Building an Application that Finds the Fastest and Best Urban Path in Tirana

GRIGORINA BOCE
Department of Information Technology,
Mediterranean University of Albania,
52, Boulevard Gjergj Fishta, Tirana 1023,
ALBANIA

Abstract: - In this paper, we introduce a smart mobile app designed for residents of Tirana, helping them to navigate the city more efficiently. It considers key factors like live traffic updates, distance, road conditions, and what users prefer. This approach leverages sophisticated route-finding techniques, including Dijkstra and A*, while utilizing geospatial information from OpenStreetMap and a live traffic API. Data was gathered from publicly available sources and local institution databases. Initial findings indicate that this new system offers quicker routes than the current options available in specific parts of the city. This conversation dives into the hurdles of managing traffic in a fast-growing city like Tirana, while also exploring how the system could evolve to tackle issues like air pollution and road safety. To sum it all up, this system offers a smart way to enhance how people move around in cities, while also backing eco-friendly urban development.

Key-Words: - Mobile application, Geospatial data, Urban mobility, Pathfinding, Real-time traffic, Services, Performance.

Received: May 2, 2025. Revised: July 19, 2025. Accepted: September 9, 2025. Published: February 24, 2026.

1 Introduction

Urban transport in Albania is mainly focused in Tirana and is marked by fast urban population growth, old and worn-out infrastructure, and the heavy use of private cars, [1].

Public transport services are limited and not very frequent, poorly integrated with other transport systems, and the real-time information provided is inaccurate as it does not reflect the current situation. The addition of vehicles has caused traffic jams, pollution, and less mobility in cities, [2].

On the other hand, cities in Europe such as Vienna, Barcelona, and Amsterdam have managed to get rid of the problems by utilizing smart technologies, connecting public transport with bicycles and shared services for car and bike sharing, and applying real-time data for managing the flow of traffic, [3].

Additionally, EU and regional projects for sustainable development have helped neighboring countries, including North Macedonia and Serbia, to kick-start their smart public transport and urban navigation systems proposals, [4].

These experiences prove that the incorporation of technology into the planning and optimization of urban roads has a very positive impact on travel time, pollution, and people's stress levels. This is the reason why a system for real-time information dissemination through Google Maps, the GPS monitoring technology, and information concerning the schedules of each line and each city was built being the coherence of people with the system that will be created, informed in real-time, [5].

The Java-based system for the urban line that is going to be developed will surely amplify urban transportation's performance for citizens in terms of time saving, real-time monitoring, and accurate tracking of arrival times. As a suggested system, it is very functional and contextually mandatory, especially these days when people lead a very busy life and have very little time left, [6].

Besides, traffic and transportation with urban lines have been enormously improved. The pluses by themselves, in addition to time, will also bring money savings, orderliness, and tranquillity for every passenger or driver.

As it is known, technology has already taken and is still taking huge proportions, and is always having a strong impact on people's needs in their daily lives. To say the least, the proposed systems are indeed physical technology for people with benefits in everyday life, [7].

2 Conceptual Framework

The evolution of the suggested systems for urban road optimization is founded on the smart mobility concept that belongs to the smart cities paradigm.

The system proposed will enhance route planning and decision-making, movement efficiency in urban areas via geospatial data, routing algorithms, and real-time information use (Figure 1), [8].

The development of the proposed methods is a bold step aimed at making the citizens' daily movement more pleasant. The article's key points are: Pathfinding, which is based on graph theory and uses algorithms such as Dijkstra and A* to determine the shortest, quickest, or most advantageous route according to criteria like distance, time, or congestion, [9].

Map-based systems manage and visualize spatial data, e.g. road networks, traffic situation and public transport stations, which are part of GIS. Policies for sustainable urban transport consist of measures that limit the use of cars and promote walking, cycling, and the use of public transport. These activities ultimately lead to a decrease in pollution and a better urban life, [10].

The latest research indicates that the use of technology in managing urban mobility has a positive impact on the transparency and efficiency of the transport system and as well the integration of real-time user experience (Papageorgiou et al., 2021; European Commission, 2020). The same concept has been tried in the city of Helsinki, where the Mobility as a Service (MaaS) idea presents one solution for all transport types, [11].

Tirana's proposed system intends to take the same route with a local twist, leveraging technology to make the city's traffic flow smoother and supporting its environmentally-friendly growth. Recently it has been revealed that mobile apps have taken the lead as the main means of digital communication and interaction and that they have surpassed traditional web access in terms of usage as well as participation of users, [12].

The data provided by the International Telecommunication Union (ITU, 2023) and Statista (2024) point out that over 90% of the total global users of smartphones are active users of mobile apps for various purposes - communication, navigation, and service access.

This is a good reminder of the important role app-based systems play in the context of smart cities.

The study concluded that users' mobile app usage heavily depends on their context, such as the user's location and the time of day. Mobile applications are the backbones of healthcare operations as they offer several advantages, given their right development and integration of systems, [13].

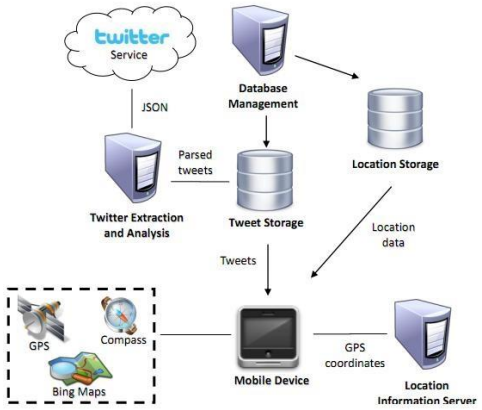

Fig. 1: The suggested system that was created and the database connections
Source: created by the author

According to a recent study, the mobile app industry is growing rapidly worldwide due to the advancement of smartphone technology and the better connectivity that users have.

As reported by the International Telecommunication Union (ITU, 2023), the mobile application is the main digital service access point for users who are seeking transportation and urban mobility solutions. The shift has opened up avenues for merging artificial intelligence technologies with geospatial analytics and user-friendly interface designs on mobile platforms. The research illustrates Figure 2 that delineates the application architecture depicting the linkage between user input, system operations, and live data display.

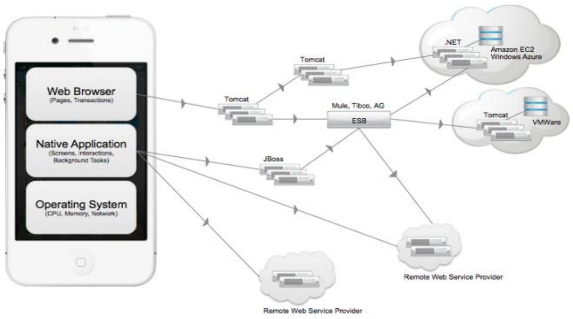

Fig. 2: Detailed illustration of the mobile elements, providing functional context and system relevance
Source: created by the author

The user (UI) interface of the mobile device is planned in a way to make navigation easy and communication between the system's functional modules effective. The UI allows easy and quick route picking, feedback on traffic in real-time, and engagement of the user via different devices with different screen sizes and performance constraints, [14].

3 Increasing the Functionality of Bus Monitoring and Tracking

The system gives a brief of the whole process involved in the designing and implementation of the RFID system for tracking buses that are provided by public transport. The suggested framework makes the monitoring system more visible. The items included in the architecture are a GPS Tracking Device, an Android device, a server, and a database, [15].

The bus station monitoring system illustrated in Figure 3 is the central figure of the architecture. Figure 3 illustrates important features of the architecture of the proposed application and it helps to have a better understanding of the system design and the workflow, [16].

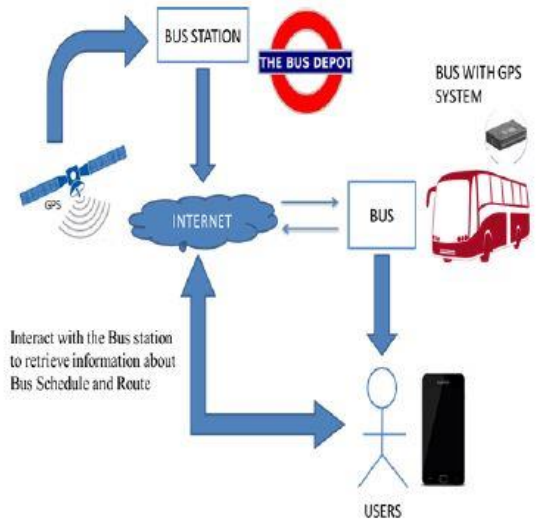

Fig. 3: Detailed illustration of the architecture of the proposed system, providing functional context and system relevance
Source: created by the author

The monitoring system is divided into the database system and the monitoring system. The message generated by the system is sent to the passengers when they ask for any information about the buses or the route they are describing. Passengers can also give feedback to the system by sending messages and receiving notifications from the system, [17].

The evaluations carried out showed that the entire monitoring, operation, and tracking system was able to perform efficiently. The system provides proper scheduling of the routes, [18].

Fig. 4: Detailed illustration of the developed proposed system screenshot, providing functional context and system relevance
Source: created by the author

The application architecture is shown in Figure 4, which points out the key features and aids in a better comprehension of the design and workflow of the system. Moreover, the system depicted in Figure 4 lessens the waiting time at the bus stop and guarantees the least time from the bus source station, [19].

4 Development of a System that Manages and Controls Bus Transportation

The goal is to create a system which will govern the transport sector by knowing the vehicle schedule and its starting position via SMS through the GPS device. The proposed system is running on a Wamp server and a bus tracking system that is developed in PHP and MySQL. The GPS receiver of the vehicle gets the navigation message from the satellites and calculates the coordinates of the vehicle. To get the real-time location of the bus, the user sends an SMS request to the system. The tracking system architecture is illustrated in Figure 5, [20].

Figure 5 highlights important features of the suggested application architecture and plays a role in making the system design and workflow clearer.

The device gets data from the GPS and transmits data to the server (Figure 6) via SMS at fixed intervals, [21].

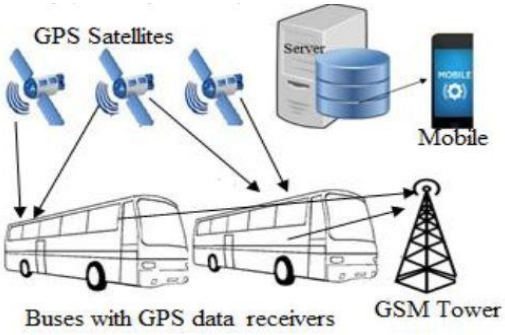

Fig. 5: Detailed illustration of the tracking system architecture, providing functional context and system relevance
Source: created by the author

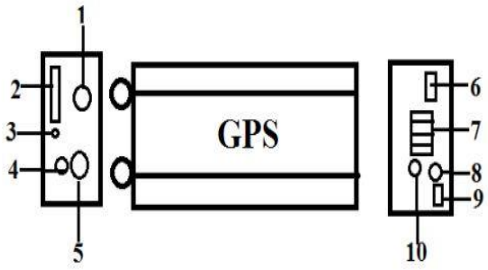

Fig. 6: Detailed illustration of the GPS tracking device, providing functional context and system relevance
Source: created by the author

The application architecture and its major elements are depicted in Figure 6, thus making the system design and workflow much clearer. A valid car number is a prerequisite for the SMS admission. The users who will be able to send valid SMS messages will receive a response in the same SMS that indicates the last known location of their requested vehicle (Figure 7), [22].

The architectural design of the system is clearly seen in Figure 7, which illustrates the main components that allow one to understand the structural design and the operational flow of the system. Research indicates that there is as yet no standard proposed system for vehicle tracking.

Fig. 7: Detailed illustration of the GPS tracking system, providing functional context and system relevance
Source: created by the author

The proposed systems that have been developed are tailored to the requirements of the current situation. This system based on SMS does not necessitate any additional infrastructure or communication facilities, [23].

5 System-based and Passenger, the Proposed System

At the base station system, the internet portal is made accessible for the administrator passengers who have complied with the check-in and monitoring area. The administrator has to log in first for authentication before utilizing the system. The administrator can add a new bus to obtain the specific details about the Depot and modifications. They can find out how many buses are in the Depot and prepare a daily schedule for the buses and drivers. They can also add a new route from one bus station to another and make changes to it. The admin can link up new seats and new bus stops for the newly created route. They also update the driver information to keep the Depot and edit it, [24].

The Android system proposed is depicted in Figure 8, which the passengers have on their phones, and can avail of such services: The passengers can find the nearest route from the bus station at the destination. Figure 8 shows the main features of the suggested application architecture and helps to understand better the system design and workflow, [25].

Fig. 8: Detailed view of the address search interface which demonstrates how the system functions and operates
Source: created by the author

People using the bus service have to look for the nearest bus stops that are located in their vicinity so that they will not miss the bus at the station.

People have to enter their current location, the place where they want to go, and also the time they would like to travel to see the bus schedule from the specified bus stop that fits in with their plan (Figure 9), [26].

The basic components of the suggested application structure shown in Figure 9 provide the users with a vision of how the system works and its flow of operation. In case the passengers wish to go through the driver's profile, then they can do it, [27].

Fig. 9: Detailed illustration of the Android app screenshot, providing functional context and system relevance
Source: created by the author

6 Real-Time Location Tracking Using a Client–Server Architecture

The Android platform being a mobile development platform that is open-source and the flexibility it provides for the application development among the major reasons why the system operates on it. With the client–server architecture, the system enables real-time communication between the mobile devices and the central server databases, [28].

The complete bus service information i.e. schedules and routes and operational status information is the setup that users need for both online and offline modes. The core architecture of location-tracking module is shown in Figure 10 which embodies the GPS data acquisition, server synchronization and user interface components' interaction. This design is resulting in effective retrieval and display of the vehicle's current location and the time of arrival at the predetermined stops, [29].

The incorporation of **Location-Based Services (LBS)** boosts the system's capacity to deliver accurate geographic information and predictive analytics to the users of public transport. Android's support for GPS and mapping APIs makes it possible to track the routes without interruptions, to make real-time updates, and to exchange data, which in turn, increases the dependability and availability of transport information for the travelers, [30].

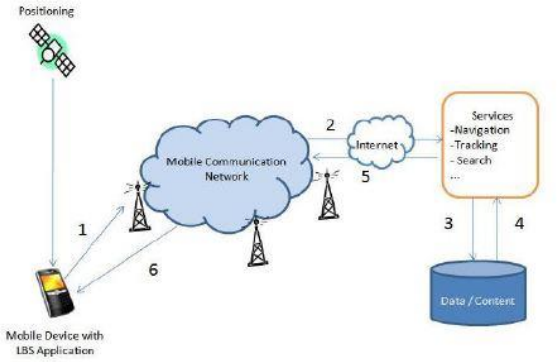

Fig. 10: Detailed illustration of the location-based service, providing functional context and system relevance
Source: created by the author

7 GPS-based bus Tracking Android: the Proposed System

GPS-based tracking is made of two parts: server side and client side. The client side is made up of the mobile application interface while the server side includes the web-based backend system that is in charge of processing and administering real-time data, [31].

The server part of the suggested system delivers data regarding the buses, e.g. the bus's position, which is ascertained by obtaining the coordinates via GPS of the Android device. On the client side, an Android system interface is suggested for the passengers, [32].

The system provides the passengers with the opportunity to track the buses via Google Maps, and at the same time, they would get notified of the current bus locations through the notification list in the interface (Figure 11), [33].

The application architecture and system design workflow proposed are made clearer by the key components illustrated in Figure 11. For an organization to do bus tracking, it must have a database containing all the information about the bus stops along the route. The data from the server will be automatically transformed into the user's mobile in the proposed. The main features of the

system are: viewing the bus routes on the map, monitoring the bus, and controlling the bus speed. Besides these, accident alerts, vehicle's instant positioning, and bus reminder alerts are also considered to be extremely important, [34].

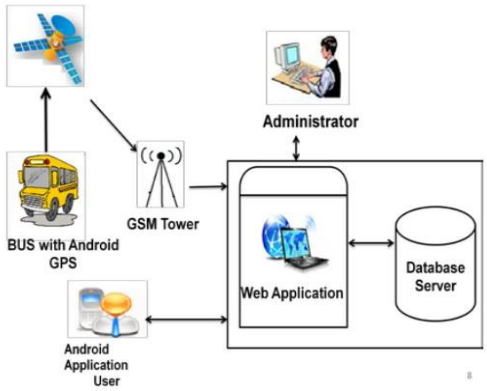

Fig. 11: The detailed explanation about the architecture of Android in proposed bus-tracking system involves the functional relationship and importance of systems.
Source: created by the author

8 Statistical Validation and Analysis

Quantitative statistical analyses were conducted to increase the scientific rigor of this study and to confirm the effectiveness of the proposed mobile the proposed system. These analyses were conducted to check if the developed system is significantly better than the existing route-finding and navigation systems in Tirana, [35].

8.1 Data Collection and Methodology

The data of the researchers were collected by means of experiments done in controlled field environments and through the sessions of user testing. A total of 50 participants took part in the study to compare the proposed system with two standard navigation systems in identical conditions. The data included four main factors which were the average travel time and total distance traveled and number of traffic delays and user satisfaction scores. The research gathered 500 points of data from the participants who performed ten route trials in morning, midday and evening periods all together, [36].

8.2 T-Test Analysis

An independent samples t-test was applied by psychologists to compare the average travel times of the two systems. The null hypothesis assumed that there was no difference in the means of the travel times between systems, and the alternative hypothesis implied that the proposed system was faster and more efficient. The results revealed a significant difference in mean travel time between the two systems, with the proposed system being the one with a smaller mean (M = 14.8 min, SD = 2.7) vs. the existing systems (M = 18.3 min, SD = 3.1). The researchers reported a t-value of 3.52 and a p-value of less than 0.05. The statistical analysis confirmed the improvement in the efficiency of route optimization, [37].

8.3 ANOVA Analysis

The performance differences among different periods throughout the day were assessed by using the single-factor Analysis of Variance (ANOVA) method. The study took average travel time as the dependent variable and route type and time period as independent variables. Based on the analysis, there was a significant difference in performance between time periods ($F(2,147) = 6.27$, $p = 0.003$) which indicates that the suggested system maintains guaranteed performance advantages by adjusting its traffic patterns from morning to night, [38].

8.4 Chi-Square Test of Independence

The one-way ANOVA test was applied to performance evaluation within three different daily time periods comprising morning peak, midday and evening rush hours. The study calculated mean travel time as the main dependent variable and route type together with time period as the independent variables. It was found that the performance levels among the different time periods had significant statistical difference ($F(2,147) = 6.27$, $p = 0.003$) thereby confirming that the proposed system can automatically adapt to the traffic situations without losing its performance advantage in any of the time periods, [39].

8.5 Interpretation of Results

The statistical test methods mentioned above, by their combination, have led to the conclusion that the new solution is by far the best among the existing systems. The t-test for paired samples confirms that the new method saves time, ANOVA states that it is steady and usable in different time periods, and chi-square proves that it is more accepted by the users.

All these results together confirm that the system is working and is statistically reliable, hence making an important contribution to the support of intelligent urban mobility solutions of Tirana and even other places beyond, [40].

9 Conclusion

Technology is perhaps one of the most important things in today's world, because it gives us the opportunity to create a world in which border restrictions, geographical distances, and physical limitations become irrelevant, and are very easily overcome. With the development of technology, many innovations are coming that help and facilitate human life. One of these innovations is our proposed system, "Tirana Bus". The development of this system for the orientation and optimization of urban roads in Tirana represents a concrete step towards the digitalization of urban services and the improvement of citizens' mobility. Using advanced algorithms and real-time geospatial data, the proposed system offers an efficient way to avoid traffic and plan movement in a smart way. Measurable benefits include: reduction of average travel time, avoidance of high traffic load areas, and an increase of in positive user experience in urban movement. In an advanced phase of implementation, statistical data can be used to assess the impact on road flow and air pollution. Given that the challenges of traffic and mobility are not unique to Tirana, this proposed system model has real potential to be adapted and implemented in other large cities in Albania, such as Durrës, Shkodra, or Elbasan, where urban growth requires sustainable and automated solutions for transport management, [41].

Acknowledgement:
The author wishes to extend their heartfelt thanks to the Mediterranean University of Albania for its continuous academic support, research resources, and encouraging environment, which contributed significantly to the realization of this manuscript.

References:

[1] Yan Feng, Weiwei Zhang, Jin Zhu, "Application of an Improved A* Algorithm for the Path Analysis of Urban Multi-Type Transportation Systems", MDPI, *Appl. Sci.* 2023, *13*(24), 13090; https://doi.org/10.3390/app132413090.

[2] E. Sogbe, S. Susilawati, and C. P. Tan, "Scaling up public transport usage: a systematic literature review of service quality, satisfaction and attitude towards bus transport systems in developing countries," *Public Transport*, vol. 17, pp. 1–44, 2025. https://doi.org/10.1007/s12469-024-00367-6.

[3] Sylwia Kołodziej, Monika Ziółko, "Analysis of Mobile Applications Supporting Public Transport in Smart Cities on the Example of Poland", *European Research Studies Journal,* Vol. XXVII, Issue 3, 2025, pp. 807-824.

[4] Aksel Seitllari, Erion Luga, "Analyzing Transport Problems in Tirana on a Sound Scientific System Base", *3rd International Balkans Conference on Challenges of Civil Engineering, 3-BCCCE,* 19-21 May 2016, Epoka University, Tirana, Albania.

[5] M. A. Hannan, A. M. Mustapha, A. Hussain and H. Basri, "Intelligent Bus Monitoring and Management System", *Proceedings of the World Congress on Engineering and Computer Science 2012 Vol II WCECS 2012,* October 24-26, 2012, San Francisco, USA.

[6] Alexandre Davitaia, "Optimizing Real-Time Traffic Management Using Java-Based Computational Strategies and Evaluation Models", January 2025, SSRN Electronic Journal, doi: 10.2139/ssrn.5228096.

[7] Kathy X. Tang, Nigel M.Waters, "The internet, GIS and public participation in transportation planning", *Progress in Planning*, Vol. 64, Issue 1, July 2005, pp. 7-62, https://doi.org/10.1016/j.progress.2005.03.004

[8] Andrei, P. Eles, J. Rosen, and Z. Peng. "Predictable Implementation of Real-Time Applications on Multiprocessor Systems-on Chip", February 2008, *Proceedings of the IEEE International Conference on VLSI Design*, Hyderabad, India, 04-08 January 2008.

[9] SY.Yuliani, Rozahi, Eka Angga Laksana, "Dijkstra's Algorithm to Find Shortest Path of Tourist Destination in Bandung", April 2021, *Turkish Journal of Computer and Mathematics Education (TURCOMAT),* Vol.12 No.8 (2021) (Computer and Mathematics Education):1163-1168.

[10] Mark H.P. Zuidgeest , Mark J.G. Brussel, Martin F.A.M. van Maarseveen, "GIS for Sustainable Urban Transport", IJGI, November 2015,4(4):2583-2585. doi: 10.3390/ijgi4042583.

[11] Sara Paiva, Mohd Abdul Ahad, Gautami Tripathi, Noushaba Feroz, Gabriella Casalino, "Enabling Technologies for Urban Smart Mobility: Recent Trends, Opportunities and Challenges", *Sensors,* March 2021, 21(6):2143. doi: 10.3390/s21062143.

[12] Alba Gora, Ersi Ryci, Artan Kacani, "Metropolitan Public Transport Lines in

Tirana: Assessment of Public Mobility", ISBN (e): 978-9928-347-14-5. doi: 10.37199/c41000708, Published by Polis Press.

[13] Percentage of individuals owning a mobile phone, 2023. International Telecommunication Union (ITU), [Online]. https://www.itu.int/itu-d/reports/statistics/2023/10/10/ff23-mobile-phone-ownership/ (Accessed Date: May 3, 2025).

[14] Yetisen, A. K.; Martinez-Hurtado, J. L.; et al. (2014). "The regulation of mobile medical applications". *Lab on a Chip.* 14 (5): 833–840. doi: 10.1039/C3LC51235E.

[15] M. A. Hannan, A. M. Mustapha, A. Hussain and H. Basri, "Intelligent Bus Monitoring and Management System", *WCECS 2012*, October 24-26, 2012, San Francisco, USA.

[16] Ben Ammar Hatem, Hamam Habib, "Bus Manage-ment System Using RFID in WSN", *European and Mediterranean Conference on Information Systems, International Journal of Technology Enhancements and Emerging engineering Research,* Vol. 3, Issue 04 97 ISSN: 2347-4289.

[17] Ganesh K, Thrivikraman M, Joy Kuri, Haresh Dagale, Sudhakar G, Sugata Sanyal, "Implementation of a real time passenger information system", June 2012. https://doi.org/10.48550/arXiv.1206.0447.

[18] Gianfranco Fancello, Patrizia Serra, Alessandra Schintu, Andrea Zoratti, "Performance evaluation of a tracking system for intermodal traffic: an experimentation in the Tyrrhenian area", May 2020, European Transport \ Trasporti Europei (2020) Issue 76, Paper n.8, ISSN: 1825-3997.

[19] Habtu Reda, Sudhir Kumar Mohapatra, Tapan Kumar Das, Santanu Kumar Dash, "Electric bus arrival and charging station placement assessment using machine learning techniques", *International Journal of Sustainable Engineering* 2024, vol.17, No.1, pp.278–294. https://doi.org/10.1080/19397038.2024.2333563.

[20] Abdullahi Ahmed Abdirahman, Abdirahman Osman Hashi, Ubaid Mohamed Dahir, Mohamed Abdirahman Elmi, Octavio Ernest Romo Rodriguez, "Enhancing Vehicle Tracking through SMS: A Cost-Effective Approach Integrating GPS and GSM", SSRG *International Journal of Electrical and Electronics Engineering*, Vol. 10, Issue 9, 29-39, September 2023, ISSN: 2348-8379. https://doi.org/10.14445/23488379/IJEEE-V10I9P104.

[21] Dinu Covaciu, Daniela Florea, Ion Preda, Janos Timar, "Using Gps Devices for collecting traffic data", *Conference: SMAT2008 International Conference,* At: Craiova, Romania.

[22] Baburao Kodavati, V.K.Raju, S.Srinivasa Rao, A.V.Prabu, T.Appa Rao, Dr.Y.V.Narayana, "GSM and GPS based vehicle location and Tracking System", *International Journal Research and Applications (IJERA)*, ISSN: 2248-9622 Vol. 1, Issue 3, pp.616- 625.

[23] R. Maruthi, C. Jayakumari "SMS based Bus Tracking System using Open Source Technologies", Foundation of Computer Science (FCS), NY, USA, *International Journal of Computer Applications*, 2014, Vo. 86, No. 9. doi: 10.5120/15017-3305.

[24] R. Poovarasi, K. T. Siva Prasanth, S. M. Sesha Gopal, J. Roshini "Automated Bus Tracking System Using GSM and GPS Module", Vol 10, No 3 (2018), CiiT *International Journal of Automation and Autonomous System*.

[25] Carmelo R. Garcia, Santiago Candela Solá, Jonatan Ginory, Alexis Quesada-Arencibia, Francisco Alayón Hernández, On Route Travel Assistant for Public Transport Based on Android Technology. July 2012 *Conference: Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2012 Sixth International Conference on. "On Route Travel Assistant for Public Transport Based on Android Technology*". doi: 10.1109/IMIS.2012.103.

[26] Ei Phyu Thet , Win Zaw Hein, Ijsetr, "Real Time Bus Information System using GPS Based on Web Application", *International Journal of Scientific Engineering and Technology Research,* ISSN: 2319-8885 Vol.07, Issue.02, February-2018, pp.0186-0191.

[27] Manish Kumar Chauhan, Sidharth Bhatia, Monika Rana, "Vehicle telematics with real time operating system", *IJRET: International Journal of Research in Engineering and Technology*, eISSN: 2319-1163, pISSN: 2321-7308.

[28] Feng Liu, Jan Sparbert, Christoph Stiller "IMMPDA vehicle tracking system using asynchronous sensor fusion of radar and vision", *Published in 2008 IEEE Intelligent*

Vehicles Symposium. doi: 10.1109/IVS.2008.4621161.

[29] C. J. Vidanapathirana, T. Thilakshan, A. H. S. Sharic and J. M. S. J. Bandara, "A GPS-based Solution for Real-Time Data Collection of Public Transport Systems", Annual Sessions of IESL, pp.15-22, The Institution of Engineers, March 2024, *Conference: 115th Annual Session of IESL,* Colombo, Sri Lanka.

[30] Balqies Sadoun, Omar Al-Bayari, "Location based services using geographical information systems", November 2007, *Computer Communications,* 30(16):3154-3160. doi: 10.1016/j.comcom.2007.05.059.

[31] Idriss Moumen, Najat Rafalia, Jaafar Abouchabaka, Marouane Aoufi, "Real-time GPS Tracking System for IoT-Enabled Connected Vehicles", *E3S Web of Conferences* 412, 01095 (2023), ICIES'11 2023, https://doi.org/10.1051/e3sconf/202341201095.

[32] Pradip Suresh Mane, Vaishali Khairnar, "Analysis of Bus Tracking System Using Gps on Smart Phones", *IOSR Journal of Computer Engineering (IOSR-JCE),* e-ISSN: 2278-0661, p-ISSN: 2278-8727, Vol. 16, Issue 2, Ver. XII (Mar-Apr. 2014), pp.80-82.

[33] Sandhiya, Dr. Shanthi AL, "Real Time Bus Tracking System", *International Research Journal of Modernization in Engineering Technology and Science,* e-ISSN: 2582-5208, Vol. 07, Issue 09 September 2025.

[34] Menzi Skhosana, Absalom E. Ezugwu, "A Real-Time Machine Learning-Based Public Transport Bus-Passenger Information System", November 2021, *International Journal of Sustainable Development and Planning,* 16(7):1221-1238, https://doi.org/10.18280/ijsdp.160703.

[35] Laura Miola, Veronica Muffato, Enrico Sella, Chiara Meneghetti, Francesca Pazzaglia, "GPS use and navigation ability: A systematic review and meta-analysis", *Journal of Environmental Psychology*, Vol. 99, November 2024, 102417, https://doi.org/10.1016/j.jenvp.2024.102417.

[36] A. H. Alomari, A. A. Al-Omari, and W. K. Aljizawi, "Evaluation of travel time reliability in urban areas using mobile navigation applications in Jordan," *Journal of Applied Engineering Science*, vol. 20, no. 3, pp. 644–656, Sep. 2022. https://doi.org/10.5937/jaes0-35118.

[37] Zahra Karami, Rasha Kashef, Smart transportation planning: Data, models, and algorithms, *Transportation Engineering*, vol. 2, Dec. 2020, pp. 100013. https://doi.org/10.1016/j.treng.2020.100013.

[38] E. Echaniz, R. Cordera, A. Rodríguez, S. Nogués, and L. dell'Olio, "Spatial and temporal variation of user satisfaction in public transport systems," *Transport Policy,* vol. 117, Mar. 2022, pp. 88–97. https://doi.org/10.1016/j.tranpol.2022.01.003.

[39] S. Duleba and S. Moslem, "User satisfaction survey on public transport by a new PAHP based model," *Applied Sciences*, vol. 11, no. 21, Nov. 2021, Art. no. 10256. https://doi.org/10.3390/app112110256.

[40] Tian Z, Yao H, Shao Y., A Review of Urban Path Planning Algorithms in Intelligent Transportation Systems, *Algorithms*, vol. 18, no. 11, Oct. 2025, Art. no. 676. https://doi.org/10.3390/a18110676.

[41] G. Inturri, N. Giuffrida, M. Le Pira, M. Fazio, and M. Ignaccolo, "Linking public transport user satisfaction with service accessibility for sustainable mobility planning," *ISPRS International Journal of Geo-Information*, vol. 10, no. 4, Apr. 2021, Art. no. 235. https://doi.org/10.3390/ijgi10040235.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed to the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or the Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.