Isabela State University Linker:
Journal of Engineering, Computing, and Technology
Volume 2, Issue 2
ISSN (Print): 3082-3676 ISSN (Online): 3082-3684
DOI: https://doi.org/10.65141/ject.v2i2.n3

Development of an Internet of Things (IoT)-Based Real-Time Public Transport Passenger Tracking System

Joy Be B. Ignacio[1], **Marissa P. Millo**[2], **Roderick Y. Vicente**[3], **Jirah Mae A. Tennom**[4]
Ifugao State University, Potia Campus, Alfonso Lista, Ifugao, 3608, Philippines[1,2,3,4]
roderickvicente@gmail.com

RESEARCH ARTICLE INFORMATION

Received: September 23, 2025
Reviewed: November 13, 2025
Accepted: December 22, 2025
Published: December 31, 2025

ABSTRACT

Public transportation systems play a crucial role in rural development, providing a wide range of benefits that contribute to the well-being of communities, the environment, and the economy. This paper presents the development and implementation of an Internet of Things (IoT)-based real-time public transport tracking and passenger monitoring system, a combination of hardware and mobile application for tracking public transport vehicle geolocation and availability of passenger availability. The design project was powered by Arduino Mega, ESP8266, Neo-6M GPS module, and infrared (IR) sensors connected to the Blynk IoT platform, utilizing a mobile app called "iRIDECommuTech" for users' operation. Geolocation includes latitude, longitude, speed of the vehicle, and the current available passenger capacity. The system was tested using a public transport 14 kilometers point–to–point travel on a national highway. GPS transmits reliable data in 15-18 seconds, while the microprocessor POST initializes in 10-15 seconds, respectively. Result of the users' survey was generally acceptable for performance, usability, and reliability, with a mean average of 4.20, while functionality is the highest among the system requirement evaluation, with 4.53 as highly acceptable.

Keywords: *Internet of Things (IOT), GPS module, ESP8266 WiFi Module, InfraRed Sensors, iRIDECommuTech*

Introduction

Smart transportation is an advancement in the conventional transport system, which improves the quality of public life by providing optimized services and enhancing the sustainability of urban cities (Farman et al., 2022). Nowadays, a variety of public transportation options are used across the nation as a result of the rapid growth of advanced technology. But despite the increasing number of public transportation options, they are still insufficient to address the issues that commuters face in terms of monitoring available public transport vehicles in commuter stations (Shaaban et al., 2021), such as real-time geo–location, passenger counting, and application monitoring (Mateo et al., 2024).

Previous research explored different technology applications of public transport tracking systems and passenger monitoring. Beginning with infrared sensors, the study of Hagenaars et al. (2021) and Jahan et al. (2023) emerged as an effective way of counting individuals (Nitti et al., 2020). Without the need for complex additional setup, this approach offers a more cost–effective solution for occupancy detection. (Andrews et al., 2020), while monitoring people's presence (Maaspuro, 2020; Rahmatulloh et al., 2020).

Furthermore, public transport can be monitored through GPS (Global Positioning Systems), which serves as a pivotal tool for accurate monitoring and efficient vehicle tracking (Bujang et al., 2020; Zohari et al., 2021), leading to optimized, precise vehicle positions (Kumar et al., 2019) and significant contributions in real–time updates, and improving efficiency through the integration of IoT (Internet of Things) (Shah, 2021; Zulkifli & Mohd Shah, 2023). Additionally, the inclusion of RFID to monitor vehicle tracking is equally effective, according to Chen et al. (2022) and Husak et al. (2021). However, despite the existing applications that are being used by public transport operators, the gap remains in providing geolocation with the integration of passenger counting systems (Mugilan & Jayamangala, 2025) or predictive analytics (Mateo et al., 2024).

The municipality of Alfonso Lista, Ifugao, a rural town, was selected as the focal area for the implementation of the study due to its ideal location, where the availability of public transport vehicles is not fully systematized in terms of passenger loading and vehicle interval dispatching. In addition, local drivers are struggling to find enough passengers and are sometimes unable to make a profit during the day. On the other side, commuters struggle to wait for public transportation and are unaware of when the public transportation available in that area will arrive, and these are all considered during the study. Despite the improvements, the gap still remains in providing generally acceptable and effective service.

To address this gap, the study introduced "iRIDECommuTech," a localized hardware system and mobile application integrating both hardware and software, such as IoT (Internet of Things), GPS (Global Positioning System)(U-blox, 2017), ESP8266 Wi-Fi module, and Blynk for application monitoring are installed in mobile phones. This system application provides a low-cost, replicable hardware-software system that can be utilized by public transport operators and passengers for the passenger monitoring application.

Methods

The methodology adopted for the development of the IoT-based public transport passenger tracking system followed the Rapid Prototyping model, comprising the need analysis, design, prototype, and development, validation, and evaluation guided by a structured approach in terms of prototype development, comprising component selection, firmware development, integration, testing, and evaluation. The methodology also integrates a quantitative approach in the evaluation of the system.

Development Methodology

The system was developed using a Rapid Prototype Model, which enables users to rapidly develop a system without the need for high-level electronics assembly, and this model works best in this scenario, where not all of the project requirements are known in detail ahead of time. The method includes system assembly, testing, and then reworking as necessary until an acceptable complete system is finally achieved. It is an iterative, trial-and-error process that takes place between the developers and the users.

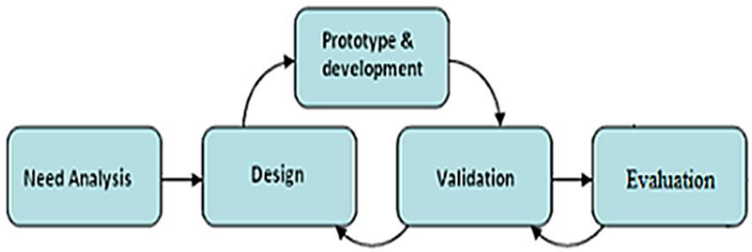

Figure 1. *Rapid Prototyping Workflow*

Circuit Diagram

Figure 2 below shows the interconnections of the IoT-Based Real-Time Public Transport Tracker and Passenger Monitoring System (iRideCommuTech), providing a visual representation of how the hardware elements work together to achieve the system's objectives, which include the Arduino Mega, IR Sensors, ESP8266 Wi-Fi module, and Neo 6M GPS module.

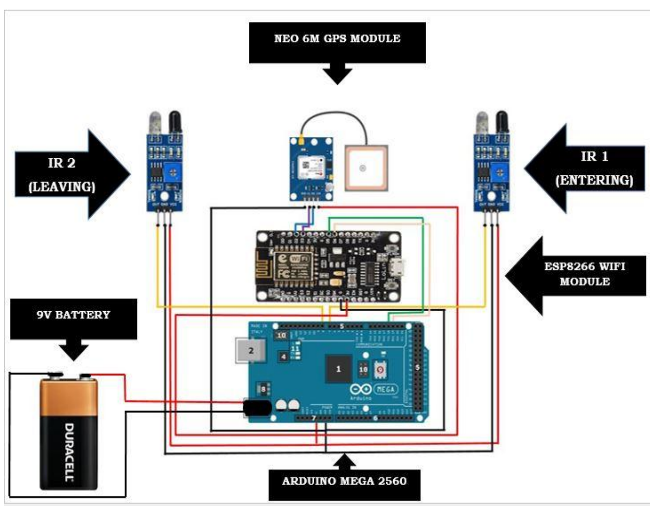

Figure 2. *Circuit Diagram*

The circuit diagram indicates that the Arduino Mega 2560 is where the power supply was connected, and a common ground for all the hardware components. IR1, which is responsible for counting passengers entering the public transport, is connected to P7 of the Arduino IR2, which is responsible as a counting tool for passengers leaving the public transport bus, is connected to P8. Arduino transmits the data from the two IR sensors through serial communication to the ESP8266 and displays it in real-time in the Blynk application. Pin 18 (RX) of the Arduino was connected to D5 pin of the ESP8266, while pin 19 (TX) was connected to D6.

The GPS module now plays a vital role in the system's functionality, for it serves as a tool in tracking the public transport location, which provides an average of 2.5m to 5m accuracy. The GPS module RX (Received) pin is connected to the D1 pin of the ESP8266, while its TX (Transmit) pin is connected to D2. The ESP8266 serves as a bridge in connecting the system's prototype in its software state. The software state of the system was used in forecasting real-time location and seat availability, which is designed for the passengers.

System Architecture

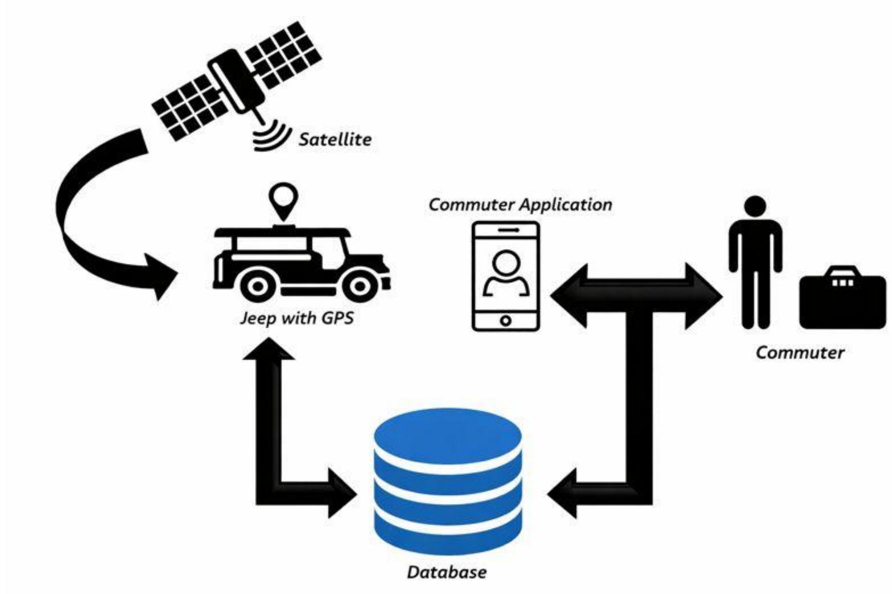

Figure 3. *System Architecture*

The GPS Module tracks the location of the public transport through a GPS library in the firmware (GPS++), extracting the geolocation-specific fields such as latitude, longitude, date, and time while connected to the ESP8266 module. The IR Sensor (Infrared) consists of three pins (signal, VCC, and GND) and is used to detect and calculate the number of passengers entering and exiting the public transport vehicle. When IR1 (Entrance) detects an object, IR2 (Exit) is delayed. This indicates that the passenger is entering the bus. When IR2 (Exit) detects an object, the first IR1 (Entrance) is delayed. This indicates that the passenger is leaving the bus. The passenger count increments when a passenger enters the bus and vice versa.

Structural Component Diagram

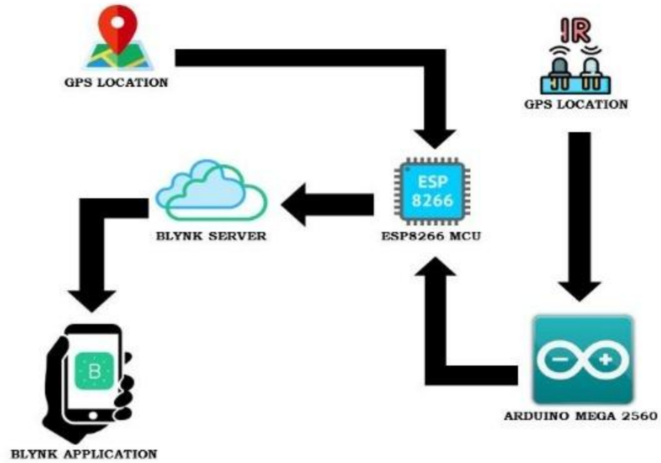

Figure 4. *Structural Component Diagram*

Figure 4 shows the iRIDECommuTech component diagram, which is crucial for the system's functionality. At the heart of the system lies the ESP8266 Wi-Fi module, which serves as the central processing unit and communication hub. This module aggregates and processes data from multiple sources, including GPS sensors and microcontrollers.

The flow of data begins with the GPS sensors, which continuously gather location information and transmit it to the ESP8266 module. Simultaneously, data from the Arduino Mega microcontrollers, equipped with IR sensors, were collected and forwarded to the ESP8266 module. These IR sensors are strategically positioned to monitor seat occupancy within the vehicle, providing valuable insights into passenger load and seat availability in real-time. Once processed, the data is transmitted to the Blynk Server, a cloud-based platform designed for IoT applications.

The Blynk Server mobile application was installed on the passengers' mobile phones for real-time tracking and monitoring of seat vacancy to optimize resource allocation of passengers and geolocation of the public transport vehicle.

***"iRIDECommuTEch"* Mobile Application**

The mobile application called "iRIDECommuTech" is built using the Blynk platform, making it easy to use and functional in the passenger's interface.

To access the iRIDECommuTech mobile application via Blynk, users must undergo a seamless login process, as it is shown in Figure 4. Once an account is created, users are prompted to enter their registered email address and password. This login protocol ensures secure access to the app's features and personalizes the user experience. The app also requires a dual authentication system as an added layer of security for the passenger's account.

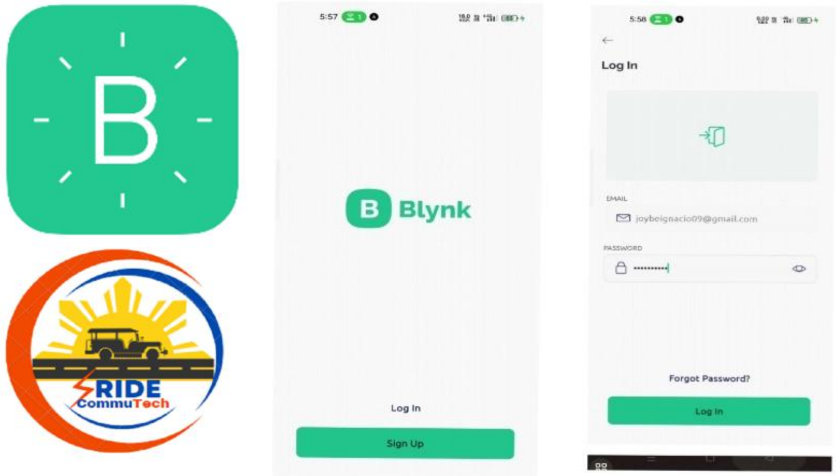

Figure 5. *"iRideCommuTech" Login Interface*

Figure 6. *Real-Time Monitoring of Transport Location, Seat Availability, Driver's Information, and Transport Plate Number*

After the log-in process, the user of the application will be directed to the iRideCommuTech application and will clearly monitor real-time updates about the public transport location, including the latitude and longitude, speed, and direction of the vehicle which is being diplayed in the map widget, the light blue circle indicates the location of the public transport vehicle, while the dark blue on tag was the location of the user of the blynk application (Refer to Figures 5 and 6). It can also be seen on the screen that there is information about the driver's name, transport plate number, seat availability, and passenger count for the monitoring of the passengers.

Table 1. Software Application Virtual Pin Specification

Virtual Pin	Specification	Description
V0	Map Widget	It is assigned to virtual pin 0 of the blynk app.
V1	Latitude	Displays the latitude of the public transport.
V2	Longitude	Displays the longitude of the public transport.
V3	Speed	Displays the speed of the GPS, which represents the speed of the public transport.
V4	Direction	Displays the satellite orientation or direction of the GPS module.
V5	Passenger Count	Displays the passenger count (enter and exit counts).
V6	Seat Availability	Displays the seat availability.
V7	Driver’s name	Displays the Driver’s name.
V8	Public Transport Plate Number	Displays the public transport plate number.

The virtual pins shown in Table 1 play a crucial role in facilitating communication between the hardware components, such as GPS modules and sensors, and the iRIDECommuTech application running on a smartphone. Virtual Pin V0, which hosts the Map Widget, serves as a visual representation of the public transport's location. The latitude and longitude data (V1 and V2) feed into this widget, accurately displaying the vehicle's current position in real-time. This provides users with a dynamic map view, enhancing their understanding of the transport's movement. V3 provides the vehicle’s speed, crucial for assessing its velocity and ensuring safe travel. V4 supplies the direction, indicating the vehicle’s orientation or heading based on GPS data. These details offer passengers insights into the transport’s movement and trajectory.

On passenger-related information, Virtual Pins V5 and V6 manage passenger counts and seat availability. V5 tracks the number of passengers onboard, distinguishing between those entering and exiting. This enables efficient monitoring of occupancy levels and facilitates informed decisions regarding capacity management. Simultaneously, V6 displays seat availability, aiding passengers in selecting suitable seating arrangements. Lastly, V7 and V8 provide visibility into the driver’s identity and the public transport.

Hardware Design

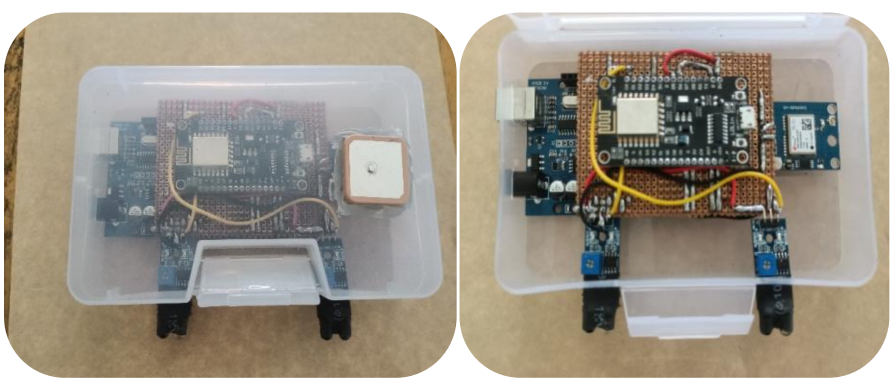

Figure 7. *Actual Hardware System Deployed*

Figure 7 shows the actual hardware for the IoT-Based Real-time Public Transport Tracker and Passenger Monitoring System *(iRIDECommuTech).*

Ethical Considerations

This study adheres to ethical research standards to ensure the integrity of the research process and the protection of all involved participants. Although the primary focus was on the development of the system, the research involved participants from the drivers and operators of Jeepney Association, and anonymity and confidentiality were maintained during the research process.

Before engagement, prior consent was obtained from all participants, and the nature of the research, research process, objectives, procedures, and their rights were explained, ensuring the protection of their rights. The study was approved through the Research Council Review Board. No ethical violations were identified.

Results and Discussion

Simulation Results

The IoT-based real–time public transport passenger tracking system (iRIDECommuTEch) was successfully developed, assembled, and tested both the hardware and mobile application. The main hardware components integrated in the system were ESP8266, Arduino Mega 2560, IR sensors, NEO 6M GPS module, and a battery that powers up the system.

The ESP8266 serves as the central hub for connectivity, enabling wireless communication between the hardware prototype and the Blynk application running on users' smartphones, ensuring real-time updates and interaction through its WiFi capabilities. The Arduino Mega 2560 acts as the brain of the operation, managing and processing data, while the two IR sensors enable passenger occupancy monitoring. In addition, the NEO 6M GPS module provides crucial geolocation information.

On the other hand, the mobile app "iRIDECommuTech" was successfully integrated into the hardware system for passenger monitoring with its user-friendly interface. By displaying the vehicle's location on a map widget assigned to virtual pin V0, passengers can easily track the transport's movement and plan their journeys accordingly, while V1 and V2 allows passengers to view the latitude and longitude coordinates of the vehicle, providing precise location information, V3 displays the speed of the GPS module, V5, V6, V7, and V8 offer valuable details about seat availability, passenger count, and driver information, respectively.

Operational Testing and Evaluation

The system was mounted at the back of the vehicle; the housing was drilled to secure it and prevent it from falling. During the powered-on self-test (POST), the Arduino stabilized between 10-15 seconds and began acquiring real–time coordinates approximately 40-60 seconds. The coordinates were processed by the ESP8266 and transmitted to the Blynk server, then reflected to the passenger's mobile application. The system was evaluated on a national highway as a test route passing through remote and rural areas from Pinto, Alfonso Lista, to Ramon, Isabela. The results showed that GPS readings were typically ±5-8 meters. The Blynk application was set to 10 seconds in information updates, but typically adjusted due to the strength of signals in other areas.

Use Interface Analysis

The “iRIDECommuTech” mobile application provided a user-friendly interface for monitoring and viewing the real-time updates of the public vehicle they are riding, from geolocations to passengers’ seat availability and speed. The practical usability of the mobile application allows flexibility for both drivers and passengers.

Figure 7. *Arduino Mega 2560 and ESP8366 Serial Monitor*

The Arduino Mega 2560's serial monitor efficiently tracks passenger count and seat availability. Once the passenger count reaches 20, it promptly alerts, “No Seat Available. Public Transport is Full!”, optimizing passenger convenience and safety. Meanwhile, the ESP8266 serial monitor provides comprehensive data, including public transport coordinates, Blynk app user location, driver details, vehicle plate number, and travel direction.

Device Evaluation

The system was evaluated by users using a five-point Likert scale: highly acceptable, very acceptable, acceptable, and not acceptable. Table 2 provides insightful feedback on various aspects of an IoT-based real-time public transport tracker's functionality. It assesses critical indicators such as system interface operation, hardware-to-software feedback speed, and program loading time. With the mean average of 4.53, described as very acceptable, means the system demonstrates exceptional performance in the three areas: hardware interface, program loading, and software system. In terms of usability, users rated navigation speed and ease of use slightly higher, with scores ranging from 3 to 5. Despite some variability, the average rating of 4.4 suggests that navigation is generally fast and straightforward. Users can move through the system with relative ease, encountering minimal delays or confusion in accessing desired features or information.

Table 2. User's Evaluation Result of the System

	Indicators	Mean Average	Experts' Response
Functionality	1. The system interface is working.	4.8	Very Acceptable
	2. Feedback coming from the hardware system going to the software system is immediate.	4.6	Very Acceptable
	3. The program loads quickly.	4.2	Acceptable
	Descriptive Rating:	**4.53**	**Very Acceptable**
Usability	4. The system interface is user-friendly.	4	Acceptable
	5. Content is readable and easy to understand.	4.4	Acceptable
	6. Navigation is fast and easy to use.	4..4	Acceptable
	Descriptive Rating:	**4.27**	**Acceptable**
Reliability	7. Data from the Arduino Mega is accepted by the system.	4.2	Acceptable
	8. Data from the Wifi Module is accepted by the system.	4.4	Acceptable
	9. Location is accurate latitude and longitude.	4..2	Acceptable
	Descriptive Rating:	**4.20**	**Acceptable**
Performance	10. Speed efficiency in passenger counting and location tracking.	4.4	Acceptable
	11. The device is durable and able to withstand harsh weather conditions.	4.2	Acceptable
	12. Accurate storing and updating of passenger counting and public transport location in the software application. (Blynk App)	4.2	Acceptable
	Descriptive Rating:	**4.20**	**Acceptable**

The system reliability got an average rating of 4.20, which is generally acceptable. This indicates that the IoT-based real-time public transport tracker offers a reliable performance in terms of accepting data from hardware components and providing accurate location information. In conclusion, performance was rated 4.20, and it is acceptable by description. This indicates that the IoT-based real-time public transport tracker offers acceptable performance in terms of speed efficiency, device durability, and accuracy in storing and updating passenger counting and transport location information. It was pointed out by the users that there is a minimal delay in the transmission of information, which may affect its reliability.

While there may be opportunities for improvement in each indicator, the system overall meets the basic requirements for performance, ensuring reliable and efficient operation in monitoring and managing public transport services.

Conclusion and Future Works

The study presented the development of an IoT-based real-time public transport tracking and passenger monitoring system tailored for rural areas where public transport dispatching is unpredictable. By seamlessly integrating IoT components such as ESP8266 NodeMCU, GPS module, Arduino Mega, and IR sensors, the system achieved its functionality successfully. The system's key features and components included hardware integration, facilitating connectivity, location tracking, processing, and passenger access to real-time information on location, speed, and passenger availability, and enabling accurate information dissemination to passengers. Utilizing platforms like Blynk enables passengers to view on their end through the mobile application "iRIDECommuTech" that serves as an interface for accessing vehicle status, location information, and resource allocation of passengers.

Key limitations include in-depth integration of signal processing techniques in the transmission of data, including configuration, and the inclusion of other networking architectures, data models, and network security. In addition to ground truthing, GPS latency, packet loss, and repeatable tests on the accuracy of GPS are conducted.

Future enhancements may focus on integrating a dedicated driver's dashboard on the software application that provides real-time updates on the vehicle's location, passenger occupancy, and relevant alerts, including the integration of AI optimization on routes and passengers' demand. An image display of the vehicle on the passenger app adds an extra layer of recognition and enhances it. Additionally, offline data storage capabilities in the microcontroller setup are essential to maintain continuity and reliability, even in remote areas with intermittent connectivity.

The "iRIDECommuTech" offers a practical and scalable system application in public transportation management through tracking geolocation and passenger monitoring. By providing real-time data on vehicle status and passenger availability, it does not only empower transportation operators to optimize operations but also enhance the overall passenger experience.

References

[1] Andrews, J., Kowsika, M., Vakil, A., & Li, J. (2020). A motion-induced passive infrared (PIR) sensor for stationary human occupancy detection. In *Proceedings of the 2020 IEEE/ION Position, Location and Navigation Symposium (PLANS)* (pp. 1295–1304). IEEE. https://doi.org/10.1109/PLANS46316.2020.9109909

[2] Bujang, S. H., Suhaimi, H., & Abas, P. E. (2020). Performance of a low-cost Global Positioning System (GPS) module in location tracking device. *IOP Conference Series: Materials Science and Engineering, 991*(1), Article 012137. https://doi.org/10.1088/1757-899X/991/1/012137

[3] Chen, R., Huang, X., Zhou, Y., Hui, Y., & Cheng, N. (2022). UHF-RFID-based real-time vehicle localization in GPS-less environments. *IEEE Transactions on Intelligent*

Transportation Systems, 23(7), 9286–9293. https://doi.org/10.1109/TITS.2021.3085824

[4] Farman, H., Khan, Z., Jan, B., Boulila, W., Habib, S., & Koubaa, A. (2022). Smart transportation in developing countries: An Internet-of-Things-based conceptual framework for traffic control. *Wireless Communications and Mobile Computing, 2022*, Article 8219377. https://doi.org/10.1155/2022/8219377

[5] Hagenaars, E., Pandharipande, A., Murthy, A., & Leus, G. (2021). Single-pixel thermopile infrared sensing for people counting. *IEEE Sensors Journal, 21*(4), 4866–4873. https://doi.org/10.1109/JSEN.2020.3029739

[6] Husak, V., Chyrun, L., Matseliukh, Y., Gozhyj, A., Nanivskyi, R., & Luchko, M. (2021). Intelligent real-time vehicle tracking information system. In *CEUR Workshop Proceedings* (Vol. 2917). https://www.semanticscholar.org/paper/Intelligent-Real-Time-Vehicle-Tracking-Information-Husak-Chyrun/00f3b0e7352af64fb0c67c63663280f0961d0fe4

[7] Jahan, N. F., Phanidhra, P. V., Lellavardhini, K., & Sahitya, A. (2023). Auditorium monitoring system using bi-directional visitor count. *International Journal of Engineering Research and Technology, 14*(3), 453–460. https://doi.org/17.0002.JECA.2024.V14I04.200786.22010

[8] Kumar, S., Sahoo, S. S., & Pradhan, D. (2019). Vehicle tracking using GPS. *International Journal of Engineering Research and Applications, 9*(3), 1–5.

[9] Maaspuro, M. (2020). A low-resolution IR-array as a doorway occupancy counter in a smart building. *International Journal of Online and Biomedical Engineering (iJOE), 16*(6), 4–18. https://doi.org/10.3991/ijoe.v16i06.13915

[10] Mateo, J. M., Tamani, J., Embat, E., & Tecson, R. (2024). HydroNutriGuard: A mobile-based hydroponics nutrient tracker with recommender system for lettuce. *Isabela State University Linker: Journal of Engineering, Computing, and Technology, 1*(2), 15-25. https://doi.org/10.65141/ject.v1i2.n2

[11] Mugilan, M., & Jayamangala, H. (2025). IoT-based vehicle tracking and monitoring system. *International Journal of Science, Engineering and Technology, 13*(3), 1–4. https://doi.org/10.61463/ijset.vol.13.issue3.118

[12] Nitti, M., Pinna, F., Pintor, L., Pilloni, V., & Barabino, B. (2020). iabacus: A Wi-Fi-based automatic bus passenger counting system. *Energies, 13*(6), 1-21. https://doi.org/10.3390/en13061446

[13] Rahmatulloh, A., Nursuwars, F. M. S., Darmawan, I., & Febrizki, G. (2020). Applied Internet of Things (IoT): The prototype bus passenger monitoring system using PIR sensor. In *Proceedings of the 8th International Conference on Information and Communication Technology (ICoICT 2020)*. IEEE. https://doi.org/10.1109/ICoICT49345.2020.9166420

[14] Shaaban, K., Elamin, M., & Alsoub, M. (2021). Intelligent transportation systems in a developing country: Benefits and challenges of implementation. *Transportation Research Procedia, 55*, 1373–1380. https://doi.org/10.1016/j.trpro.2021.07.122

[15] Shah, M. (2021). Decentralized fleet monitoring and tracking system. *International Journal of Engineering Science and Computing, 9*(3), 14–17.

[16] U-blox. (2017). *NEO-6 data sheet (GPS.G6-HW-09005).* https://www.u-blox.com/sites/default/files/products/documents/NEO-6_DataSheet_%28GPS.G6-HW-09005%29.pdf

[17] Zohari, M. H., Hakimi, M., Zohari, B., Bin, M. F., & Nazri, M. (2021). GPS-based vehicle tracking system. *International Journal of Scientific & Technology Research, 10*(4), 278–282.

[18] Zulkifli, N. A., & Mohd Shah, S. (2023). Three-level car security system with GPS tracker using IoT. *Journal of Electronic Voltage and Application, 4*(1), 30–40. https://doi.org/10.30880/jeva.2023.04.01.004

Acknowledgement

The researchers dedicate this work to their family, the community, and the institution they belong to for their unwavering love, support, and constant inspiration. They also extend sincere gratitude to the College of Engineering and Technology, Ifugao State University, Potia Campus, through Dr. Minerva M. Medina, the Director, and Ms. Jocelyn T. Salviejo, Campus Executive Director, for providing academic support. Likewise, they wish to thank the Department of Research and Development, Extension and Training and Intellectual Property Office, chaired by Engr. Roderick Y. Vicente and Ms. Donna P. Delizo, for their research mentorship. Lastly, they would like to extend their appreciation to the ISU Linker Journal Editorial Team for the valuable feedback, review process, and publication of this research paper.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Artificial Intelligence (AI) Declaration Statement

This study employed artificial intelligence (AI) tools during the preparation of the manuscript only, specifically Google AI and Chat GPT, for grammar, literature review, and enhancement of understanding of the research topics. All AI content is reviewed and edited by the author. No AI was used in the test, deployment, or validation of results.