Identification of Bus Stations on the Urban Transport Network Based on GPS Tracking Data

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Abstract. In contemporary urban settings, inhabitants use public transportation to engage in events and commercial transactions; therefore, transportation holds significant relevance. This study introduces an approach for identifying critical public transportation stations based on integrating information from sensors on the pedestrian walkway of the sector and GPS locations. Urban transportation systems can incorporate technologies that generate large amounts of information, which can be analyzed to obtain valuable insights related to mobility. In the first place, the topology of the road network is considered as the dynamic characteristics of the flow of traffic, to develop a mechanism that identifies the autobus stations considering the spatiotemporal ones from the GPS traces obtained from the spatial detection of the affluence of people. Later, an algorithm is presented that uses the structure of the road network and the influence of traffic between nearby roads to identify critical roads based on traffic volume. Finally, the bus-GPS track sector data compiled in Santa Elena, Ecuador is analyzed. We conducted a thorough analysis to observe the spatiotemporal changes in bus services, the most relevant routes, and intersections. Furthermore, the correlation coefficient has been used to evaluate the algorithm's performance in identifying multiple critical points. The findings indicate that this method is more effective and practical than the conventional congestion index analysis. The research carried out should be useful in the management of urban transport and the creation of alternative stations.

Keywords: Urban Transport · Big Data · GPS Trajectories · Autobus Stations

1 Introduction

The process of urbanization in cities has generated a growing need for citizen mobility, making it a critical issue. The geographical structure of urban environments implies that people must move around to carry out social and economic activities. In this sense, public transportation systems are the cornerstone of urban mobility, representing the population's most efficient, sustainable, and economical transportation mode [1]. Understanding the relationship between citizen flow to critical points within the urban area

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and public transportation is essential to improving city mobility. To meet the changing demands of urban areas, such as housing, offices, and markets, drivers make additional unplanned stations based on passengers' needs rather than the municipality's planned stations. Some of these stations are maintained and become designated long-term stations. Therefore, most unplanned autobus stations are possible candidates for new autobus stations due to increased public demand from rapid urbanization. Designing a platform to extract location and real-time data from users at these unplanned autobus stations provides an accurate estimate of the new autobus stations required by public authorities. On the other hand, the collected information can help travelers know all autobus stations and their schedules through application interfaces, making travel more scheduled and efficient. Therefore, the study of the infrastructure of the urban public transport network in the cities has received considerable attention in research and practice [2, 3]. Modern smart cities are using technology to improve urban services [4]. One of the research fields related to smart cities is Intelligent Transportation Systems (ITS), which use technological systems to track the location of buses and improve mobility regarding road service for buses, cars, and pedestrians. Additionally, large amounts of urban data can be collected to understand citizen mobility better [5].

The urban public transportation system is a complex network comprising a physical road network and a traffic demand network. In turn, it is made up of intersections and street segments. The flow of traffic on the traffic demand network reflects the movement of vehicles off the roadway. However, the street sections of the urban transit network do not have the same importance, because some paths or stations are less traveled. Therefore, it is crucial to acknowledge the significance of proper road usage and optimal station placement within road networks. Furthermore, identifying critical routes and stations is essential to alleviate urban traffic congestion, develop emergency response plans, and implementing effective urban transportation planning and management.

One of the main objectives of the analysis of the urban transport network is to determine the most important routes and stations that directly imply the information on the routes of the urban public transport lines, the duration of the journey and distances between the stations, which would be useful to design a more efficient urban transport network. Various methods have been studied in the literature to identify metrics in quantifiable graphs, such as the distance between stations and the number of elementary travel lines [6]. Therefore, it is possible to use it to quantify the relative importance of stations in an urban road network. However, it needs to consider detailed traffic flow. In the same way, we proposed a measure of centrality called DelayFlow, which considers the time of delay of the trip and the volume of the flow of passengers, to decide the critical stations in an urban transport network [7]. In addition, a method that can determine the critical stations of the urban transport network according to the measure of the local system [8, 9]. On the other hand, a fundamental objective of urban transportation road network analysis is to identify critical routes. Various measures have been proposed to evaluate the criticality of routes, some of which can be found in studies [10, 11].

Since 2012, Big Data has become an access point for research in all areas of life, such as academia, industry, education, medical services, and government agencies, among others. Big Data analysis is of great importance in multiple areas of life. Large traffic data in the city can be used effectively to improve transport management and urban

road planning. The Global Positioning System (GPS) sensor in mobile vehicles has been used to automate data extraction related to traffic and urban roads. As an essential part of the public transportation system, buses are one of the most popular means of transportation that serve citizens in urban and suburban areas. GPS trajectory data from buses contain a wealth of spatiotemporal information, which enables the potential for gaining knowledge in understanding urban commerce, human mobility behavior, and road network dynamics. Understanding the dynamics of mobility is crucial to improving transport systems. For example, to improve the quality of the urban bus services, a method for detecting abnormal tray sectors online is proposed to analyze the points in which the buses are stopped with the longest time to collect or leave users. This proposed method was evaluated based on GPS trajectories of the buses in real time, the travel patrons of the passengers on the entire route were modeled based on GPS trajectories of the urban buses for the identification of stations [13, 14]. According to this model, specific parameters were established to evaluate the performance of urban road transportation. The effectiveness of the proposed algorithm was validated using GPS data from buses collected in Santa Elena, Ecuador. The results revealed that the method could provide high-quality inspection and detailed information about urban traffic to construct stations in the urban road network. However, there are several challenges in identifying autobus stations, especially unplanned ones. Unplanned autobus stations may also include ad-hoc locations due to traffic congestion or other similar factors and may not necessarily be actual boarding points for passengers.

The urban transport network is a dynamic multimodal network that includes road networks with static structural characteristics on the roads and traffic flow with dynamic characteristics. Methodologies for identifying critical stations and segments of the urban transport network associated with the static structure have been extensively researched in the last decade. However, only some studies have considered the dynamic traffic characteristics in the urban transport network. In this article, we will develop a complex network algorithm to capture the urban transport network's static and dynamic characteristics. The main contributions are summarized below:

– An urban transport network is proposed through the combination of the static structure of the road network and the dynamic traffic flow. The static structure represents the roads that connect the city, while GPS data provides detailed information about dynamic changes in urban traffic flow. Therefore, the proposed model allows for capturing both the temporal and spatial characteristics of the urban transport network.
– As a case study, a comprehensive analysis was conducted using data collected from the GPS-equipped buses in Santa Elena, Ecuador, to visualize the spatiotemporal changes in bus services, critical routes, and critical stations. Furthermore, the correlation coefficient was used to quantify the algorithm's performance in identifying multiple critical points. The results demonstrate that the proposed algorithm effectively identifies critical lanes and stations in the urban transport network.

The rest of this document is organized as follows. In Sect. 2, a weighted complex network is proposed for an urban transport network. Next, Sect. 3 provides a mixed Implementation of intelligent solutions in the urban transport system. Section 4 presents the results of the benefits of urban public transport by incorporating state-of-the-art technologies. Finally, the conclusions and our future work are presented in Sect. 5.

2 Proposed System

Complex networks have been applied in various fields, such as biology, engineering, medical science, social sciences, telecommunications, transportation, and more. Of course, the application of the complex networks focused on the study of the transport network has greater relevance. For the urban transport network, there is a dual alternative representation of the road network, where its stations become nodes. This approach allows for analyzing and studying the relevant topological characteristics of the urban transportation network [15].

Depending on the direction of the roads, there is unidirectional and bidirectional traffic on the urban transport network. The circulation of descending traffic is directly influenced by ascending traffic. Similarly, the flow of ascending traffic is also affected by the flow of descending traffic in case of blockages. The importance of the stations in the urban transport network on the ground is affected by its ascending and descending station, but also by the topology of the urban road network. Therefore, the importance of nodes in the urban transportation network is examined from two perspectives: the spatial position of the station in the static road network and the dynamics of traffic flow in the urban transportation network.

2.1 Description and Pre-processing of Data

The GPS trajectory data are compiled in the city of Santa Elena, Ecuador. Santa Elena is the capital of the province of Santa Elena in zone 5 of Ecuador. There are 39,681 inhabitants in the urban sector of the province of Santa Elena [16]. The urban area of Santa Elena is 632.4 square kilometers (see Fig. 1). There are 8 urban transport cooperatives with 240 units in the province of Santa Elena in the cities of La Libertad, Salinas, and Santa Elena [17]. The data from the GPS tray sector of the buses has been compiled from September to December 2020. The GPS log is periodically sent to the data center via a GPS-enabled device on board the bus. Each record provides the identification, length, latitude, time stamp, movement speed, direction and operating status of the vehicle. The sampling interval of the trajectories point is 30 s.

Raw GPS tracking data often contains abnormal signals due to random and systematic errors. However, to address missing points in time intervals of less than 30 s, the linear interpolation method adds a missing point between adjacent positions in the urban road network. In this article, the characteristics of the urban transport network are analyzed for a period of one hour.

Data analysis involves collecting and processing raw data to extract relevant information that provides supporting evidence for decision-making (see Fig. 2). Therefore, a space-time algorithm of the urban transport network was built based on GPS track sector data. The suitable main network model includes approximately 235 bus service stations.

The data analysis process begins and ends in real time. In urban environments, this involves collecting raw data from a city, such as in the case of Santa Elena. For him, the data analysis process on the GPS trajectories of the public urban transport buses is made up of several phases. Initially, the raw data needs to be processed, which involves organizing them into tables, reviewing datasets, and refining them to detect corrupt or inaccurate records. After that, the analysis of the data is carried out using algorithms

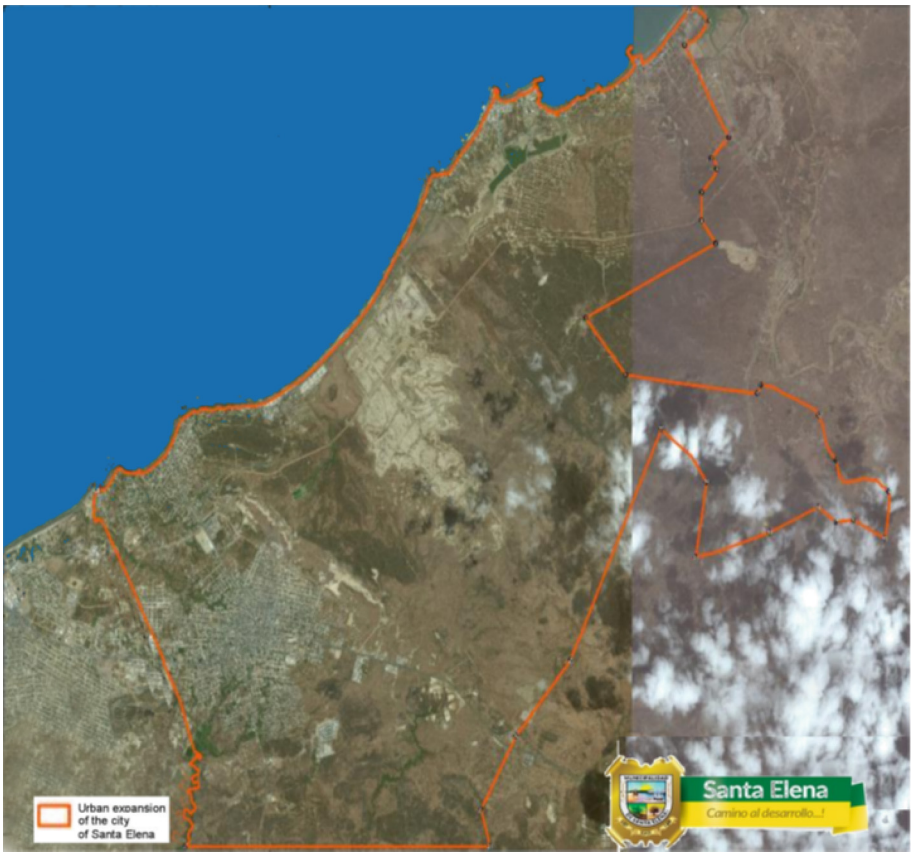

Fig. 1. Map of Expansion Urbana-Ciudad Santa Elena (GAD)

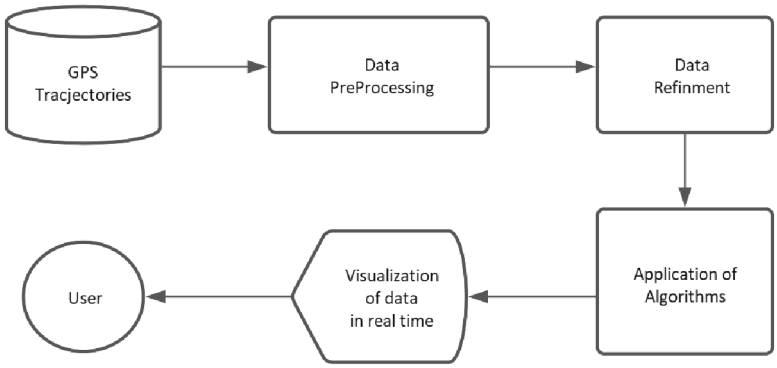

Fig. 2. Data analysis workflow applied in this work.

that have the objective of describing the behavior of urban transport. Urban data often come from diverse and dynamic sources, such as sensors and mobile devices, making it necessary to detect inaccuracies for urban data analysis. Finally, the results are typically communicated to the user using visualization techniques.

The objective of the visualization of data is to efficiently show the quantities measured through graphs. However, urban data analysis involves the combination of quantitative and qualitative data, which requires more advanced means of visualizing results effectively. Since urban data often have a vital geographic component, urban data visualization combines classical statistical charts with geographic information systems (GIS).

2.2 Analysis of the Conditions of Urban Traffic

A system of evaluation of the congestion of the traffic according to the conditions of the road traffic of the province has been established. Urban public transport is one of the many components that the National Traffic Agency (NTA) tries to manage and control, according to the established statutes and regulations [18]. However, NTA mentions that urban transport buses commonly have a problem due to infractions received regarding speed limits. NTA seeks an alternative to reduce accidents and violations caused by public transport, it presents information systems for road routes in public transport to improve traffic management.

The buses are allowed to move at 50 km/h inside the urban center following the NTA [19]. The congestion level in a city varies over time and space, depending on the daily travel demand of urban residents. The variation in rural traffic occurs due to congestion on the road due to business hours. The moons increase gradually, and the maximum peaks are at 7:00 am and 6:00 pm. The main reason is the entrance to the institutions and exit from the same. On weekends, vehicle congestion is less than on weekdays. However, this is because the activities of urban residents tend to be more regular on weekdays than on weekends.

2.3 Data Collection System

The bus stations are the places where an autobus stations for a finite duration. Therefore, it is possible to extract two locations from the urban roads using the GPS device, observing the points where the speed of the bus is zero. In order to analyze the spatio-temporal characteristics of the locations of the stations, a field study was carried out to extract several GPS points from the stations on the urban roads considering designated stations and unscheduled stations.

The special coverage average between stations is between 100 m, however, for some urban bus stations they can go further than 100 m. Therefore, it is essential to consider that both the spatial and temporal distribution of bus stations exhibit high variability, making it challenging to use a threshold-based approach to detect autobus stations automatically. The average waiting time for buses at non-designated stations also varies considerably.

2.4 Passenger Information System

A passenger information system is based on a digital monitor designed to track the location of each bus using GPS technology. In addition, all the information is stored and

processed on a web server that provides bus locations in real time, together with web applications for use by each passenger (see Fig. 3).

The design of the passenger information system uses a data base and a server connected to the satellite. The GPS is installed in each bus and the information screens are installed in each bus station. In addition, the passenger information will be available at the stations as well as on their mobile devices. Finally, the passenger information system would be monitored from the central Urban Public Transport office in the city of Santa Elena.

2.5 Mobile GPS Monitoring Device

There is a GPS tracking module on the bus, together with a GSM modem and a microcontroller that serves to transmit information in the form of bus position coordinates. The latitude and longitude information are stored on the server, which data are in real time. In addition, the bus routes, departure and arrival time, number of passengers and bus speed can be stored.

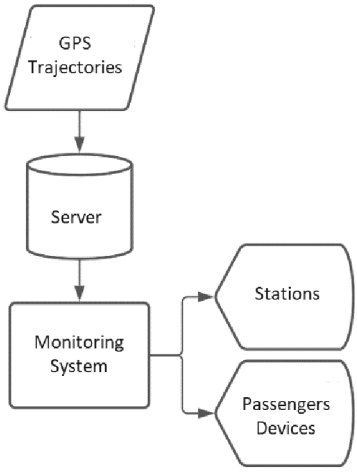

Fig. 3. Scheme of the passenger information system

The electronic devices obtain the data from the GPS and periodically transmit and verify the information on the server. The GPS device sends the information to the server using the SIM card to later download the information to the passenger application. To obtain the signal from the satellite, the GPS device is activated, which is able to obtain the current location of the bus (latitude and length) in each time interval.

With a mobile application for the passenger, you can facilitate the arrival at destinations with the suitable number of buses, which will be found in an interactive way with a pleasant user interface. The users with the application of the passenger information system will tend to access the current position of the bus until the time of arrival at the station. In addition, the system also refreshes or updates the coordinates of the time of arrival of the bus to the passengers.

When the passenger enters the bus, the information about the unit is updated in a database, which is available to the rest of users, which can decide whether there are places available on the bus. In addition, users have the ability to see the bus route or other information contained in the application. On the other hand, when selecting the bus, the application shows its position on the user's screen and informs the time of arrival and departure.

A modern passenger information service is a control and monitoring system that is used to provide a reliable and real-time transport base that helps plan the transport system of the city of Santa Elena. In addition, it is an intelligent transport system for urban areas in Ecuador, especially in the city of Santa Elena.

3 Intelligent Urban Transport System

An intelligent urban transport system for the needs of the city of Santa Elena implies implementing intelligent solutions in the existing urban transport system. In the big cities there are street networks for urban transport using buses, which is a dominant form of public transport. Therefore, a paradigm shift is needed in the modern urban transportation system.

Smart solutions for urban transport should include intelligent issuance of tickets and automated collection of fares; fast transit bus systems: buses; and autobus stations based on smart GPS.

3.1 Issuance and Automated Collection of Tickets

The use of urban public transport helps to reduce road congestion, managing to increase the mobility of people, which in turn indirectly contributes to the productivity of the city of Santa Elena. The automated issuance of tickets is one of the technologies that reduce the operating cost and facilitate passages to the passengers of urban public transport. Automatic ticket issuing is a system that utilizes a microchip, embedded in a smart card, to store the information of a travel ticket electronically. The automated issuance of tickets is a useful tool for the sectors of urban public transport and the bodies in charge due to which they can track the number of passengers on the routes, the time taken by the passengers, and the accounting of earnings is carried like a box common This system will help for future planning in the development of urban public transport routes. Additionally, tickets are more secure against fraudulent activities. The electronic card can be deactivated once the theft is reported, and the remaining balance can be refunded or transferred to a new electronic card. Automated ticket issuing also strengthens the case for mobile ticketing. Figure 4 shows a schematic of the electronic card process for issuing tickets to passengers.

3.2 Fast Transit Bus Route

The traffic congestion on the main routes of Santa Elena, La Libertad, and Salinas poses a challenge to the mobility of urban public transportation, including buses. The limitations for buses mobility are:

– Size and number of buses in the fleet.

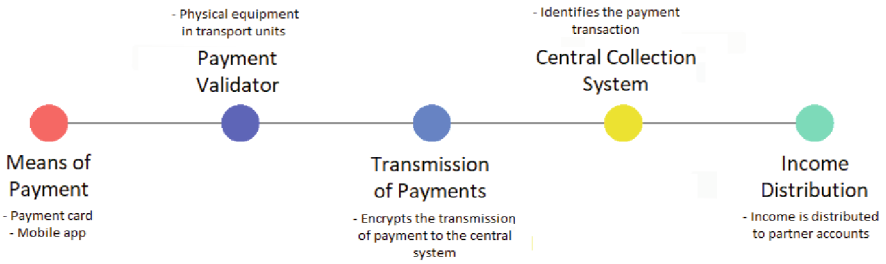

Fig. 4. Scheme of the passenger information system

– Congestion of vehicles on the main urban roads at peak hours.
– Technology implemented on the buses.

A possible solution to the limitations mentioned in urban public transportation mobility is implementing a system known as Bus Rapid Transit (BRT), which offers a high-quality urban service that is fast, comfortable, and affordable urban service for all passengers. BRT utilizes exclusive bus lanes, the priority right of way for buses, level boarding platforms, and other quality services like information technology. Therefore, this allows for combining the flexibility of buses with the high-performance standards and design of metro transportation systems, resulting in a surface-level transportation style like a metro. The proposal is to construct an exclusive bus lane like a metro line.

The exclusive rails for the buses guarantee a fast and reliable service, which is why it is essential to have exclusive rails on the sides of the road on the main avenues that possess only one-way, to be effective and free of obstacles. The central rails must be separated from the other vehicle and motor rails with a continuous physical divider.

In the city center, BRT systems have a shared central station instead of two separate autobus stations, one for each direction. These stations are in the middle of the roadway, between both directions of traffic, and provide access to buses traveling in both directions.

The central stations are more compact and take up less space than two edge stations, making them more cost-effective in construction and operation than bus stations on both sides of the bus lanes.

The central stations managed to optimize the use of space on the street.

3.3 Bus System and Bus Stations Based on GPS

The current issue in the bus transportation system of the city of Santa Elena is the need for real-time information for passengers regarding the location of buses and arrival/departure schedules. Due to the lack of information in real time, passengers arrive late at work and, at times, are forced to take private transport such as taxis. The passenger information system facilitates access to information about buses, timetables and estimated arrival times. It is possible to obtain the location of the buses by enabling them with GPS technology (see Fig. 5).

The studies in the city of Santa Elena show that some of the passengers arrive late at their destination because they decide to wait for a bus without knowing if the bus is

arriving punctually. On the other hand, the location of the buses in the cities would be beneficial for the passenger to plan the exit to the bus station.

The information system for passengers is based on a GPS track stored in the cloud that incorporates a prediction algorithm to provide real-time information about the bus service. The passenger information system provides at any time given the location of the buses and can predict the time of arrival of the bus to the station. This technology allows travelers to obtain information on the number of passengers in real time, in addition, through interfaces on websites, applications for smart phones and screens of stations at autobus stations.

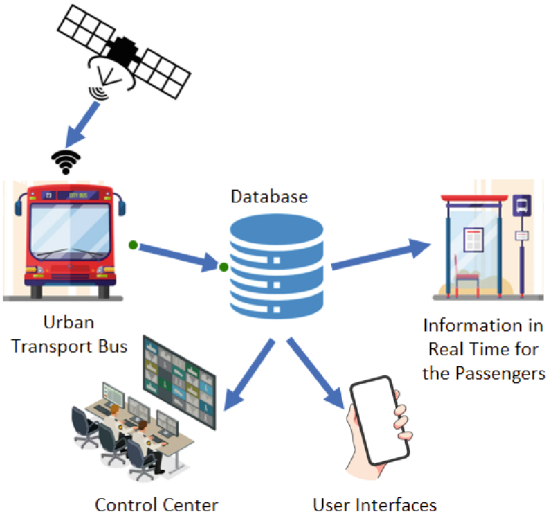

Fig. 5. GPS-based bus and bus station transport system diagram

4 Results

The architecture of the proposed system consists of several modules through which passengers can draw the maximum benefit from urban public transport through the incorporation of latest generation technologies. The architecture can be divided into three modules:

- Bus Transmitter Module;
- Bus Control Module;
- Passenger Service Module.

4.1 Bus Transmitter Module

The bus location is obtained through a GPS module connected to a high-performance single-board computer called Raspberry Pi (Rpi) and a GSM module (see Fig. 6). The

GPS module provides the bus location, which the Rpi processes. Additionally, data from a passenger count sensor on the bus is collected and processed by the Rpi, and updates are transmitted via WiFi. The sensor for counting the number of passengers can be an infrared sensor. The WiFi/GSM module transmits the information to the bus terminal control module.

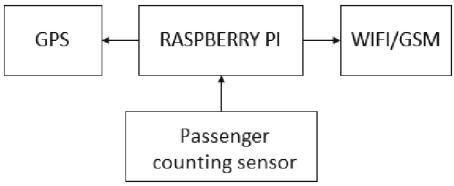

Fig. 6. Block Diagram of the Bus Transmitter Module.

4.2 Bus Control Module

The module consists of a WiFi-enabled RPI that receives the bus coordinates, arrival times, and passenger information on board. Subsequently, the RPI processes this information and sends it in real time to a central server. It can be accessed through a user interface like a smartphone application and displayed in real time at the bus station (see Fig. 7). Passengers can check live updates of the location and arrival times of their desired bus at the station from the comfort of their homes through the smartphone application that allows wireless internet access.

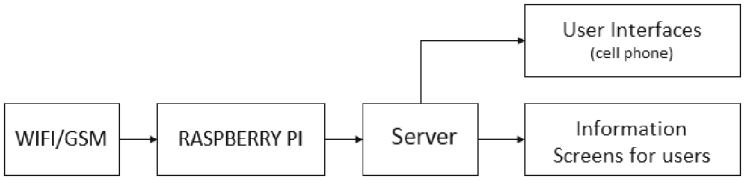

Fig. 7. Block diagram of the bus control module.

4.3 Passenger Service Module

The passenger service module consists of a smartphone with an application to locate the bus and estimate its arrival time at the station. As such, it is beneficial for passengers to plan their departure from home to the bus station, having advance information about the bus arrival time. The passenger service module may also include screens at the bus stations to display the coordinates and arrival schedules of the buses. Additionally, information about the number of passengers on board the bus is also reflected in the information channels. Passengers can access the schedule information through the wireless Internet connection available on smartphones. By using the passenger information

system in real time, we can also respond quickly to complicated situations such as robots through the implementation of panic buttons.

5 Conclusion

The urban public transport buses in the cities of Santa Elena, La Libertad and Salinas in Ecuador, were inspired to plan viable technological solutions in an efficient way for the sustainable growth of the cities and their inhabitants. The objective of having a management and monitoring system in these cities is a challenging aspect, but it can be achieved with the active participation of citizens. In this work, a proposal was presented in one of the sectors of an intelligent city, which is transport in modernized urban buses. Different solutions related to urban public transport were compared, such as the BRT system, electronic cards for tickets, buses with GPS technology and bus stations with information screens interconnected to a central cloud system. In the proposed model, passengers will not have to wait for buses without prior planning. Models have been implemented that allow passengers to accurately access information about the location of buses and arrival/departure schedules by incorporating cutting-edge technological solutions into the existing bus transportation system. Passengers can now obtain information about urban transportation through smartphone applications. The limitation of the project lies in the lack of detailed information regarding the implementation process and specific challenges encountered. While the study presents an approach to identify critical public transportation stations through the integration of sensor information and GPS locations.

In future work, it is important to continue exploring the potential of integrating advanced technologies into urban transportation systems. The approach proposed in this study, which combines sensor information from pedestrian walkways and GPS locations, shows promise in identifying critical public transportation stations. Future research can focus on refining and expanding this approach to larger urban areas, evaluating its effectiveness in diverse urban contexts, and integrating it with other smart city initiatives.

References

1. Grava, S.: Urban transportation systems. Choices for communities (2003)
2. Feng, S., Hu, B., Nie, C., Shen, X.: Empirical study on a directed and weighted bus transport network in China. Physica A **441**, 85–92 (2016)
3. Xing, Y., Lu, J., Chen, S.: Weighted complex network analysis of shanghai rail transit system. Discrete Dyn. Nat. Soc. (2016)
4. Deakin, M.: From intelligent to smart cities. In: Smart Cities. Routledge, pp. 27–44 (2013)
5. Putra, A.S., Warnars, H.L.H.S., Gaol, F.L., Soewito. B., Abdurachman, E.: A proposed surveillance model in an intelligent transportation system (ITS). In: 2018 Indonesian Association for Pattern Recognition International Conference (INAPR), pp. 156–160. IEEE (2018)
6. Hawick, K., James, H.: Node importance ranking and scaling properties of some complex road networks (2007)
7. Cheng, Y.Y., Lee, R.K.-W., Lim, E.P., Zhu, F.: DelayFlow centrality for identifying critical nodes in transportation networks. In: Proceedings of the 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining, pp. 1462–1463 (2013)

8. Shao-Hai, L., Jin-Zhao, W., Na, A.: An identification method for the hub node of urban transport network based on the local modularity. J. Theor. Appl. Inf. Technol. **48** (2013)
9. Zhang, X., Li, W., Deng, J., Wang, T.: Research on hub node identification of the public transport network of Guilin based on complex network theory. In: CICTP 2014: Safe, Smart, and Sustainable Multimodal Transportation Systems, pp. 1302–1309 (2014)
10. Scott, D.M., Novak, D.C., Aultman-Hall, L., Guo, F.: Network robustness index: a new method for identifying critical links and evaluating the performance of transportation networks. J. Transp. Geogr. **14**, 215–227 (2006)
11. Taylor, M.A., Sekhar, S.V., D'Este, G.M.: Application of accessibility-based methods for vulnerability analysis of strategic road networks. Netw. Spat. Econ. **6**, 267–291 (2006)
12. Zhang, H., Dai, L.: Mobility prediction: a survey on state-of-the-art schemes and future applications. IEEE Access **7**, 802–822 (2018)
13. Harb, R., Yan, X., Radwan, E., Su, X.: Exploring precrash maneuvers using classification trees and random forests. Accid. Anal. Prev. **41**, 98–107 (2009)
14. Bermingham, L., Lee, I.: A probabilistic stop and move classifier for noisy GPS trajectories. Data Min. Knowl. Disc. **32**(6), 1634–1662 (2018). https://doi.org/10.1007/s10618-018-0568-8
15. De Vos, J.: The influence of land use and mobility policy on travel behavior: a comparative case study of Flanders and the Netherlands. J. Transp. Land Use **8**, 171–190 (2015)
16. Acosta, R.Á., Guale, L.N., Pineda, F.C., Tarabó, A.E.M.: Production and commercialization of fish skin tanning products, Santa Elena-Ecuador. J. Soc. Sci. **26**, 353–367 (2020)
17. Arce Bastidas, R.F., Suárez Domínguez, E., Solís Argandoña, E.V., Argudo Guevara, N.: Analysis of tourist products: the case of Península de Santa Elena, Ecuador, Podium, pp. 139–158 (2020)
18. Tinoco, W.W., Montalvan, E.A., Tinoco, W.W., et al.: Análisis Del Expenditure Tributario En La Exoneración De Impuestos A La Piedad Vehicular: Caso De Estudio De Santa Elena, 2021. Revista Universidad de Guayaquil **135**, 45–54 (2022)
19. Pico, Á.A.R., Jumbo, K.J.S., Torres, L.J.A.: Traffic ordering models in the City of Loja. Science **21**, 31–43 (2019)