or Deep Learning yet, aligning the technical requirements strictly with the capabilities of the MERN stack.
- 6 **Data Source Limitation:** The system does not rely on or integrate with commercial mapping APIs (such as Google Maps API) to ensure cost-effectiveness and control over data quality, instead utilizing OpenStreetMap (OSM).

## Conceptual Framework

This research utilizes the Input-Process-Output (IPO) model to provide the general structure and conceptual guide for the study. This model illustrates the inputs required, the

processes that will be undertaken to transform those inputs, and the final output of the project. A feedback loop is included to show that the results of the user evaluation will inform future iterations and improvements of the system.

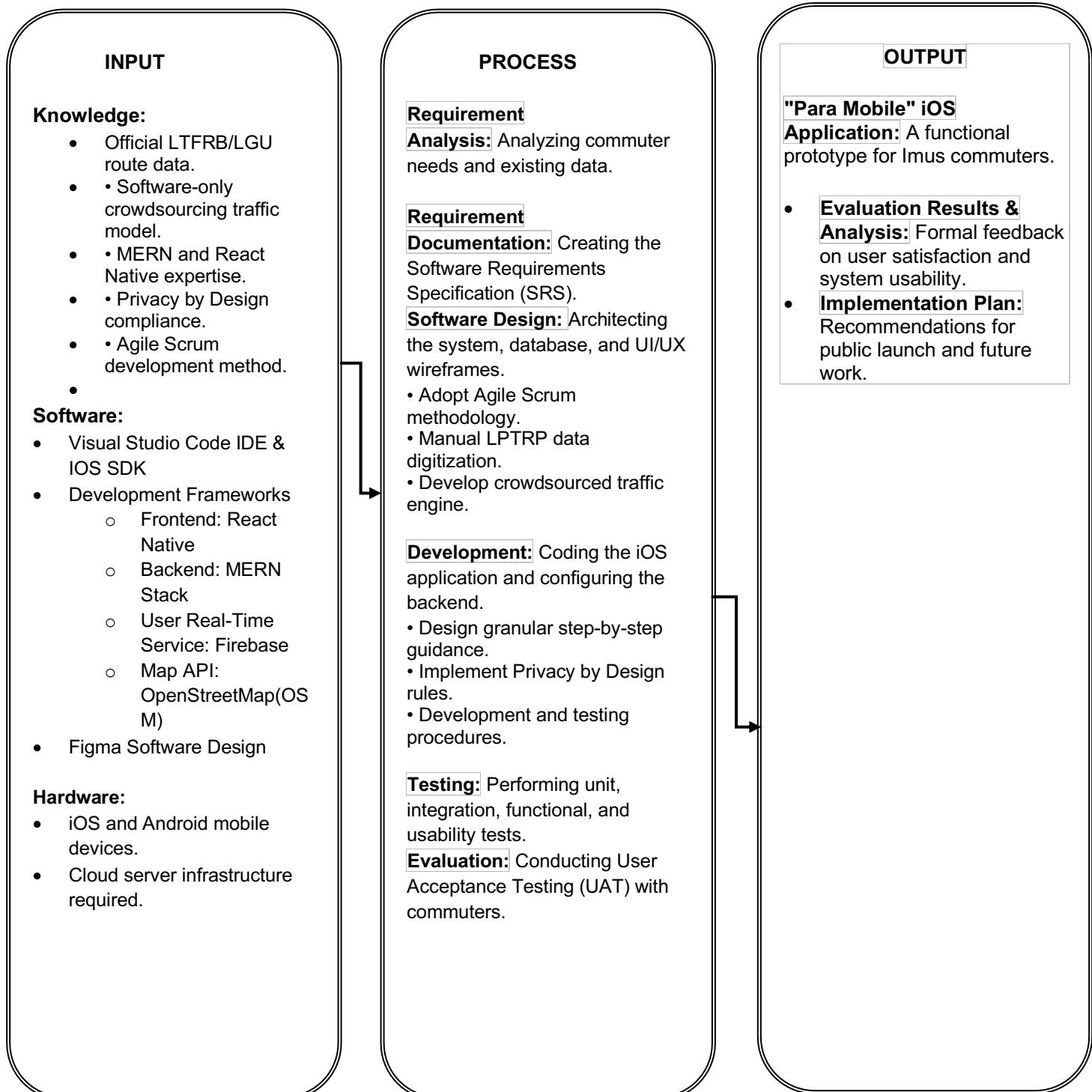


Fig 1. Input-Process-Output Model

The framework shown above demonstrates how the project will systematically transform the specified Inputs consisting of foundational knowledge (like PUJ route data and the LTFRB matrix), modern software (React Native, Firebase, Figma), and essential hardware (Apple MacBook and iPhone) into the final product. This transformation is achieved through a rigorous Process of requirement analysis, design, development, and iterative testing.

The final Output of this framework is not only the functional "Para Mobile" iOS application but also the critical evaluation results from user acceptance testing and a prepared implementation plan, with the feedback loop emphasizing the study's commitment to continuous improvement based on user validation.

## V. Definition of Terms

The following terms are defined operationally and conceptually to ensure a clear and consistent understanding throughout this research paper.

- a. **Para Mobile:** The name of the mobile application developed in this study. It functions as a smart transport guide for commuters in Imus City. The name is derived from the Filipino word "para," a common term used by commuters to signal a jeepney driver to stop.
- b. **Cloud Integration:** Refers to the architectural approach of using cloud-based services (e.g., backend servers, databases) to store, manage, and process the application's data, such as route information and user accounts, as inspired by modern systems (Levis, K. A., et al., 2024).
- c. **Gamification:** The project's psychological engagement feature where it allows commuters to empirically time and compare routes for efficiency, and the "Achievement Score" system rewards users for completing trips, transforming the commute into a goal-oriented activity

- d. **Commuter:** An individual who travels, particularly on a regular basis, between their home and a place of work or study using the public transportation system.
- e. **Loading and Drop-off Spots:** Refers to the specific, often unmarked, locations familiar to local commuters and drivers where Public Utility Jeepneys (PUJs) typically stop to pick up (load) or let passengers alight (drop-off).
- f. **Privacy by Design:** The mandatory ethical and legal framework integrated into the system, which ensures that all mass location tracking is strictly opt-in, anonymized, and aggregated on the server side to comply with the Philippine Data Privacy Act and enhance the project's distributability and safety
- g. **Public Utility Jeepney (PUJ):** A primary and iconic mode of public transportation in the Philippines, characterized by its fixed routes and shared seating.
- h. **Real-Time Traffic:** Refers to live data on road congestion and vehicle flow, updated at frequent intervals. In this project, it is sourced from a third-party API and displayed visually on the app's map to help commuters make informed route choices.
- i. **Smart Transport Route:** A travel path suggested by the "Para Mobile" application. The route is considered "smart" because its algorithm integrates static public transport route data with dynamic, real-time traffic conditions to propose the most efficient trip.
- j. **Traffic Monitoring:** The specific function of the "Para Mobile" application that provides a visual representation of live traffic congestion levels on the user's map interface.
- k. **React Native:** A cross-platform development framework. For this project, it is the technical tool used to build the application for the iOS (iPhone) operating system, allowing for a single codebase to be used.
- l. **Firebase:** This is a Backend-as-a-Service (BaaS) platform. It will technically provide the project's backend infrastructure, including the real-time database (for

- storing route data and user information), user authentication, and other cloud functions.
- m. **OpenStreetMap (OSM):** The open-source platform utilized for map integration to generate free geodata, which is a key technical decision aligning with the project's financial feasibility by avoiding the costly licensing fees associated with commercial mapping APIs.
  - n. **10. Urban Planning Data:** The verifiable route and traffic data collected by "Para Mobile," which is intended for contribution and use by stakeholders such as the City Planning and Development Office (CPDO) of Imus to support informed urban planning decisions.

## REVIEW OF RELATED LITERATURE

### I. System Technical Background

To understand the literature related to Para Mobile, it is essential to first define the project's core technical concepts. The "Para Mobile" project is a specialized mobile application designed using the React Native framework. Its purpose is to provide a comprehensive, real-time navigation solution for commuters using all registered public transportation, including jeepneys, buses, and tricycles.

The system's foundational stack adheres strictly to a unified JavaScript ecosystem, known as the MERN stack (MongoDB, Express.js, Node.js), managing user accounts, route information, and location data. Critically, to fulfil the "budgeted feasible" and "Cross-Platform" requirements, the mobile development tool is mandated as **React Native**. This technical decision allows a single development team to build one codebase deployable across both iOS and Android platforms, replacing the less efficient approach of using separate native tools like Android Studio. Furthermore, for geospatial data integrity and cost control, the project utilizes **OpenStreetMap (OSM)** for map integration, ensuring access to free geodata and avoiding the costly licensing fees associated with commercial mapping APIs. Critical-path services, such as User Authentication and Real-Time Push Notifications, are handled by mandated third-party services like Firebase, as the MERN stack cannot natively support these features.

The system's technical superiority is derived from its unique data inputs and innovative real-time processing mechanism. The project rejects reliance on incomplete or static data, dedicating its core technical effort to building a **100% Manually Verified Database**. This involves the meticulous manual acquisition and digitization of the Local Public Transport Route Plan (LPTRP) from the Land Transportation Franchising and Regulatory Board (LTFRB) and the Local Government Unit (LGU), which are then loaded into the MongoDB database. To

generate dynamic traffic information, the project employs a **Software-Only Commuter Crowdsourcing Model**, eliminating the unfeasible multi-million peso requirement of installing physical in-vehicle GPS hardware. The system generates real-time location and traffic data by tracking the aggregated, anonymous movement of opted-in users (similar to a Waze-like model). This inferred data allows the application's Smart Routing logic to identify congestion and propose the most efficient, traffic-aware routes to the user.

Technically, the application provides enhanced utility through specific UI functions and its underlying ethical framework. The system delivers **Step-by-Step Guidance** by integrating the verified route data with explicit, user-friendly details, such as displaying the specific vehicle signboard text and the exact locations of designated drop-off/pick-up points. Furthermore, the UI integrates the **Verified Fare Matrix** directly into the route plan, displaying the precise cost for each step of the journey via a currency icon, a technical function based on official LTFRB/LGU data. To encourage data contribution, the project employs **Gamification**, utilizing a technical function where a "stopwatch" records journey times, feeding data back into the Fastest Route Comparison engine, while an "Achievement Score" system provides positive reinforcement upon successful trip completion. Finally, addressing modern legal and ethical liabilities, the technical architecture mandates **Privacy by Design**, ensuring that all location sharing is strictly opt-in, anonymized, and aggregated on the server, a critical technical requirement for maintaining compliance with the Philippine Data Privacy Act.

The following tables outline the software and hardware specifications necessary for the development, testing, and deployment of the *Para Mobile* application, adhering to standard guidelines for mobile systems engineering.

<b>Category</b>	<b>Component</b>	<b>Engineering Specification</b>	<b>Rationale (Project Justification)</b>
<b>Core Development Stack</b>	MERN Stack (MongoDB, Express.js, Node.js)	Unified JavaScript ecosystem for the backend and data management <sup>1111</sup> .	Ensures rapid development, consistency across tiers, and scalability for real-time traffic data handling.
<b>Client Framework</b>	React Native	Cross-platform development methodology <sup>2222</sup> .	Enables deployment across both <b>iOS and Android</b> platforms from a single codebase, fulfilling the feasibility objective <sup>3333</sup> .
<b>Geospatial Integration</b>	OpenStreetMap (OSM) API	Free and open-source geodata platform <sup>4444</sup> .	Essential for budget feasibility and avoiding costly commercial mapping licensing fees <sup>55555555</sup> .
<b>Critical Services</b>	Firebase (or equivalent services)	Backend-as-a-Service (BaaS) for user authentication <sup>6666</sup> and real-time push notifications <sup>777</sup> .	Manages crucial services that the MERN stack does not natively support <sup>8</sup> .
<b>Process Control</b>	Agile Methodology (Scrum)	Iterative development framework <sup>99</sup> .	Facilitates continuous testing and effective management of dynamic requirements <sup>10101010</sup> .
<b>Auxiliary Tools</b>	Visual Studio Code (IDE) & iOS SDK, Figma	Standard development environment and design platform <sup>111111</sup> .	Necessary for coding, compiling, testing, and developing UI/UX wireframes <sup>12</sup> .

Table 01: Software Requirements

<b>Category</b>	<b>Component</b>	<b>Role in Project</b>	<b>Rationale (Engineering Justification)</b>
<b>Development Host</b>	Computer/Laptop	Environment for coding, building the MERN backend, and running necessary SDKs (e.g., iOS SDK) <sup>13</sup> .	Must be capable of supporting high-load tasks such as cross-platform compilation and multiple concurrent emulators.
<b>Target Client Devices</b>	iOS and Android Mobile Devices	Primary devices for running functional, integration, and <b>User Acceptance Testing (UAT)</b> <sup>14141414</sup> .	Required to validate the application's performance and usability on actual end-user hardware.
<b>Infrastructure</b>	Cloud Server Infrastructure	Host environment for the MERN backend, MongoDB database, and the <b>real-time traffic aggregation engine</b> <sup>151515</sup> .	Ensures accessibility, scalability, and persistence of the central verified route data and crowdsourced data.

Table 03: Hardware Requirements

## II. Related Literature/Studies

This section contains a review of available studies related to the project being conducted. It presents a comparison and contrast of what has already been done, focusing on the methodologies, scopes, limitations, and technologies used in existing systems.

The challenge of navigating public transportation in the Philippines is a well-documented and persistent issue, forming the foundational problem for a growing body of research. Commuters widely report systemic inefficiencies that lead to significant stress, uncertainty, and financial costs. Studies such as **LibotTana** (Bolivar et al., 2024) for Pampanga, **Byahero** (Fillone et al., 2024) for Iloilo City, and **Routie** (Lara et al., 2024) for the general Philippine context all identify a common set of problems: commuter uncertainty about correct routes, lack of clear fare information, and general difficulty in locating transport hubs. The research for **Lakbay Cavite** (Santiago et al., 2024) is the most geographically proximate, confirming these same challenges specifically within Imus, Cavite. This collective body of literature establishes a clear and urgent need for a technological intervention.

While the identified problem is consistent, the proposed solutions diverge significantly in their methodology, technological architecture, and core scope. Methodologically, the approaches range from LibotTana's use of Rapid Application Development (RAD), Routie's focus on user evaluation via the User Experience Questionnaire (UEQ), and Byahero's use of a descriptive and developmental research design. Para Mobile aligns its process with the **Agile methodology**, positioning it for dynamic requirements and continuous testing.

Technologically, the systems present a clear divide. LibotTana (Bolivar et al., 2024) is built on a web-centric stack using PHP's Laravel framework and MySQL. Lakbay Cavite (Santiago et al., 2024) and Para Mobile both leverage the modern **MERN stack** (MongoDB, Express.js, React, Node.js) for backend development. However, a critical divergence appears in mapping and platform deployment. Lakbay Cavite integrates with Google APIs for its mapping data. In contrast, Para Mobile strategically adopts **OpenStreetMap (OSM)** and **React Native**. This technical decision is central to Para Mobile's "budgeted feasible" objective, as it provides a single, cross-platform (iOS and Android) codebase while simultaneously avoiding the costly commercial licensing fees associated with other mapping providers.

The most significant differences arise in the core features and data philosophy of each project. Lakhay Cavite (Santiago et al., 2024) centers its innovation on social features, proposing a "community module" for user interaction and an "event tracker" to manage route changes from local events. Para Mobile identifies this as a potential "feature-bloat" and explicitly defines this as a limitation, *removing* the "Community with Event Tracker" feature to ensure the project remains lean and focused on its primary objective: **data veracity**.

This focus on data is Para Mobile's primary contribution. While all studies, including Routie (Lara et al., 2024) and LibotTana(Bolivar et al., 2024), aim to provide route and cost estimates, Para Mobile is the only system to propose a **manually digitized data** for all routes and *official fare matrices*, with data sourced directly from the **LTFRB and LGU**. Furthermore, it addresses the challenge of real-time traffic monitoring by pivoting away from the "unfeasible and excessively costly" in-vehicle hardware proposed by other systems. Instead, Para Mobile adopts a software-only **commuter crowdsourcing model**, a more feasible and scalable solution for real-time data that Routie and Byahero do not specify.

Finally, Para Mobile introduces two key concepts absent in the related literature. First, it integrates **gamification**, specifically, a route timing feature and achievement feature as a psychological engagement tool to incentivize data contribution. Second, it is the only project built on an explicit "**Privacy by Design**" ethical framework, ensuring all crowdsourced location data is opt-in, anonymized, and aggregated in compliance with the Philippine Data Privacy Act. This synthesis of verified data, a feasible crowdsourcing model, novel gamification, and a robust privacy-first framework differentiates Para Mobile from existing studies by focusing not just on building an app, but on creating a verifiable, scalable, and secure data service.

### III. Synthesis

The body of related literature confirms that the commuting experience in the Philippines is defined by systemic inefficiencies that impose significant stress (Morales et al., 2024; Galvez et al., 2025), uncertainty (Fillone et al., 2024), and financial burdens (Galvez et al., 2025) on the public. These challenges are not isolated to a single region but are documented across the country, from Metro Manila (Morales et al., 2024) to Iloilo (Fillone et al., 2024) and Pampanga (Bolivar et al., 2024).

Multiple studies have proposed technological interventions to address these issues. The Routie prototype, developed by Lara et al. (2024), aims to simplify navigation by suggesting routes and transportation options. Similarly, the Byahero app by Fillone et al. (2024) was designed as a GPS-based tool to help commuters in Iloilo City locate the exact transportation needed for their destination. The LibotTana application by Bolivar et al. (2024) targets commuters in Pampanga, providing a travel guide with fare matrices for local jeepneys and tricycles. The most geographically relevant study, Lakbay Cavite (Santiago et al., 2024), also proposes a navigation application for Imus, Cavite, which includes features like fare estimation and a community-based module for information sharing.

While these systems validate the need for a digital solution, the proposed Para Mobile project justifies its novelty by addressing critical gaps in data veracity, technological feasibility, and user engagement that these studies do not fully resolve.

**First**, Para Mobile pivots from being just another routing app to functioning as a high-quality data service. Its primary contribution is the establishment of a 100% manually verified, ground-truth data service for all public transport routes and official fare matrices within Imus. This approach directly solves the problem of data reliability, a limitation of systems that may rely on unverified or scraped data. This data is sourced directly from official government

stakeholders, namely the Land Transportation Franchising and Regulatory Board (LTFRB) and the Local Government Unit (LGU).

**Second**, Para Mobile is designed for budgeted feasibility and scalability, making two strategic technical decisions. It deliberately avoids the "expensive, unfeasible in-vehicle hardware tracking" model and instead adopts a software-only, "Waze-like" commuter crowdsourcing model to generate real-time traffic data from its users. Furthermore, while other systems like Lakbay Cavite (Santiago et al., 2024) use Google APIs , Para Mobile leverages OpenStreetMap (OSM) to "avoid costly licensing fees" and ensure long-term, cost-effective operation.

**Finally**, Para Mobile introduces a unique gamification structure, such as a "route timing feature" and "achievement scores" , to incentivize user participation and directly address the negative psychological impacts of commuting. This is coupled with a robust "Privacy by Design" ethical framework, ensuring all user data is anonymized and aggregated in compliance with the Data Privacy Act.

In summary, while existing literature identifies the problem and proposes similar application concepts, Para Mobile is new because it focuses on creating a verifiable, officially sourced data foundation, utilizes a more feasible and cost-effective crowdsourcing architecture, with added psychological and privacy-centric features non-present in the related systems.

Furthermore, A comparative table below are related systems based on the features discussed in the provided documents.

Feature	Para Mobile	Routie	Lakbay Cavite	Byahero	LibotTana
Official (LTFRB/LGU) Verified Routes	✓	(User-Submitted Fare Matrix)	(Community- Validated)		
Official (LTFRB/LGU) Verified Fare Matrix	✓	("Estimated" Cost)			
Real-Time Traffic Monitoring	✓	✓	✓	✓	✓
Crowdsourced (Software-Only) Traffic	✓				
Granular Guidance (e.g., Signboard Text)	✓	✓			
Community / Social Module	(Explicitly Removed)	✓	✓		
Event Tracker	(Explicitly Removed)		✓		
Gamification (e.g., Scores, Timers)	✓				
OpenStreetMap (OSM) Integration	✓				
Google Maps API Integration	(Explicitly Removed)		✓	✓	✓
"Privacy by Design" Framework	✓				

Table 1: Related Systems Comparison Overview

## METHODOLOGY

### I. Design of Software, Systems, Product and/or Processes

The conceptual design and systems architecture for "Para Mobile" were meticulously engineered to deliver a top-of-the-line, highly useful solution that strictly adheres to **budgeted feasibility** and modern development standards. This phase encompasses all upfront conceptual and feasibility work required before coding begins. The core objective is to pivot the focus from generic features to verifiable data integrity, achieved through a strategic technical stack.

#### a. Requirement Analysis

The **requirement analysis phase** systematically identified the fundamental functional deficiencies of the current provincial public transport system, establishing the exact details and functions the "Para Mobile" must solve. This analysis is structured around the problems faced by the key people involved and the environment of Imus City, Cavite.

The ecosystem of stakeholders encompasses a diverse array of actors integral to the urban transit landscape. The primary beneficiaries are the **Commuters** and **Public Utility Vehicle (PUV) Drivers**, who are directly impacted by the system's utility. Furthermore, the framework crucially involves regulatory bodies, specifically the **Land Transportation Franchising and Regulatory Board (LTFRB)** and the **Local Government Unit (LGU)**, who serve as the authoritative sources for verifying route and fare data. Finally, the verified data repository is designed to support **Future Researchers** and urban planners, allowing them to leverage high-quality datasets for subsequent studies and infrastructural development.

The central operation involves a sophisticated, user-centric mobility experience designed to mitigate commuter uncertainty. Upon inputting a destination, the application necessitates user consent for anonymized location sharing, adhering to an ethical "Privacy by

Design" framework. The system subsequently utilizes a **Smart Routing Engine** that leverages historical crowdsourced data; specifically, aggregated from the **timer feature** to calculate and propose the most efficient trajectory. Simultaneously, the interface displays a **Verified Fare Matrix**, providing immediate financial transparency based on official regulatory standards.

As the commute commences, the backend system initiates a data logging mechanism (contingent on user permission) to monitor travel duration and verify traffic conditions. The application delivers a **Step-by-Step Guidance**, explicitly detailing critical information such as expected traffic congestion, specific lane positioning, and precise fare costs for each leg of the journey. Users retain the agency to toggle between this detailed view and a generalized travel overview. To sustain engagement, the platform integrates a **Gamification Module**, wherein commuters accumulate "Achievement Scores" upon reaching their destination, effectively transforming the mundane commute into a goal-oriented and measurable activity.

The operational scope of this study is strictly delimited to the geographic boundaries of **Imus City, Cavite**. This area serves as the Minimum Viable Product (MVP) environment for validating the system's data veracity and functional reliability before any potential expansion to the broader Cavite province or Metro Manila.

While traffic volume typically surges during traditional rush hours, the specific demand for the *Para Mobile* application peaks largely during moments of **situational uncertainty**. The system becomes most critical when commuters attempt to navigate unfamiliar locations or routes where they lack prior knowledge. Consequently, usage intensifies when individuals face ambiguity regarding transport modes or specific drop-off points, driving the need for the application's granular guidance and verified information.

The existing manual procedure is fundamentally compromised by **systemic inefficiencies** and a pervasive **lack of verifiable data**. Developers may currently forced to rely on guesswork or "tribal knowledge" due to the absence of a reliable digital database for

provincial routes. This information vacuum leads to significant **financial anxiety** regarding correct fares and psychological **stress** due to the unpredictability of travel times. Furthermore, the process of acquiring accurate data is hindered by the logistical difficulty of coordinating with government agencies like the LTFRB and LGU, a gap this project bridges through manual digitization.

The Gantt chart illustrates the **schedule feasibility** for the *Para Mobile* project by outlining the planned timeline and resource allocation for the **2025-2026 Academic Year**.

## Para Mobile

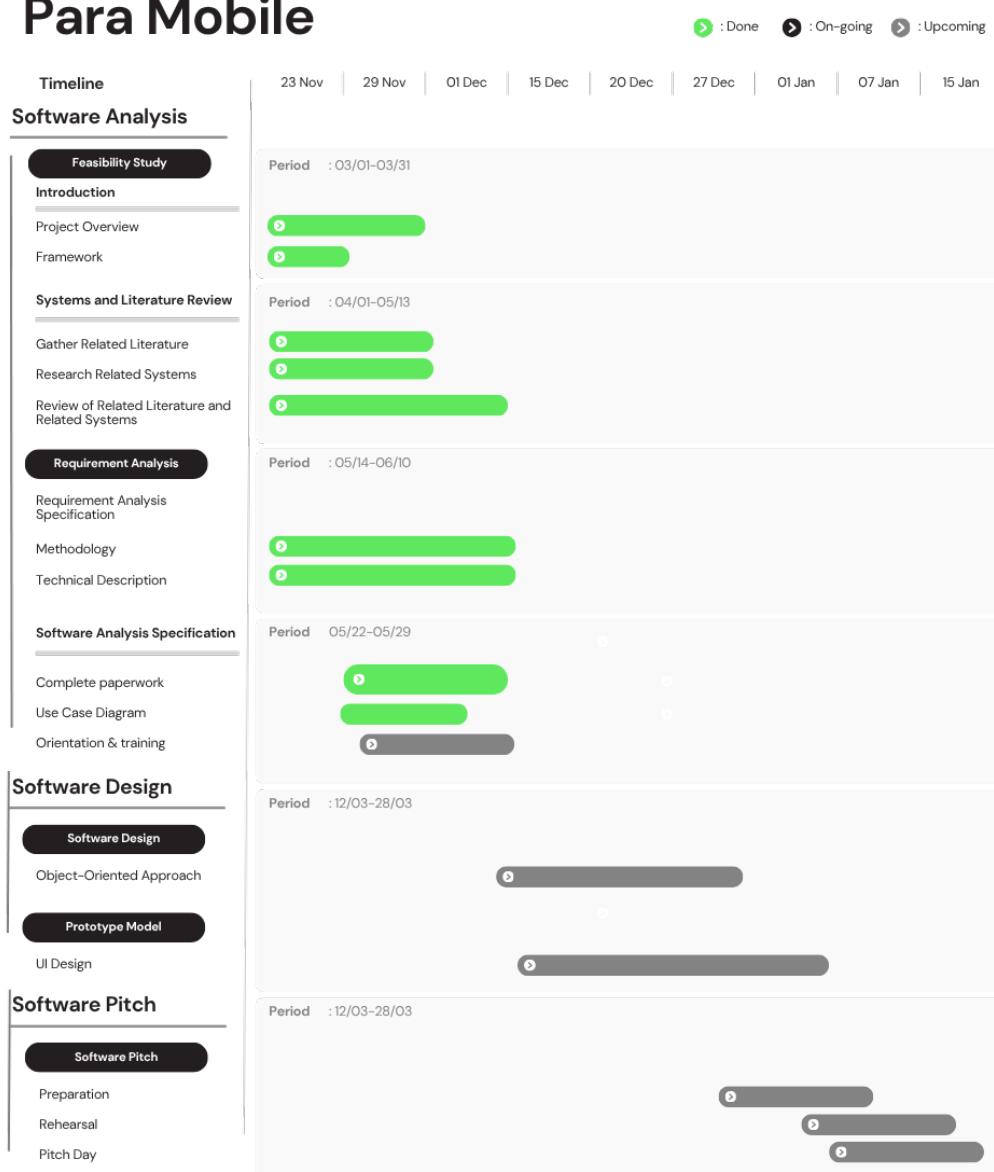


Fig 02: Para Mobile GANTT Chart

The chart visually separates the project into sequential, measurable phases: **Feasibility Study** focusing on initial viability and objectives, **Systems and Literature Review**, dedicated to research and informing novelty, **Requirement Analysis**, detailing the functional specifications and methodology , **Software Analysis Specification**, including documentation and use case development , **Software Design**, covering architecture and UI/UX , and **Software Pitch**, encompassing final presentation and validation efforts.

This systematic breakdown confirms the project's complexity is managed through defined stages and achievable deadlines, reinforcing its schedule viability within the academic timeline.

The Fishbone Diagram is used for operational feasibility which should delineate the systemic **factors** to the successful integration and long-term **usability** of the proposed solution within the existing user environment.

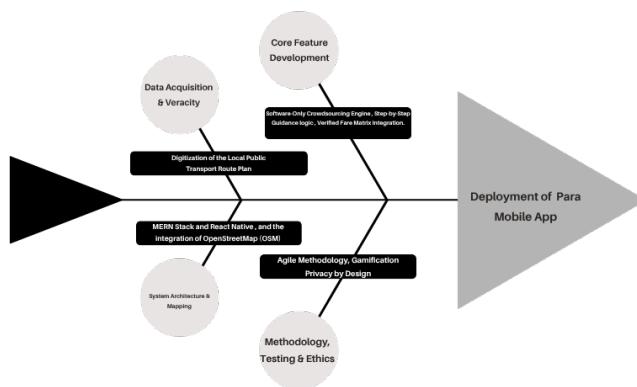


Fig 03: Fishbone Diagram

the Fishbone Diagram must illustrate the critical **Causes** needed to successfully produce the desired **Effect** in the given specific, solution-oriented nature of the research, fishbone diagram is structured around the key operational components necessary for success, as defined in the project objectives.

## b. Requirements Documentation

The Requirements Documentation phase details the specific functional and non-functional specifications of the “Para Mobile” solution.

The proposed system is structured around six core modules designed to systematically address commuter challenges regarding uncertainty, inefficiency, and financial planning, positioning the project as a **high-quality data service**.

### 1. Data Verification and Route Management Module

This module ensures the foundational validity and accuracy of all information presented to the commuter, serving as the system's unique value proposition.

- a. **100% Verified Database:** The system must incorporate and maintain the only 100% manually verified, ground-truthed database of all public transportation routes, stops, and fare matrices specifically for Imus, Cavite.
- b. **Official Data Input:** The system must be able to ingest and manage data digitized from official sources, namely the Local Public Transport Route Plan (LPTRP) from the Land Transportation Franchising and Regulatory Board (LTFRB) and the Local Government Unit (LGU).
- c. **Comprehensive Vehicle Support:** The system is required to provide route planning and guidance for all registered modes of public transportation, including Jeepneys (PUJs), buses, taxis (cabs), and tricycles.

### 2. Dynamic Navigation and Traffic Monitoring Module

This module provides the real-time functionality of the application, prioritizing a cost-effective, software-based approach over expensive hardware.

- a. **Real-Time Location Tracking:** The application must accurately provide real-time GPS tracking of the user's current location.

- b. **Software-Only Crowdsourced Traffic Engine:** The system must generate real-time traffic updates solely from data crowdsourced directly from active, opted-in "Para Mobile" users, similar to Waze. This is a critical requirement to maintain **budgeted feasibility**, eliminating the unfeasible need for physical in-vehicle GPS hardware.
- c. **Smart, Traffic-Aware Routing:** The system must utilize the crowdsourced data to dynamically identify high-congestion areas and propose the most efficient, traffic-aware route to the user's destination.
- d. **Fastest Route Comparison:** The system must use route timing data collected via the stopwatch feature to compare different options and identify the fastest paths available.

### 3. Commuter Guidance and User Interface (UI) Module

The UI must deliver actionable, granular information to eliminate commuter uncertainty and confusion.

- a. **End-to-End Route Planning:** The system must map routes from the user's origin to the final destination, clearly indicating all necessary transfers.
- b. **Granular Step-by-Step Guidance:** The UI must provide highly detailed, turn-by-turn directions for each segment of the journey, explicitly including the specific vehicle signboard text (e.g., "signboard").
- c. **Hub Mapping:** The application must clearly display the specific locations of designated drop-off and pick-up points (hubs).

### 4. Financial Utility and Cost Planning Module

This module ensures the application aids in financial decision-making, fulfilling the requirement for cost-effectiveness.

- a. **Verified Fare Matrix Integration:** The system must integrate the official fare matrices sourced directly from the LTFRB and LGU.
- b. **Per-Step Fare Display:** The UI must display the precise fare for each step of the journey (e.g., via a currency icon), allowing users to accurately plan their budget and preventing overcharging.

## 5. Engagement and Data Contribution (Gamification) Module

This module is required to incentivize user participation, ensuring a continuous supply of crowdsourced traffic data, and mitigating the negative psychological impacts of commuting.

- a. **Route Timing Stopwatch Feature:** Users must be able to activate a "stopwatch" feature to time their journey from start to end point, providing the data necessary for the fastest route comparison engine.
- b. **Achievement Score System:** The system must implement an achievement score system that rewards users with points upon the successful completion of a transport route, transforming the commute into a goal-oriented activity.
- c. **Social Sharing:** Users must be able to share their earned achievements and completed trips on social media platforms.

## 6. System Architecture and Ethical Compliance Module

This module defines the non-functional requirements vital for long-term scalability, ethical operation, and technical feasibility.

- a. **Cross-Platform Deployment:** The system must be developed using **React Native** to ensure a single codebase can deploy efficiently to both iOS and Android platforms.
- b. **Cost-Effective Mapping:** The system must integrate **OpenStreetMap (OSM)** for all geospatial data needs to avoid the high cost of commercial mapping APIs.

- c. **Real-Time Service Mandate:** Essential services like User Authentication and Real-Time Push Notifications must be implemented using a mandatory Backend-as-a-Service (BaaS) platform, such as **Firebase**, as the MERN stack cannot natively support these features.
- d. **Privacy by Design Compliance:** The system must adhere to a strict ethical framework requiring all location sharing to be **opt-in, anonymized, and aggregated** at the server level, confirming compliance with the Philippine Data Privacy Act.

## c. Software Design

This section details the user interface (UI) and user experience (UX) design of the *Para Mobile* application, as depicted in the provided wireframes. The design emphasizes clarity, accessibility, and intuitive interaction to address the identified commuter challenges.

### a. Home Screen

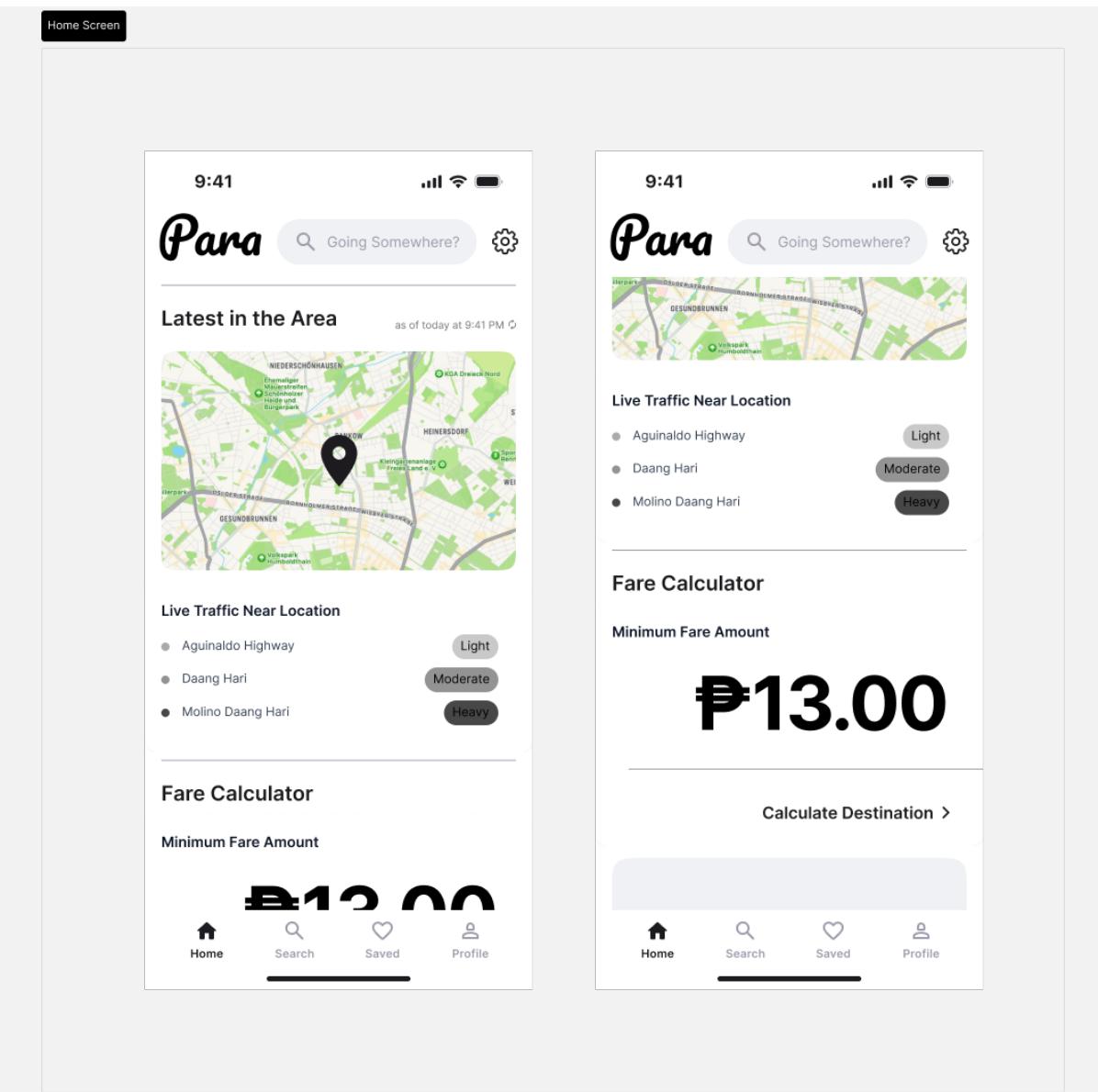


Fig 04: Home screen Design

**Function:** The Home screen serves as the primary entry point for users, offering immediate access to critical, context-aware information. It is designed to provide quick situational awareness and foundational planning tools upon application launch.

- **"Latest in the Area" (Map View):**

- **Function:** Displays the user's current location on a map, providing an immediate geographical context. This fulfills the need for spatial orientation, especially for users navigating unfamiliar areas.
- **Design Rationale:** The map is prominent, leveraging established UI patterns for navigation applications. The "as of today at 9:41 PM" timestamp ensures users understand the recency of the displayed data.

- **"Live Traffic Near Location":**

- **Function:** Informs users about current traffic conditions on major thoroughfares (e.g., "Aguinaldo Highway," "Daang Hari," "Molino Daang Hari").
- **Design Rationale:** Utilizes clear, color-coded labels ("Light," "Moderate," "Heavy") to provide an at-a-glance understanding of congestion levels, directly addressing the stress caused by unpredictable delays.

- **"Fare Calculator (Minimum Fare Amount)":**

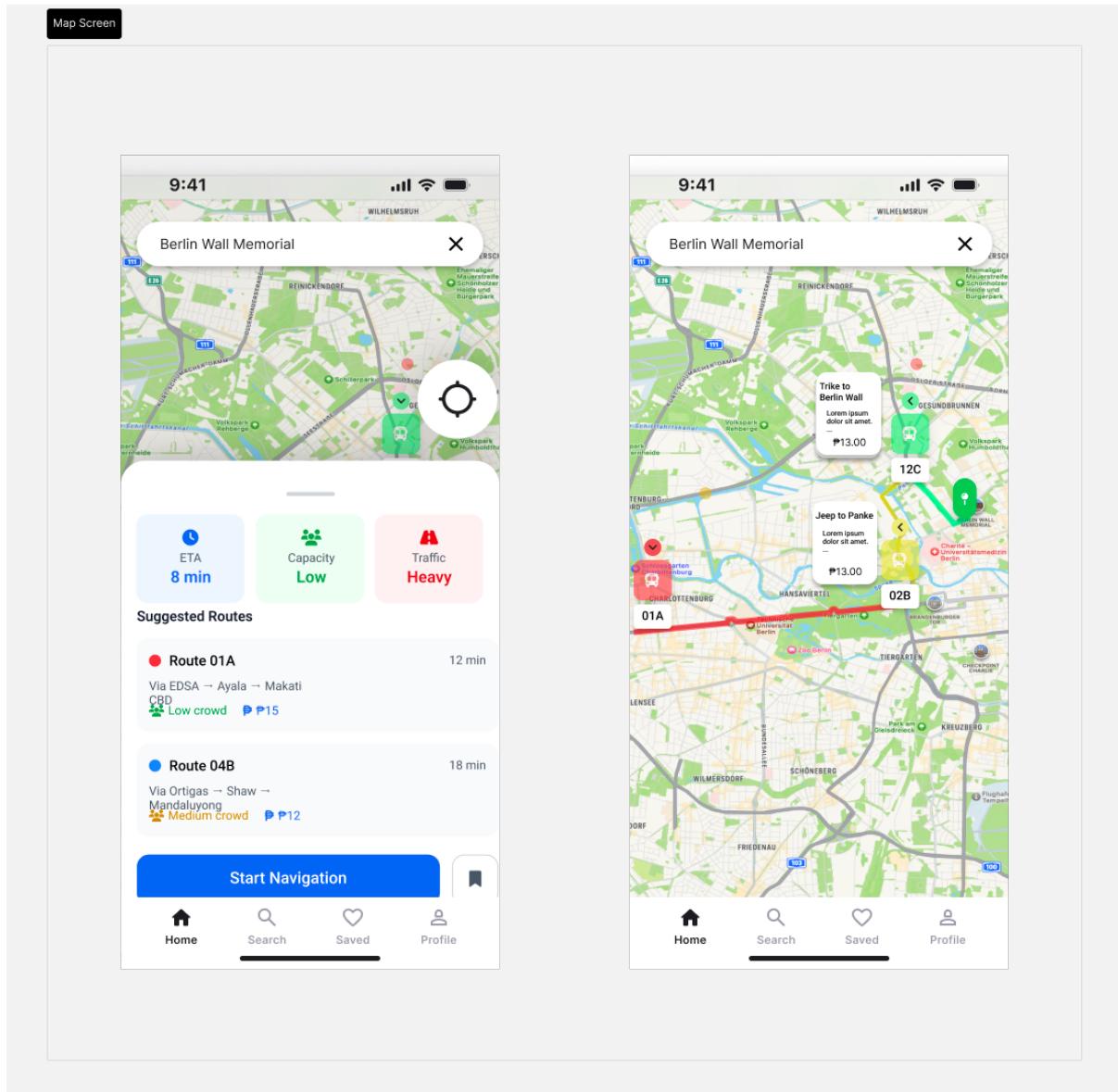
- **Function:** Displays the minimum fare amount (e.g., "₱13.00"). When scrolled, the second iteration of Image 1 shows an expanded "Fare Calculator" section with a "Calculate Destination" button.
- **Design Rationale:** Provides immediate financial transparency, addressing commuter anxiety regarding fare budgeting. The "Calculate Destination" CTA

guides users towards a more detailed fare estimation based on their specific journey.

- **Navigation Bar (Bottom):**

- **Function:** Persistent access to core application sections: Home, Search, Saved, and Profile.
- **Design Rationale:** Standard mobile navigation pattern ensures ease of access to primary functionalities throughout the user's journey.

### b. Map Screen / Route Search



### Fig 05: Map Screen / Route Search

**Function:** This screen is central to the application's core value proposition, allowing users to search for destinations, view suggested routes with real-time data, and initiate navigation.

- **Search Bar ("Berlin Wall Memorial"):**
  - **Function:** Allows users to input their desired destination, triggering route calculation. The "X" icon enables quick clearing of the input.
  - **Design Rationale:** Clear and intuitive search functionality, a standard for navigation apps. The prominent placement makes it easily accessible.
- **Map View with Route Overlay:**
  - **Function:** Visually displays the suggested routes (e.g., "Route 01A," "Route 04B") on the map, along with points of interest or transit stops.
  - **Design Rationale:** Provides a clear visual context for the suggested routes, enhancing user comprehension and decision-making. The circular icon with crosshairs likely indicates a re-centering or 'my location' function.
- **Route Information Cards:**
  - **Function:** Presents essential details for each suggested route, including Estimated Time of Arrival (ETA), estimated "Capacity" (crowd level), and "Traffic" conditions.
  - **Design Rationale:** Consolidates critical decision-making information (time, crowd, traffic) in an easily digestible format. The second screen of Image 2 shows detailed pop-up information for a specific leg of the journey ("Tribe to Berlin Wall," "₱13.00," "12C," "02B"), crucial for **Granular Guidance**.

- **"Start Navigation" Button:**

- **Function:** Initiates turn-by-turn or step-by-step guidance for the selected route.
- **Design Rationale:** Clear call-to-action for the primary user goal after selecting a route.

- **Crowd and Fare Indicators:**

- **Function:** Provides estimations for crowd levels and specific route fares (e.g., "Low crowd P15," "Crowd P12").
- **Design Rationale:** Directly addresses commuter concerns about comfort and cost, offering comparative data for route selection.

### c. Profile / Achievements Screen

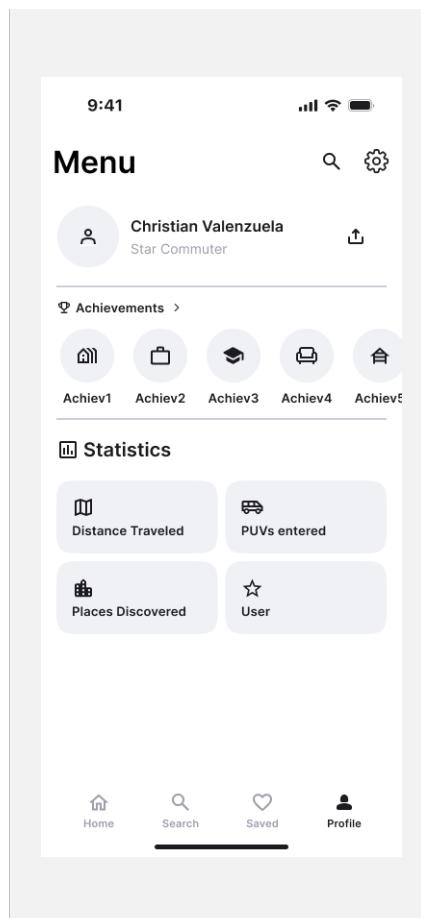


Fig 06: Profile Screen

**Function:** The Profile screen serves as the user's personal dashboard, showcasing their engagement, statistics, and **Gamification** achievements.

- **User Information:**

- **Function:** Displays the user's name ("Christian Valenzuela") and status ("Star Commuter"). The upload icon suggests an option to update the profile picture or share.
- **Design Rationale:** Personalizes the user experience and offers a sense of identity within the application.

- **"Achievements" Section:**

- **Function:** Visually represents achieved milestones (e.g., "Achiev1," "Achiev2"). The arrow indicates that this is a navigable section for more details.
- **Design Rationale:** Directly implements the **Gamification Module**, incentivizing continued use and data contribution through recognition and rewards.

- **"Statistics" Section:**

- **Function:** Displays aggregated user data such as "Distance Traveled," "PUVs entered," and "Places Discovered."
- **Design Rationale:** Provides users with a summary of their travel patterns, fostering a sense of accomplishment and contributing to their personal commuting insights.

#### d. User Authentication

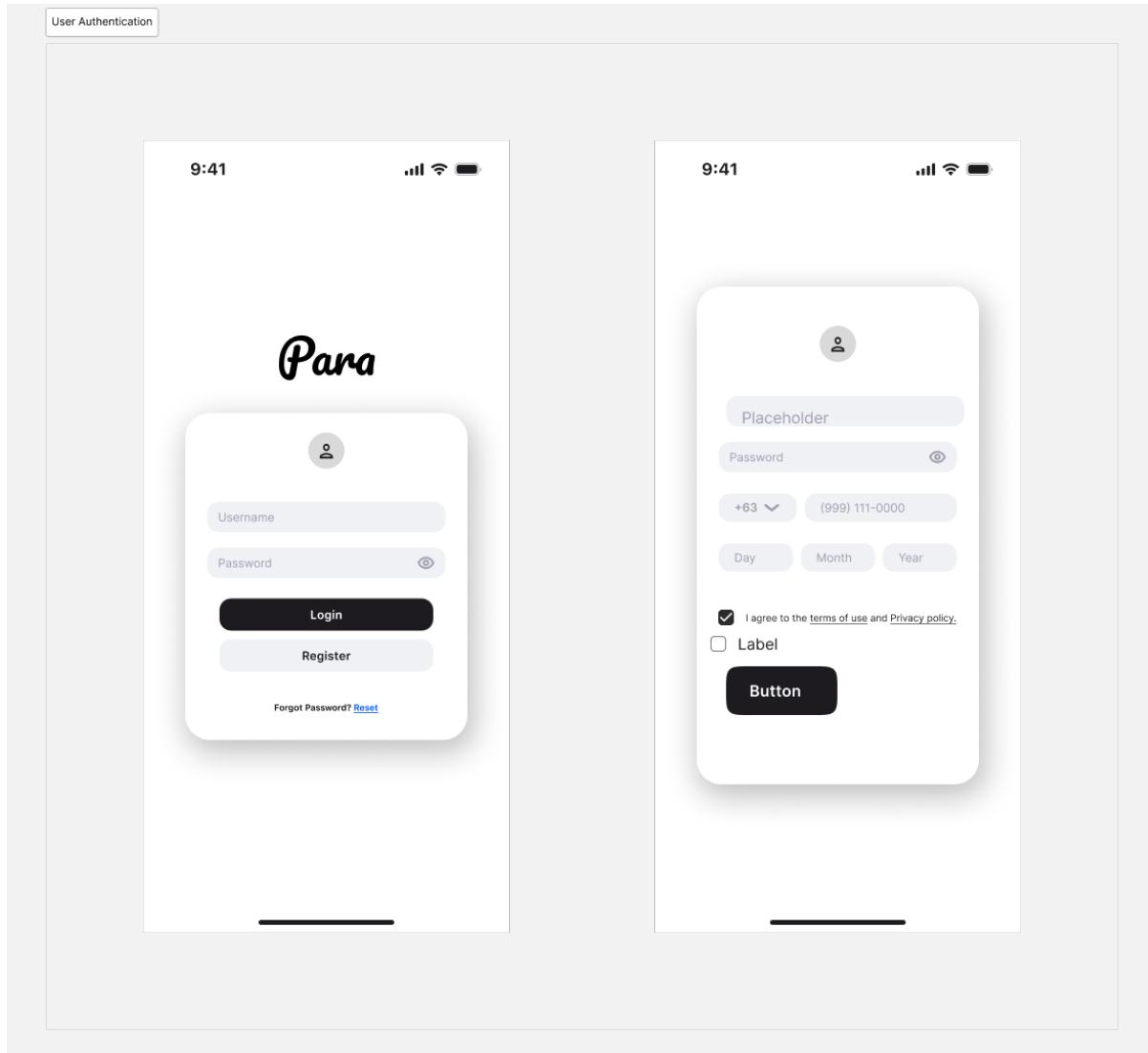


Fig 07: User Authentication

**Function:** These screens manage user registration and login, serving as the gateway to personalized features and data.

- **Login Screen:**

- **Function:** Allows existing users to access their accounts using a username and password.
- **Design Rationale:** Standard authentication interface for secure access to personalized features, aligning with the "Privacy by Design" framework by managing individual user data.

- **Registration Screen:**

- **Function:** Enables new users to create an account, collecting necessary information like username, password, contact details, and agreement to terms.
- **Design Rationale:** Provides a clear process for onboarding new users. The "I agree to the terms of use and privacy policy" checkbox is critical for legal compliance and transparent data handling, especially given the app's use of location data.

Overall, the wireframe designs effectively translate the *Para Mobile* project's core objectives into a user-friendly and functional interface, prioritizing verified information, real-time context, and user engagement.

## a. Process Execution

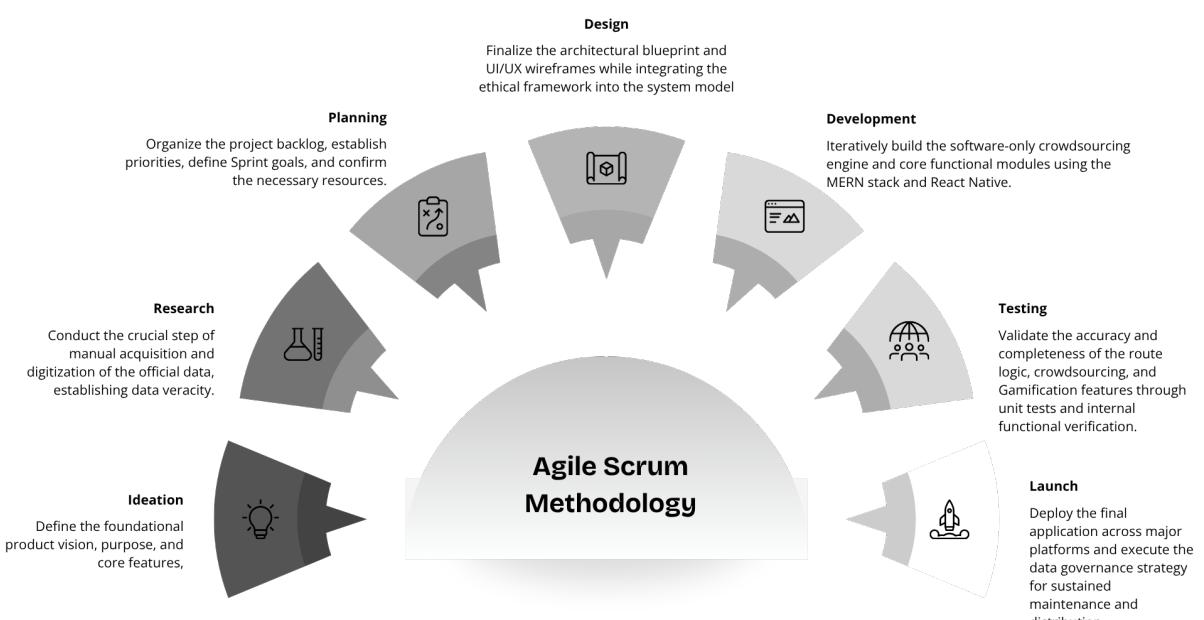


Fig 03: Agile Scrum Methodology

The **Agile Scrum Methodology** structures the project into short, iterative cycles, beginning with **Ideation**, where core features and the vision for the **Para Mobile** product are established. This is immediately followed by **Research**, which involves the crucial **Manual LPTRP data digitization** and acquisition of verified **LTFRB/LGU route data**. **Planning** translates requirements into a backlog, setting priorities and formulating the initial Sprint goals, and confirming the resources (MERN/React Native/OSM) and the **Agile** approach. **Design** finalizes the **UI/UX wireframes**, models the database architecture, and implements the **Privacy by Design** ethical framework. **Development** is the core coding phase, where continuous Sprints build the **software-only crowdsourcing engine** and the functional modules. **Testing** is integrated throughout, validating data integrity, functional reliability, and conducting **User Acceptance Testing (UAT)** with commuters. Finally, **Launch** involves deploying the finished application across major platforms and executing the data governance strategy.

## II. Systems Testing

The Systems Testing phase systematically validates the functional capabilities, operational reliability, and data integrity of the developed "Para Mobile" application, culminating in user evaluation to confirm its utility. The primary goal is to ensure the solution genuinely addresses commuter challenges and adheres to modern compliance standards.

### Testing and Validation Procedures:

The testing process involves performing unit, integration, functional, and usability tests. Specifically, the project aims to systematically test the foundational functional capabilities:

- **Route Accuracy Validation:** Testing must validate the accuracy and completeness of the **end-to-end route planning capabilities**, including necessary transfers, based entirely on the verified data set.
- **Real-Time Data Verification:** The system must verify the reliable ingestion and use of **real-time traffic data crowdsourced exclusively from active user location inputs**, confirming the feasibility of the software-only crowdsourcing model.
- **Gamification Functionality:** Testing must confirm the successful operation of the **achievement score system** and the **route timing feature**, ensuring they accurately generate measurable route efficiency data and incentivize user contribution.
- **Ethical Compliance Audit:** A critical evaluation must confirm the system's adherence to the **Philippine Data Privacy Act** by verifying that all location sharing is strictly **opt-in, anonymized, and aggregated** at the server level, proving a model for privacy-by-design.

The final output of this phase includes the developed "Para Mobile" application, which will then be subjected to rigorous **User Acceptance Testing (UAT) with commuters**, generating formal feedback and evaluation results that inform the final implementation plan.

### III. IMPLEMENTATION

The implementation plan outlines the strategic transition of the *Para Mobile* prototype into a deployable, scalable, and sustainable civic application, focusing on robust cloud infrastructure and formalized data governance.

#### a. Phased Deployment Strategy

The project will adhere to a phased rollout model, starting with rigorous testing before achieving public distribution.

- **Alpha/Beta Testing:** Following internal development, the application will undergo **User Acceptance Testing (UAT)** with targeted Imus commuters. This stage is critical for validating the precision of the **Smart Routing Engine**, the accuracy of the **Verified Fare Matrix**, and the reliability of the **Crowdsourcing Engine**.
- **Public Rollout (Distribution):** The stable application bundles (APK and IPA) will be submitted to the Google Play Store and the Apple App Store, respectively. Utilizing these official distribution channels ensures maximum accessibility across both target platforms (iOS and Android).

#### b. Infrastructure and Technical Architecture

The architecture is built on a decoupled, scalable framework designed explicitly for cost-effectiveness and performance.

- **Backend Hosting (MERN Stack):** The Node.js/Express.js API (the application logic) will be deployed on a **Cloud Computing platform** (e.g., a Virtual Private Server or managed cloud instance). This cloud environment is necessary to handle the real-time processing and aggregation of traffic data from numerous concurrent users.
- **Database Management: MongoDB**, the non-relational database component of the MERN stack, will be hosted via a **managed service** (e.g., MongoDB Atlas). This

ensures the necessary stability for storing the core structured **Verified Route Data** and the dynamic **Traffic Data**.

- **Front-end & Services:** The React Native application bundles will connect to the backend API and use **Firebase** for secure user authentication and essential push notifications. The application will fetch its foundational map tiles and geodata directly from the **OpenStreetMap (OSM)** API, a strategic choice that avoids the costly commercial licensing fees associated with other map providers.

#### c. Data Governance and Sustainability Plan

The long-term viability of **Para Mobile** hinges on the sustainability of its high-quality data service, necessitating formalized governance.

- **Route and Fare Maintenance:** A formal **Data Governance Strategy** will be established for continuous maintenance. This involves continuous coordination and liaison with the **LTFRB** and the **City Planning and Development Office (CPDO) of Imus** to manually acquire and digitize any official updates to routes or fare matrices immediately.
- **Crowdsourcing Integrity:** Automated validation checks will be implemented to ensure the real-time data ingestion adheres strictly to the "**Privacy by Design**" framework, confirming that all location data remains opt-in, anonymized, and aggregated.
- **Resource Contribution:** As a project with civic utility, the plan includes a strategy for distributing the foundational **high-quality public transport data set** to future researchers and urban planning bodies, maximizing the academic and civic value of the collected information.

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