Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

# NextGen Pune Mobility Platform

## An AI-Enabled Multimodal Public Transportation System for Urban Mobility in Pune

Onkar Doge, Praharsha Chaudhari, Varada Korlahalli, Priya Chauhan
Department of Computer Engineering, Savitribai Phule University
Sinhgad Academy of Engineering, Kondhwa (Bk), Pune – 411048
Prof. A. H. Kagne
Department of Computer Engineering, Savitribai Phule University
Sinhgad Academy of Engineering, Kondhwa (Bk), Pune – 411048

***Abstract*— In the growing urban landscape of Pune, commuters often face disorganized transport systems, irregular PMPML bus timings, and limited digital coordination between buses and metro routes. The proposed project, Smart Pune Commute, introduces a unified, cross-platform mobile application that integrates Pune's PMPML bus and Metro services into one intelligent interface. The system leverages GPS and AI-based route optimization to provide real-time tracking, smart digital passes, and multimodal trip suggestions. Accessibility is improved through voice command support and chatbot assistance. By combining transport data and advanced technologies like Google APIs, this application promotes efficiency, inclusivity, and sustainability, supporting Pune's Smart City objectives.**

***Keywords*— Smart Transport, AI Chatbot, Public Transit, Real-time Tracking, Flutter, Flask, PMPML, Metro Integration.**

## I. INTRODUCTION

Urban public transportation forms the indispensable backbone of economic and social activity for millions of commuters in densely populated metropolitan areas like Pune. Despite the crucial services offered by existing infrastructure, such as the Pune Mahanagar Parivahan Mahamandal Limited (PMPML buses) and the newly developed Pune Metro, commuters continually face a series of systemic challenges. These challenges include the frustration of irregular schedules, the inconvenience of disconnected routes and last-mile service gaps, and the inefficiency of outdated, fragmented ticketing systems that force users to manage multiple passes or payment methods. The Smart Pune Commute project directly addresses these critical pain points by proposing and implementing a comprehensive solution: a single, unified digital platform that seamlessly integrates bus and metro services. This platform is powered by advanced technology, providing users with accurate real-time tracking, intelligent AI-based route suggestions generated through sophisticated optimization algorithms, and modern, secure digital ticketing features. Furthermore, by incorporating voice-enabled accessibility and AI chatbot assistance, the project significantly enhances the overall commuter experience, making daily travel faster, safer, more reliable, and ultimately supporting Pune's ambitious Smart City mission to create a truly connected urban ecosystem.

## II. LITERATURE SURVEY

The "Smart Pune Commute" system draws on established theories in smart city transportation, emphasizing integration of public transport modes like buses (PMPML) and metro rails. This section outlines key theoretical frameworks, supported by illustrative diagrams, to underpin the proposed unified assistant app. These theories address gaps in real-time tracking, AI-driven planning, and multimodal accessibility, as identified in the survey.

### *A. Multimodal Transport Integration*

Public transport works best when bus, metro, and walking connect smoothly. This theory says one app should plan the full journey – from PMPML bus to Pune Metro – using real-time data (GPS, IoT). It reduces wait time, cost, and pollution.

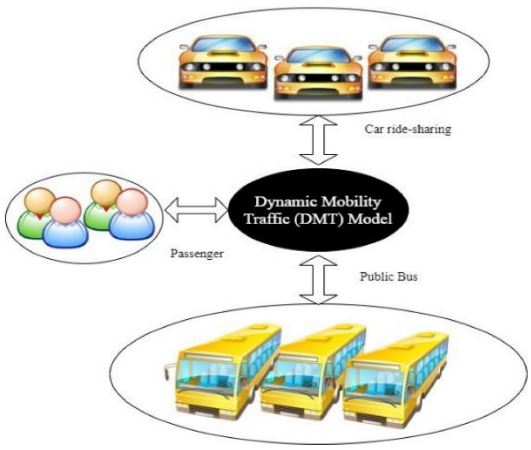


Fig. 1 Dynamic Mobility Traffic Model illustrating integration of passengers, car ride-sharing, and public buses in smart cities.

The model above exemplifies how passengers interact with multiple modes via a central traffic model, adaptable to Pune's context for bus-metro feeders. Advantages include up to 80% emission reductions (per 2024 survey), though challenges like data silos persist.


(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

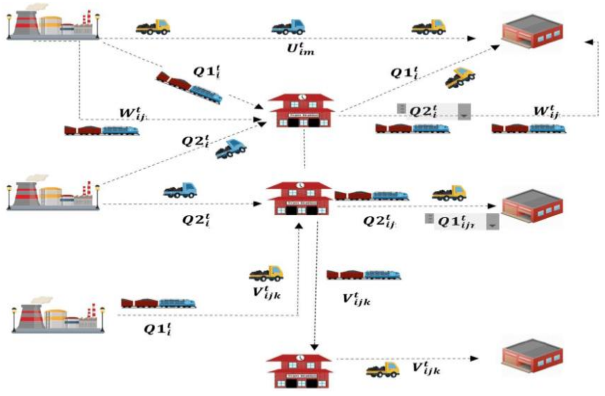

Fig. 2 Underlying structure of multimodal transportation networks, showing interconnected nodes for efficient urban planning.

### B. *AI-Powered Optimization in Public Transport*

AI predicts delays, suggests fastest routes, and answers user queries via chat (NLP). Based on UTAUT model, it ensures users accept and trust the system. Crowdsourced data improves accuracy.

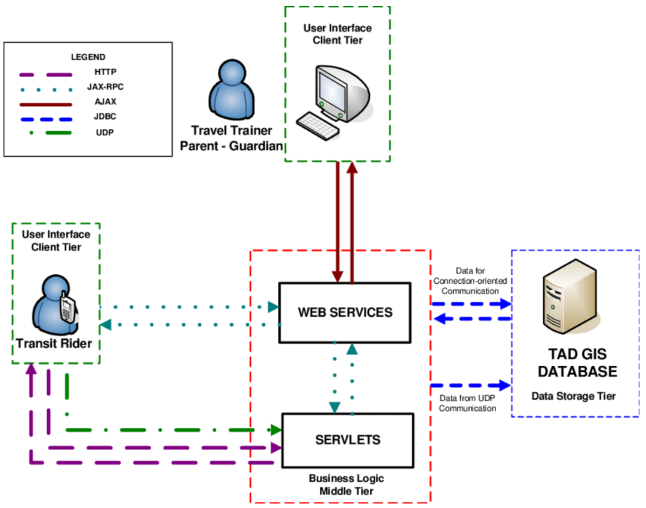


Fig. 3 Detection in bus-metro operations

The architecture depicts modular components like user interfaces and backend servers, ideal for Pune's unified app with real-time updates. Benefits include 24/7 accessibility, but disadvantages involve privacy risks and tech literacy barriers. This prototype emphasizes sensor-AI fusion, recommending extensions for voice modes (2025 Chennai app inspiration) to aid disabled users.

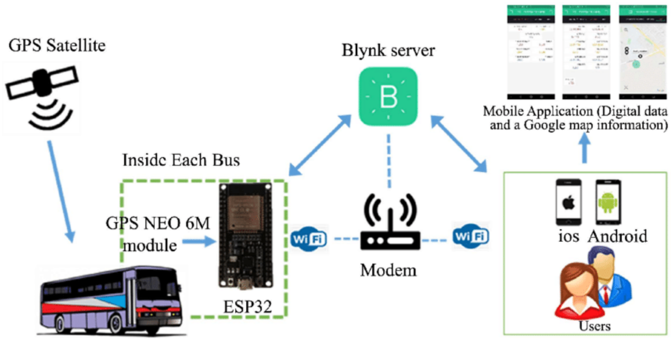


Fig. 4 Prototype architecture for smart public transportation, integrating sensors and AI for multimodal assistance.

### C. *Unified Ticketing (MaaS)*

One QR ticket for bus + metro removes multiple apps and cash. Inspired by Mumbai/Chennai One apps, it enables seamless travel and boosts ridership.

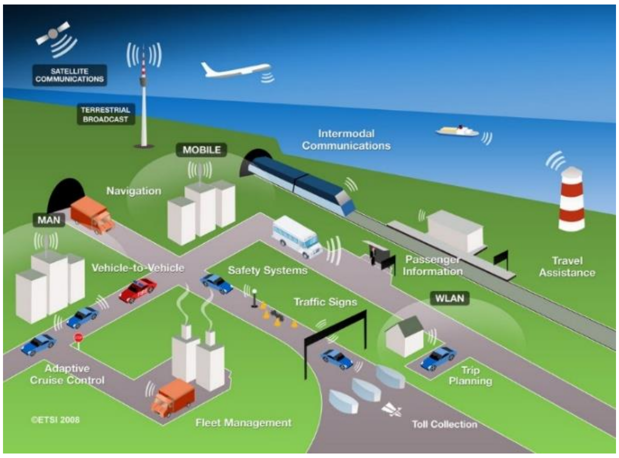


Fig. 5 Conceptual diagram of a smart multimodal transport system, highlighting integrated planning for urban public transit.

Though not a direct flowchart, this system diagram illustrates QR integration potential, with advantages in ridership boosts but challenges in adoption.

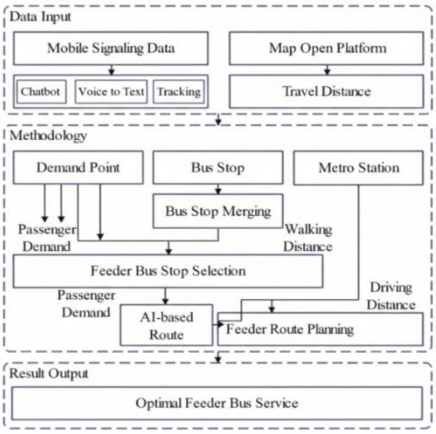


Fig. 6 Research framework



(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

Recommendations include adapting Maas for Pune via AI feeders and dynamic QR generation.

### D. Summery

TABLE I
SUMMERY OF LITERATURE SURVEY

| Sr no. | Problem | Year | Proposed Approach | Recommendation |
|---|---|---|---|---|
| 1. | Pune Metro: low ridership, no unified tracking with buses. | 2025 | PKC-Maha Metro pilot: GIS, feeders, safety tech. | Build unified PMPML-Metro AI assistant. |
| 2. | Multiple tickets delay journeys; no accessibility integration. | 2025 | Chennai One App: QR ticketing for all transit. | Add voice mode; link to real-time tracking. |
| 3. | Fragmented ticketing; no unified QR for Pune bus-metro. | 2025 | Mumbai One App: single QR for all modes. | Adapt for Pune with AI route planning. |
| 4. | Heritage core: congestion, narrow roads, siloed governance. | 2024 | LAMP with HUL: pedestrianization, NMT focus. | Pilot near metro; decentralize PMC. |
| 5. | Parking crisis (4M+ vehicles); congestion in old areas. | 2024 | GIS-based parking matrix; promote NMT & BRT. | Feeder buses; graded parking fees. |
| 6. | IoT data overload; need ML for routing & safety. | 2024 | IoT-ML (RF, SVM) for congestion & accident detection. | Apply ML to Pune bus-metro anomalies. |
| 7. | Underused open spaces reduce liveability near transit. | 2023 | Placemaking: theme parks with citizen input. | Add GIS; connect to bus stops. |
| 8. | Poor walkability & safety in Aundh-Baner; NMT-transit disconnect. | 2023 | Smart Streets: footpaths, cycle tracks, 4D design. | Scale via PPP; link to bus-metro hubs. |
| 9. | Traffic, parking, safety gaps; no real-time transit data. | 2022 | Mobile crowdsourcing via smartphones for live updates. | Standardize data protocols for Pune ITS. |
| 10. | Pune public transport: overcrowding, low adoption (18%), no real-time info. | 2020 | AI Chatbot with NLP & GPS for routes, tickets, complaints. | Integrate with PTIS; pilot multimodal chatbot. |

## III. METHODOLOGY AND SYSTEM DESIGN

### A. Problem Statement

Urban commuters face several persistent challenges due to the inefficiencies of current public transport systems. The use of multiple applications for buses, metros, and ticketing services creates confusion and inconvenience, as users must navigate between different platforms for various purposes. The absence of real-time arrival information further contributes to commuter frustration, resulting in long waiting periods at stops or stations without clarity on delays. Manual and limited ticketing processes add to the problem, often causing delays, long queues, and operational inefficiency during peak hours. Moreover, the lack of predictive crowd analysis and intelligent route optimization prevents travellers from making informed decisions, leading to overcrowded vehicles and suboptimal travel routes. Accessibility remains another major concern, as most existing systems provide limited features for differently-abled and senior citizens, thereby restricting inclusivity. Additionally, transport authorities lack access to live analytical data, hindering their ability to monitor demand patterns, manage traffic flow, and make data-driven decisions for effective route planning and public transport management.

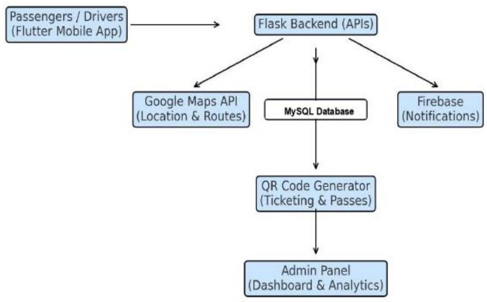


Fig. 7 Architecture of project

The Smart Pune Commute system is founded on a robust client-server architecture, using a Flutter-based front end to facilitate cross-platform accessibility and crucial user interactions, including input via Chatbot and Voice-to-Text, and managing the digital Ticket Option. The system's intelligence resides in the Python Flask backend, which processes a rich set of data—from implicit Mobile Signalling Data to explicit real-time feeds like Real-time Bus Tracking and Google Maps APIs for distance calculation. Data persistence is ensured through a hybrid model, utilizing MySQL for static records and Firebase for high-velocity, real-time data handling. The core methodology is driven by AI algorithms that execute a three-stage process: first, Bus Stop Merging consolidates redundant stops; second, Feeder Bus Stop Selection allocates passenger demand based on walking distance; and finally, Feeder Bus Route Planning uses optimization techniques to generate the AI-based Route that minimizes total travel time, ultimately delivering the Optimal Feeder Bus Service while adhering to necessary security protocols route prediction.



(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

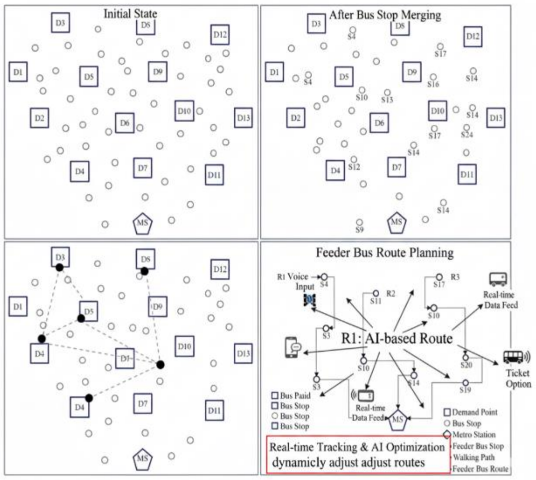


Fig. 8 Graphical representation of the proposed methodology

The system modules include user management, route planning, pass generation, and an AI chatbot for query resolution.

*B. Obtaining Comprehensive Passenger Demand via Multi-Source Data Fusion*

Accurately determining Passenger Demand is the foundational step for the Smart Pune Commute system's route optimization. Unlike traditional methods relying solely on Mobile Signalling Data, our system leverages a multi-source data fusion approach to capture both implicit and explicit traveller intentions, ensuring the generated AI-based Route is robust and dynamic. The platform integrates four primary data streams to model a comprehensive Origin-Destination (OD) matrix between demand points and transit stations (Metro and Feeder Bus Stops).

The core process involves three key steps, utilizing the integrated application components:

**Step 1**: Real-Time and Explicit Demand Capture

This step focuses on gathering immediate, user-initiated travel requests and real-time transit status, which is essential for dynamic rerouting.

**Step 1.1**: Capture Explicit Traveler Demand(Chatbot/Voice)

- The application uses the AI Chatbot (powered by Flutter NLP) and Voice-to-Text features to immediately capture user intent (e.g., "Need a bus from location X to Metro Station Y at this time").
- This data is instantly logged to the Firebase Real-time Database as a high-priority demand signal, providing real-time data .

**Step 1.2**: Integrate Real-time System Status

- Real-time Tracking data (bus occupancy, current location, and speed) is continuously streamed via the Google Maps API and processed by Firebase.
- This provides crucial data on immediate capacity constraints and potential service gaps, acting as a secondary input to the OD matrix by quantifying unmet demand.

**Step 2**: Inferring Implicit Trajectories via Mobile Signalling

This step retains the established method of inferring travel patterns for long-term planning and background demand modelling.

**Step 2.1**: Differentiate Transit Zones

- The system differentiates urban areas using base station information, classifying them into Ground Base Stations (GBSs), Metro Base Stations (MBSs), and key Feeder Bus Stop Zones.
- The system extracts and anonymizes traveller trajectories based on the sequence of GBS-MBS interactions (similar to the logic used by Zhang et al. [38]).

**Step 2.2**: Establish OD Matrix Baseline

- By tracking mobile interactions—specifically the sequence of GBS $\to$ MBS (entry) and MBS $\to$ GBS (exit)—the system establishes a baseline OD matrix representing habitual travel flows between demand points and the Metro Station. This is stored in MySQL for historical analysis.

**Step 3**: Generating Finalized Passenger Demand Model

The final step merges the real-time explicit demands (from Step 1) with the long-term implicit demands (from Step 2) to create the input for the Feeder Bus Stop Selection phase.

The Flask Backend performs data fusion, combining the immediate demand signals from Firebase with the historical patterns from MySQL, resulting in a robust, time-stamped Passenger Demand matrix ready for the AI methodology.

*C. Bus Stop Merging Based on the Dijkstra's Algorithm*

The purpose of the final route planning step is to determine the optimal sequence of Feeder Bus Stops and the Metro Station (MS) to minimize the total travel time or driving distance. This process generates the final AI-based Route that efficiently serves the collected passenger demand. Therefore, the focus is on finding the single shortest path within the road network graph. The Dijkstra's Algorithm is highly suitable for this task because it efficiently computes the shortest path from a single source node to all other nodes in a graph with non-negative edge weights.

The fundamental principle of the Dijkstra's Algorithm is to iteratively explore the graph, starting from a source node (e.g., the first feeder bus stop in a potential route), and permanently marking the shortest distance found to each node. Setting the nodes as selected feeder bus stops and the Metro Station (MS), and the edge weights as the driving distance or travel time between them, provides the framework for optimization.

The algorithm classifies nodes during the process based on their current distance:

1. Source Node: The initial node from which all paths are measured (Distance $= 0$).
2. Unvisited Nodes: All nodes whose shortest path from the source has not yet been finalized.



(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

3. Visited Nodes: Nodes whose shortest path from the source has been finalized and will not change.

The process continuously selects the unvisited node with the smallest known distance from the source, marks it as visited, and then relaxes the edges connected to it. Relaxation involves checking if traveling to an adjacent unvisited node via the current node offers a shorter total distance than the path currently recorded for that adjacent node. This ensures that the final set of paths found represents the shortest distance from the source to all other reachable stops in the network. For route planning, this ensures the most efficient AI-based Route to the Metro Station is identified.

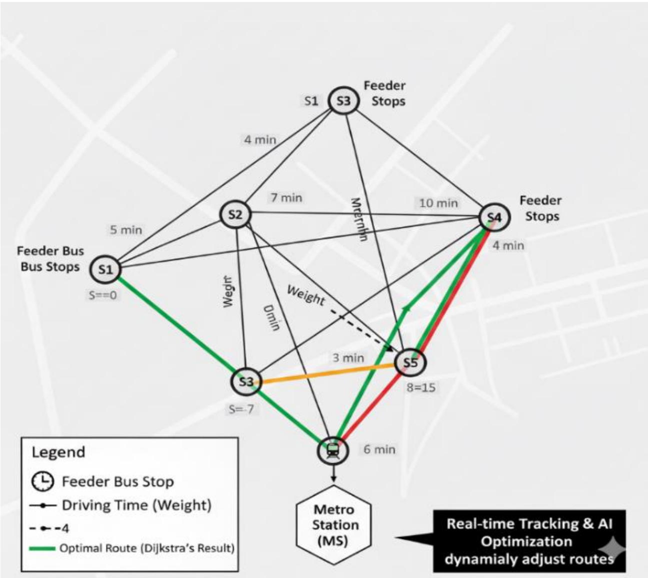


Fig. 9 Graphical representation of the Dijkstra's algorithm

### *D. AI Chatbot and Voice-Enabled Accessibility*

The Smart Pune Commute application integrates conversational AI to enhance the user experience, providing immediate, natural language access to complex service information and accommodating diverse user needs.

#### 1. AI Chatbot Assistance

The AI Chatbot module is designed to act as a primary interface for quick information retrieval, directly capturing user intent to feed the demand model.

- Functionality: The chatbot allows users to inquire about routes, current fares, pass validity, and real-time transit status using simple text queries. This explicit user input(e.g., "How long will the next bus take?") serves as a critical, real-time demand signal.
- Implementation: The module is integrated into the Flutter front end, utilizing its NLP capabilities to process and classify user requests. The backend logic is connected to the Firebase database to fetch the most current data instantly.

#### 2. Voice-to-Text and Accessibility

To promote inclusivity and improve the user experience for commuters who are visually impaired or unable to type while commuting, the application incorporates voice capabilities.

- Voice-to-Text (Speech-to-Text): This feature allows users to articulate their queries or input their desired destinations verbally. The spoken language is converted into text and processed by the AI chatbot, effectively turning vocal commands into demand inputs for the system.
- Text-to-Speech: Conversely, the system is designed to read out critical information, such as route directions, delay alerts, and fare confirmations, providing an essential layer of accessibility for visually impaired users.
- Role in Demand Capture: These voice-enabled features allow the application to capture immediate and accurate Passenger Demand signals, which are instantaneously sent to the Python Flask backend for inclusion in the real-time AI route planning cycles.

## IV. IMPLEMENTATION

The implementation of the Smart Pune Commute system involved developing and integrating key modules such as user authentication, real-time tracking, AI chatbot assistance, and digital pass management. The system was built using Flutter for the mobile frontend and Flask for the backend, ensuring a smooth and responsive experience. Firebase and MySQL databases were used for secure data storage and synchronization of user profiles, routes, and payment details, with Firebase specifically handling the high-velocity streams from Real-time Bus and Metro Tracking. Real-time location updates and route visualization were achieved using the Google Maps API. An AI chatbot powered by Flutter's NLP was implemented to help users easily find routes, fares, and pass-related information through simple text or voice queries, enhanced by speech-to-text and text-to-speech for accessibility. The Flask backend is critically responsible for executing the core AI-based Route logic, using clustering algorithms for Bus Stop Merging and optimization algorithms for Feeder Bus Route Planning, which process the aggregated real-time and historical demand data. The digital pass generation module integrated Razor pay for secure online payments, and each pass was assigned a QR code for verification. This comprehensive setup ensures efficient route optimization, smart navigation, and a user-friendly interface, making daily commuting in Pune faster, safer, and more convenient. The Smart Pune Commute system successfully integrates PMPML and Metro data, providing users with a seamless experience for journey planning.


(This work is licensed under a Creative Commons Attribution 4.0 International License.)

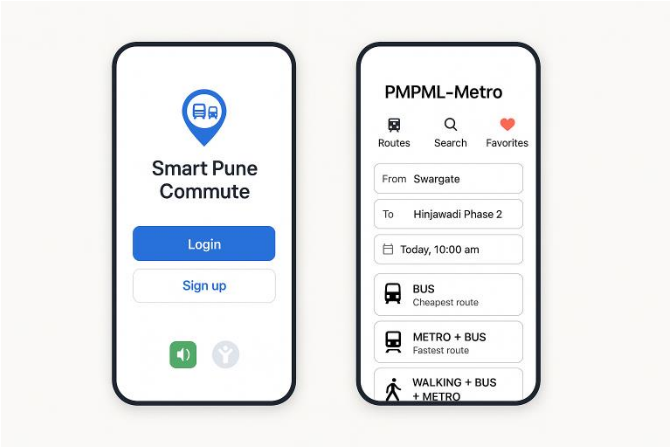


Fig. 10 Planned Output

Testing showed significant reductions in wait times and improved accuracy in real-time tracking. The AI route suggestion module performed well in dynamically changing traffic conditions, and users appreciated the intuitive design and accessibility options.

## V. RESULT OF PROJECT

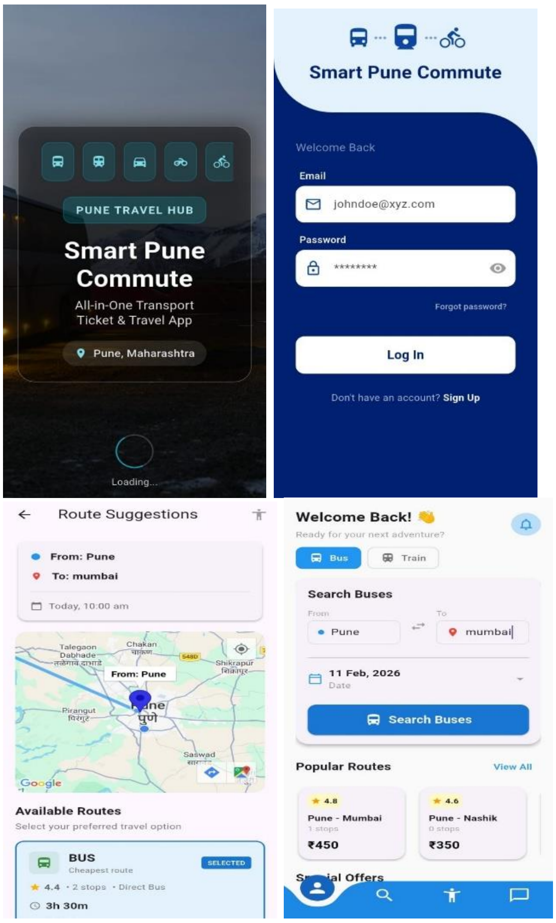


Fig. 11 Actual Result

The implemented system demonstrates improved accessibility to public transport information and enhanced user awareness of service availability. By presenting unified and timely information, the system reduces uncertainty in travel planning and supports better commuter decision-making. The modular architecture allows efficient system operation and potential future expansion. User feedback indicates improved convenience and satisfaction compared to traditional information sources.

## VI. SOLUTION APPROACH

The solution approach for the Smart Pune Commute project is a comprehensive strategy built on Data Fusion, AI-driven Optimization, and a Unified Digital Experience. The process begins with Data Fusion, aggregating both implicit demand from Mobile Signalling Data and explicit, dynamic requests collected via the A

I Chatbot and Voice-to-Text. This data is managed using a hybrid architecture, leveraging Firebase for high-speed, Real-time Tracking and instantaneous demand signals, and MySQL for historical and static data, all underpinned by Google Maps APIs for location intelligence. The core of the solution is the sequential, three-stage AI Methodology: first, redundant stops are eliminated through Bus Stop Merging via clustering algorithms; second, Feeder Bus Stop Selection allocates demand based on minimizing walking distance; and finally, Feeder Bus Route Planning uses Dijkstra's Algorithm (or similar optimization) to generate the most efficient AI-based Route by minimizing driving distance. This intelligent service is delivered through a single Flutter application that offers seamless features like a digital Ticket Option, ensuring an accessible, fast, and convenient commuting experience.

## VII.CONCLUSIONS

This paper presented an Intelligent Urban Mobility System aimed at improving public transportation efficiency in Pune. The system demonstrates how integrated digital platforms can enhance commuter experience and support sustainable urban mobility. Future work may include advanced predictive assistance, inclusion of additional transport modes, enhanced analytics for authorities, and expansion to other urban regions.

## VIII.ACKNOWLEDGMENT

The authors sincerely thank Prof. A. H. Kagne for valuable guidance throughout this project. We also express gratitude to the Department of Computer Engineering, Sinhgad Academy of Engineering, Pune, and Savitribai Phule Pune University for their continuous support and encouragement.

The authors would like to express their sincere gratitude to the project guide for continuous guidance, motivation, and valuable suggestions throughout the development of this work. The authors are also thankful to the Head of the Department and the faculty members of the Department of Computer Engineering for providing necessary support and facilities. Special thanks are extended to the institute for creating a conducive academic environment that encouraged research and innovation. The authors also acknowledge the support and cooperation of peers whose constructive feedback contributed to the improvement of this study

## IX.REFERENCES

[1] D. Onkar Somling Doge, A. H. Kagne, Praharsha Chaudhari, Varada Korlahalli, and Priya Chauhan, “Smart Pune Commute – A Unified Public Transport Assistant for PMPML & Metro,” International Research



(This work is licensed under a Creative Commons Attribution 4.0 International License.)

Journal of Modernization in Engineering Technology and Science (IRJMETS), vol. 07, no. 11, Nov. 2025, e-ISSN: 2582-5208, doi:10.56726/IRJMETS84435.

[2] Li, Weijun & Cheng, Guozhu. (2025). Designing Feeder Bus Routes: A Two-Stage Programming Model Using Existing Bus Stops. IEEE Transactions on Intelligent Transportation Systems. PP. 1-14. 10.1109/TITS.2025.3553156.

[3] Pune Mahanagar Parivahan Mahamandal Ltd. (PMPML). "Public Transportation | Pune Municipal Corporation – PMC for Punekar" [Online]. Available: https://www.pmc.gov.in/en/pmc-for-punekar/public-transportation. [Accessed: 21-Oct-2025].

[4] Maharashtra Metro Rail Corporation Ltd. (Pune Metro). "Welcome to Pune Metro: Official site of Pune Metro Rail Project" [Online]. Available: https://www.punemetrorail.org/. [Accessed: 21-Oct-2025].

[5] Ministry of Housing and Urban Affairs, Government of India, "Smart Cities Mission," [Online]. Available: https://smartcities.gov.in/. [Accessed: 21-Oct-2025].

[6] A. Kumar and S. Gupta, "AI-based Route Optimization for Public Transportation Systems," *International Journal of Computer Applications*, vol. 182, no. 16, pp. 10–15, 2023.

[7] R. Sharma, V. Singh, and A. Bansal, "Design and Implementation of Real-Time Bus Tracking System using GPS and Android," *IEEE International Conference on Intelligent Transportation Systems*, pp. 112–117, 2022.

[8] M. Patel and D. Mehta, "Integration of Metro and Bus Systems for Smart Urban Mobility," *International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE)*, vol. 12, no. 5, pp. 33–39, 2022.

[9] A. Tiwari and P. Jain, "Smart City Mobility: A Case Study on AI-Powered Transportation Systems in Indian Cities," *Journal of Smart Technologies and Sustainable Urban Development*, vol. 8, no. 3, pp. 45–52, 2023.

[10] K. Ganesh, M. Thrivikraman, Joy Kuri, Haresh Dagale, G. Sudhakar & Sugata Sanyal, "Implementation of a Real Time Passenger Information System," *arXiv*, 2012.

[11] Narges Rashvand, Sanaz Sadat Hosseini, Mona Azarbayjani & Hamed Tabkhi, "Real-Time Bus Departure Prediction Using Neural Networks for Smart IoT Public Bus Transit," *arXiv*, 2025.

[12] T. A. Salih & N. K. Younis, "Design an Intelligent Real-Time Public Transportation Monitoring System Based on IoT," *Open Access Library Journal*, vol. 8, 2021.

[13] Samer I. Mohamed & Muhamed Abdelhadi, "IoT Bus Navigation System with Optimized Routing using Machine Learning," *International Journal of Information Technology and Computer Science (IJITCS)*, Vol.13, No.3, pp. 1-15, 2021.

[14] "Designing and Implementing a Public Urban Transport Scheduling System Based on Artificial Intelligence for Smart Cities," *Applied Sciences*, vol. 14, 2024.

[15] Donatella Darsena, Giacinto Gelli, Ivan Iudice & Francesco Verde, "Sensing Technologies for Crowd Management, Adaptation, and Information Dissemination in Public Transportation Systems: A Review," *arXiv*, 2020.

[16] "Integrated Public Transportation System with Shared Autonomous Vehicles and Fixed-Route Transits: Dynamic Traffic Assignment-Based Model with Multi-Objective Optimization," *International Journal of Intelligent Transportation Systems Research*, 2023

[17] "AI-Driven Optimization of Urban Logistics in Smart Cities: Integrating Autonomous Vehicles and IoT for Efficient Delivery Systems," *Preprints.org*, 2024.



(This work is licensed under a Creative Commons Attribution 4.0 International License.)