

Bus Tracking and Arrival Prediction System

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Abstract:- This project is a GPS (Global Positioning System) based system which helps passengers to know the expected time of arrival of the bus to their prospective halt or a particular location using present GPS data of the passenger and the bus. Within the ‘Bus Tracking and Arrival Prediction System’, each bus has a GPS tracker to track the bus. GPS tracker on the bus is used to locate the bus its coordinates and the speed of the bus are pushed on to the server to calculate an accurate arrival time to a user desired destination. Moreover, the server uses the received information on buses location and speed to identify the moving patterns. So, the owners of the private buses or the relevant authorities can monitor the moving pattern of their fleet and will be able to give feedback to the users. All system information is maintained in a database. Stored information will help to develop better algorithms in the future on predicting more accurate arrival time of their next bus service to the passengers.

Keywords:- GPS, Tracking, Prediction, Passengers.

I. INTRODUCTION

The introduction outlines a project aimed at designing and developing a mobile application titled ‘Bus Tracking and Arrival Prediction System’ to address issues in Sri Lanka’s public transportation system. The motivation stems from the decline in public transportation usage due to various problems, leading to increased traffic and a negative impact on the economy. [1]The statement of the

problem emphasizes challenges such as the lack of punctuality in bus schedules and the resulting inconvenience for passengers. Additionally, the introduction highlights limitations, including the cost of certain Google APIs and slower response times from the Sim 900 modem. The introduction outlines a project aimed at designing and developing a mobile application titled ‘Bus Tracking and Arrival Prediction System’ to address issues in Sri Lanka’s public transportation system. The motivation stems from the decline in public transportation usage due to various problems, leading to increased traffic and a negative impact on the economy. [1]The statement of the problem emphasizes challenges such as the lack of punctuality in bus schedules and the resulting inconvenience for passengers. Additionally, the introduction highlights limitations, including the cost of certain Google APIs and slower response times from the Sim 900 modem. The scope of the research involves providing users with information about buses on a given route, including short and long routes, start and end points, and stops until the destination. The application aims to guide users to the nearest bus station and notify them about possible routes if they are in a location without planned routes. The summary concludes with a mention of using Google Map API for notifying nearest bus stops, leveraging its routines and protocols to adapt results to the application’s scope. The individual contributions of the project include addressing issues in public transportation, proposing solutions, and developing algorithms for efficient route planning and passenger guidance.

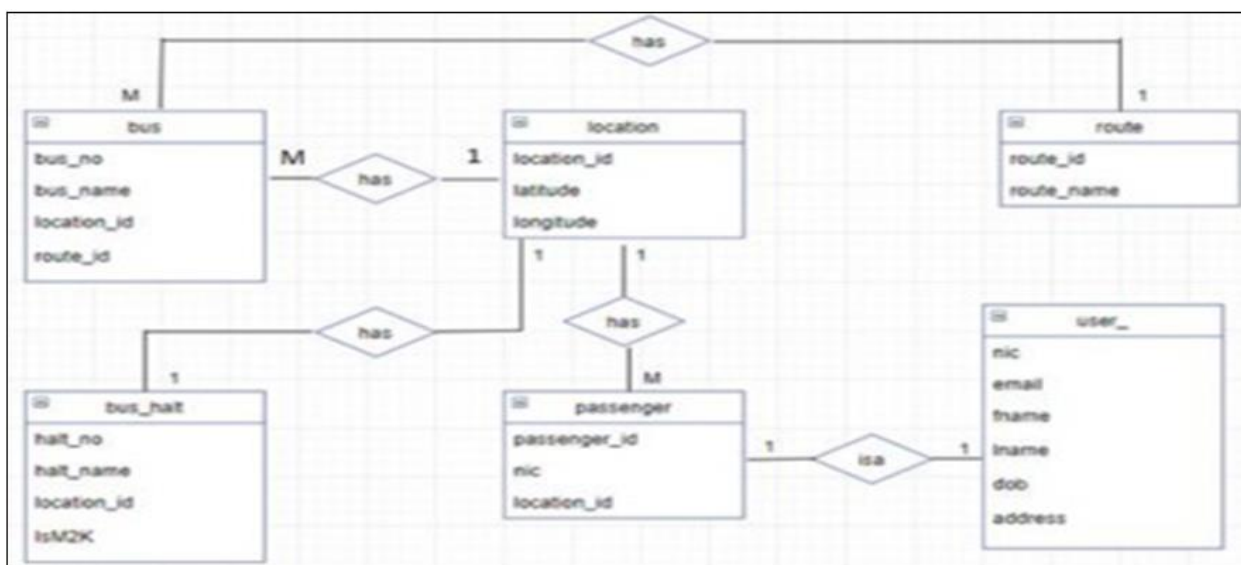


Fig 1 Database Design Diagram

II. LITERATURE REVIEW

The background section indicates the key tasks involved in the proposed project, encompassing the design and implementation of the Database, Hardware (including GPS Tracker, LCD panel, Power Supply), and the Mobile Application for Android. The goal is to integrate these modules seamlessly and provide a comprehensive solution, complemented by a suitable cover for the tracker units and the implementation of a project website. For efficient data management [4] and quick access, the project necessitates a commercial, high-performance, cross-platform supported, lightweight database. MySQL is chosen based on recommendations from database experts, known for its viability in web and mobile application development. In the prototype implementation, MySQL will be hosted locally on Windows or Linux, with database access facilitated through a web service on an Apache server. Basic database administration, such as adding, deleting, updating, and listing records, will be conducted through SQL queries. The initial feasibility study involves using Amazon Cloud9 database to confirm compatibility with a cloud-hosted MySQL server. The database schema [5] is structured around main entities and actions performed on the data. Tables identified for the prototype include Passenger Information, Transport Entity Information (bus details, authorities, GPS device), GPS Device Information (device ID, fixed location), Route Information (start, end, distance), Stops Information (stop locations, distance, bus routes via the stop), Route Schedule (timetable, cities, buses on the route), Distance Map (distance mesh of major Sri Lankan cities), and Application Settings (connection, provider information). The design emphasizes scalability, [6]with additional tables expected as features expand. The research paper will further detail the updated database design, underscoring the project’s commitment to robust data organization and accessibility. Finding the Shortest Route Dijkstra’s algorithm used to calculate shortest path between two given points. Flow chart of shortest path algorithm is given below. The inputs of this algorithm are two coordinates of location. One coordinate is current location of bus, and second location coordinate is stopping location. Source node coordinate is user’s coordinate. Stop coordinate is using for destination node. Google’s Encoded Polyline Algorithm [7] is designed for delineating paths between two points on a map, particularly for displaying routes on Google Maps. The Polyline algorithm is employed to illustrate the route, requiring intermediate points between the source and destination. The algorithm facilitates the calculation of these intermediate points. The encoding process is crucial for reducing data size, converting binary values into a series of character codes using the base64 encoding scheme. This process is applied to sets of coordinate pairs, resulting in an ASCII string. The encoded polylines serve to store substantial coordinate data efficiently, projecting lines or shapes on a map, typically on platforms like Google Maps. The algorithm involves taking the difference [8] between two coordinate pairs, multiplying it by $1e5$, rounding the values, converting them into binary, and ultimately translating the binary values into ASCII characters. This methodology ensures a compact

representation of geographical data for effective map visualization. The research paper will include a flowchart illustrating the steps of Google’s Encoded Polyline Algorithm, offering a visual representation of the encoding process for the benefit of readers and researchers. The Map Matching Algorithm discussed [9] is an extended version of the Kalman Filter Algorithm, incorporating position, speed, and time attributes. It effectively utilizes data on the vehicle’s direction to prevent abrupt shifts in mapped locations between disconnected street links. The algorithm’s process begins with nodal matching, identifying the correct link among all links connected to the nearest node to the GPS point. This step determines the physical location of the GPS point on that link. Subsequent steps assess if the next GPS point can be matched to the previously identified link and then determine its physical location on that link. This method ensures accurate mapping of GPS points to specific road links, enhancing the precision of location tracking. To notify users about nearest bus stops, [10]the system employs Google APIs, a set of developer tools specifying routines, protocols, and tools for building software applications. Google Map API is specifically utilized for this purpose, providing essential traffic data and road information. The integration of these APIs enhances the application’s capability to inform users about nearby bus stops effectively. Coordinate calculations play a crucial role [11] in finding the nearest bus stop. The system possesses a blueprint of the city’s bus stops, containing coordinate information for each stop. The algorithm compares user coordinates with the coordinates of all bus stops, utilizing a specific formula for the calculation. This systematic approach ensures accurate identification and notification of the nearest bus stop, contributing to the overall functionality and user experience of the application. The research paper will provide more in-depth details and possibly visual representations of these algorithms, contributing to the understanding of their role in the proposed Bus Tracking and Arrival Prediction System.

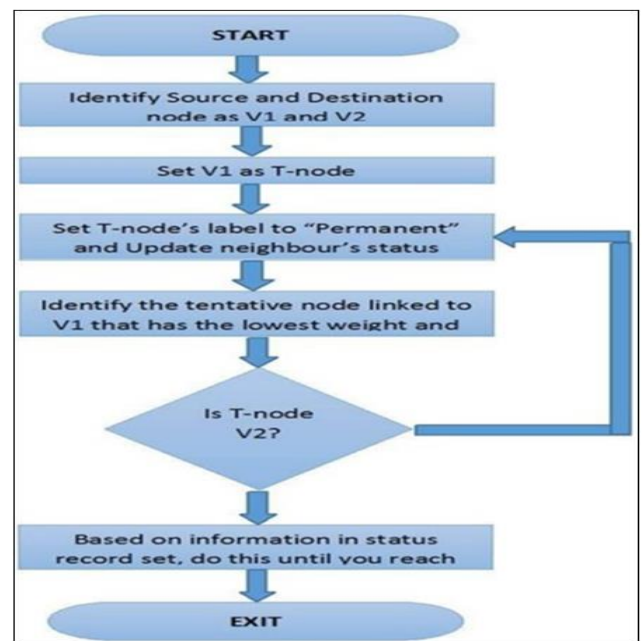


Fig 2 OSPF Algorithm

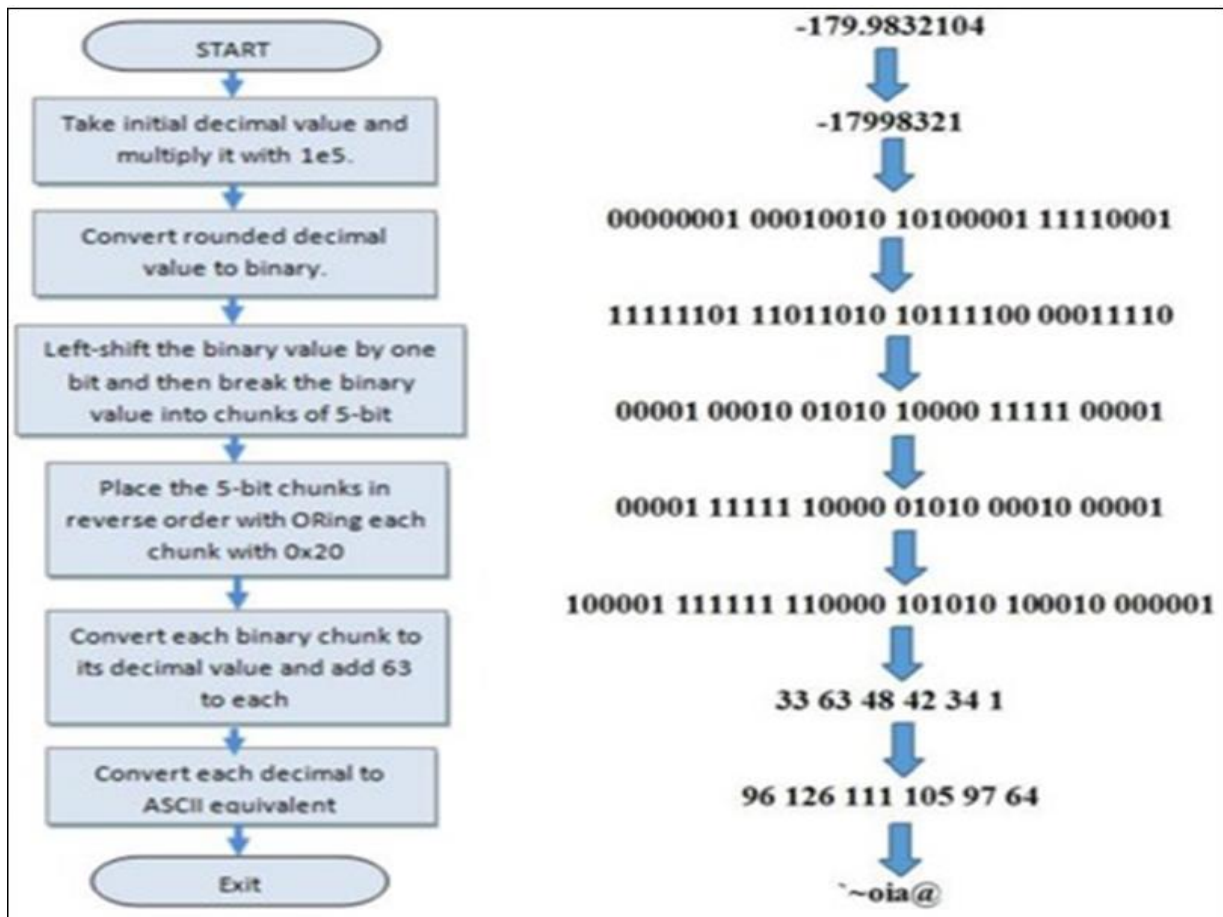


Fig 3 -Google Polyline Algorithm

$$\text{Min}(S - D_i) > Tr$$

Fig 4 Coordinates Calculation

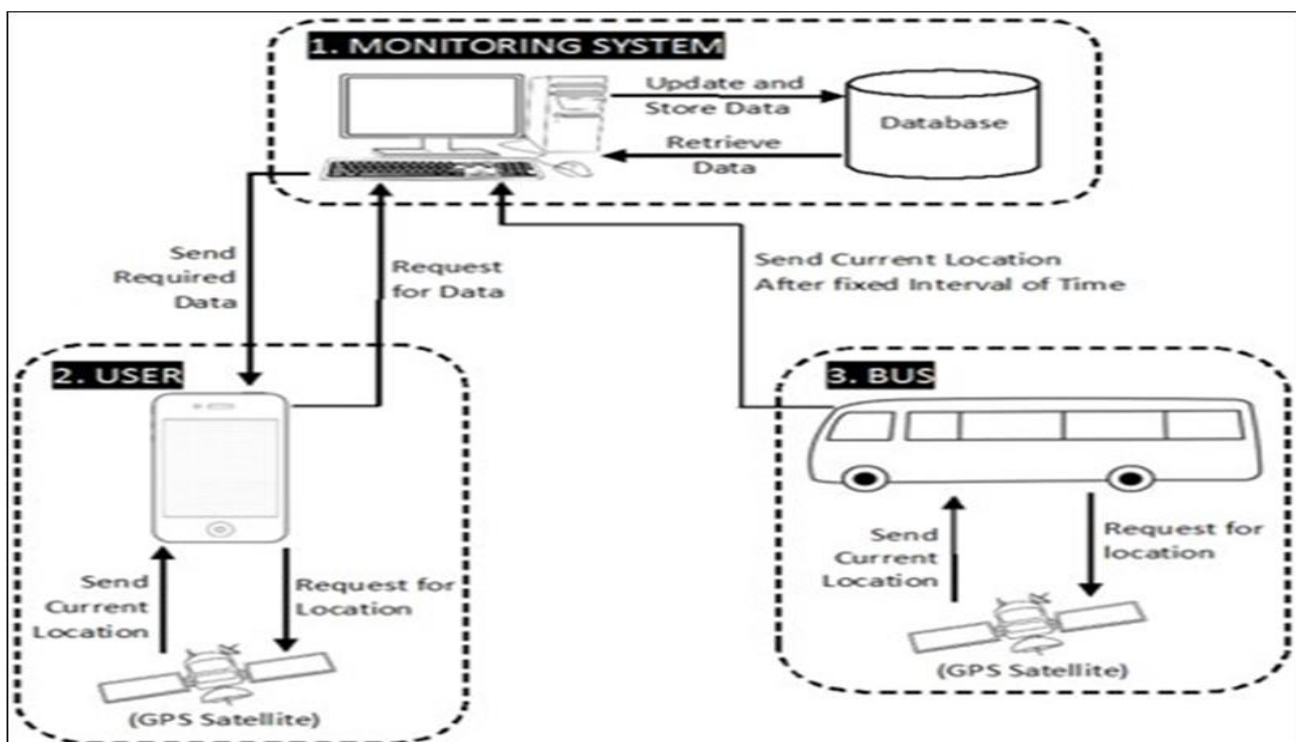


Fig 5 High level System Architecture

➤ According to the Function of Fig 4,

- S – User location coordinates (Current location of passenger)
 - Di – bus stop coordinates (Current location of bus)
 - Tr – Threshold value (Distance between two bus stops)
- Arduino UNO, SIM 900 shield, notification LCD panel and power supply units will be used.

➤ Following Modules will be Designed.

- GPS tracker using Arduino.
- Power supply unit for different components.
- Notifications LCD display.

➤ The system is Composed of Three Main Components,

- client-side application.
- server side.
- GPS module side.

The Bus Module in the proposed system involves a GPS-enabled GPS tracker installed on the bus. This tracker continuously captures the bus's current location, initiating

the tracking process from the point of departure. The obtained coordinates are then transmitted to a central dedicated server. The GPS tracker is programmed to perform this task, establishing the foundation for real-time tracking of the bus's movement. The server plays a pivotal role in the system [11], serving as the repository for the entire information database. It utilizes an SQL database to store and manage relevant data. Real-time tracking requires the server to continuously update the user application with the latest coordinates of the bus, ensuring accurate and up-to-date information for passengers. In terms of system communication, the flow involves the GPS tracker on the bus sending location coordinates to the central server. The server, equipped with an SQL database, stores this information. When a passenger accesses the application, the system retrieves and processes data from the server to provide real-time information on the bus's location. [12] This communication structure forms the backbone of the Bus Tracking and Arrival Prediction System. The research paper will delve deeper into the technical intricacies of the server, the GPS tracker's programming, and the communication protocols between these components, contributing to a comprehensive understanding of the system's functionality.

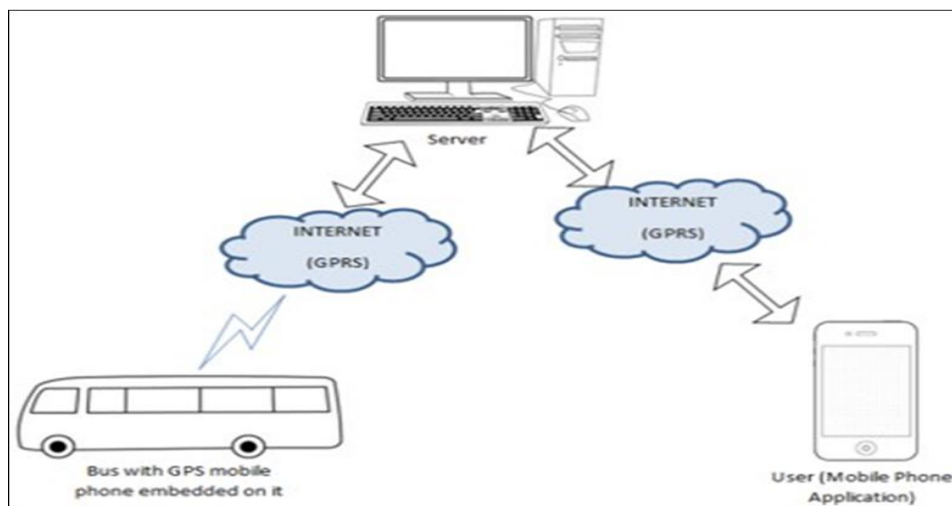


Fig 6 Central Server Communication

➤ Software Interfaces

- Client: Mobile Application
- Database: MySQL
- Development End: Android Studio, PHP, JSON
- Server: Cloud based server

III. METHODOLOGY

The project execution involves a sequential timeline for hardware implementation, with tasks such as the design of the GPS module (comprising GPS, GSM-GPRS, and microcontroller), unit installation, and unit testing. The parallel development of the database and mobile application is emphasized, considering their less-coupled nature during mid and later stages. The conceptual

framework involves leveraging online courses and tutorials to acquire expertise in mobile application development and database implementation. Android Studio serves as the primary Integrated Development Environment (IDE), with Java as the main programming language for software development. MySQL is chosen as the database to store essential application information, and open-source database management software aids in viewing and managing data through SQL queries. In the online mode of the GPS tracker module, NMEA strings are generated, containing location details such as latitude, longitude, number of satellites in lock mode, and signal strength. Satellite data is stored in the database for real-time access and future pattern analysis. The mobile application and the vehicle tracker module fetch data through a web service, relying on their internet connection. The system concept is visually represented in a diagram, providing an overview of the interconnections

between the GPS tracker module, database, web service, and mobile application. This systematic approach ensures a comprehensive understanding of the project's execution and conceptual structure. The research paper will delve deeper into each phase of the project execution, detailing the methodologies and technologies used, contributing to the

academic understanding of the Bus Tracking and Arrival Prediction System. The section discusses the importance of Database Management Systems (DBMS) in creating and managing databases. A DBMS serves as system software, providing a systematic approach for users and programmers to create, retrieve, update, and manage data.

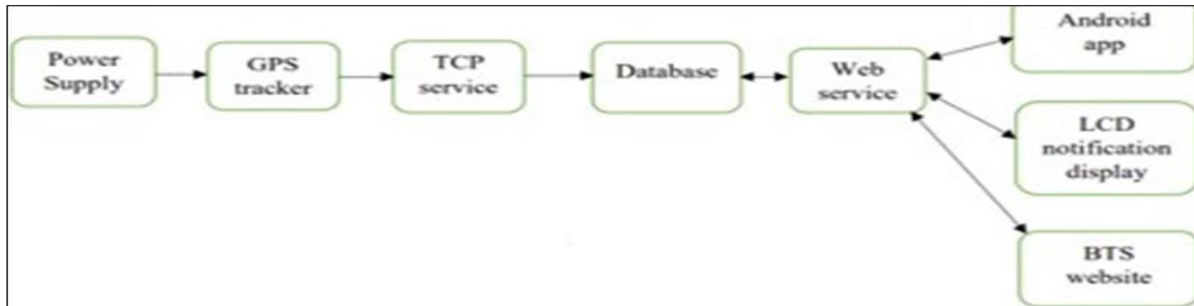


Fig 7 Overall System

It acts as an interface between databases and end users or application programs, ensuring organized and accessible data. Various DBMS options exist, including PostgreSQL, Oracle Database, SQLite, and the open-source MySQL. MySQL, highlighted in this context, is an open-source DBMS known for its versatility and wide usage. It allows end users to interact with databases efficiently, making it a suitable choice for the Bus Tracking and Arrival Prediction System. The section also introduces the Transmission Control Protocol (TCP), emphasizing its connection-oriented and reliable nature. TCP provides a reliable transport service between processes on End Systems (ES) using the network layer service provided by the Internet Protocol (IP). Operating at the transport layer of the Internet model, TCP facilitates host-to-host connectivity. It shields applications from the complexities of data transmission mechanisms, such as IP fragmentation, ensuring a seamless and reliable communication service. In the context of the research paper, this information contributes to the understanding of the foundational technologies and protocols underpinning the Bus Tracking and Arrival Prediction System. It provides context for the utilization of MySQL as the database management system and highlights the reliability and connectivity features of TCP in the communication infrastructure. This section outlines the motivation behind the "Bus Tracking and Arrival Prediction System" by drawing inspiration from developed countries with advanced transportation systems. In countries like Australia, passengers have access to online applications displaying route schedules on digital boards at transportation hubs. However, existing apps lack the capability to provide real-time location tracking of buses, estimated waiting times, and relevant notifications. The researcher's personal experiences highlight the challenge of estimating bus arrival times and the desire for a system that allows passengers to plan their journeys more effectively. The envisioned system aims to address this gap in Sri Lanka's public transportation by incorporating features such as real-time bus monitoring, passenger information, bus tracking, notification of the nearest bus stop, online payment options, and location notifications. The "Bus Tracking and Arrival Prediction System" utilizes GPS technology to

provide passengers with the expected time of arrival for buses at specific stops or locations. Each bus is equipped with a GPS tracker to monitor its location and a LCD panel for displaying messages. The GPS tracker sends the bus's coordinates and speed to a central server, enabling the calculation of accurate arrival times for users' desired destinations. This innovative system not only improves the accuracy of arrival predictions but also introduces additional services like locating the nearest bus stop, facilitating online payments, and sending location notifications. The implementation of GPS-based tracking enhances the overall efficiency of the public transportation system and improves the passenger experience. In the research paper, this section provides valuable insights into the researcher's motivation, personal experiences, and the identified shortcomings in existing transportation systems, setting the stage for the proposed solution.

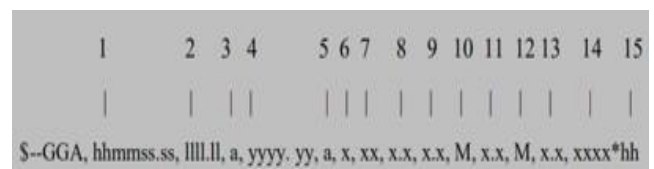


Fig 8 Sentence Identifier Format

IV. RESULTS AND DISCUSSIONS

The Results section provides detailed information on the final outcomes, development, testing, and implementation of the proposed system. The GPS tracker, a crucial component of the system, utilizes NMEA (National Marine Electronics Association) data strings to determine the current location and other specific data. NMEA defines standardized communication between marine electronics devices like gyrocompasses, sonars, autopilots, and GPS receivers. The NMEA data format includes PVT (position, velocity, time) computed by the GPS receiver. NMEA data strings are structured with a two-letter prefix 'GP,' and each sentence begins with a dollar sign and ends with a carriage return. These strings are compatible with various software applications, expanding the system's versatility. Applications such as DeLorme Street Atlas, ESRI, Google

Earth, Google Maps Mobile Edition, and others support the NMEA data format, contributing to the system’s compatibility and integration capabilities. This information is essential for understanding the technical aspects of the GPS tracker’s functionality and its compatibility with a range of software applications. In the research paper, this section lays the foundation for the subsequent discussions on the system’s development, testing, and implementation.

- Time (UTC)
- Latitude

- N or S (North or South)
- Longitude
- E or W (East or West)
- GPS Quality Indicator, 0 – fix not available, 1 – GPS fix, 2 – Differential GPS fix
- Number of satellites in view, 00 – 12
- Horizontal Dilution of precision
- Antenna Altitude above/ below mean – sea – level (geoid)
- Units of antenna altitude, meters

```

1 CREATE TABLE bus(
2 bus_no INT(10) NOT NULL,
3 bus_name varchar(50) NOT NULL DEFAULT '',
4 route_id INT(10),
5 location_id INT(20) NOT NULL,
6 FOREIGN KEY(location_id) REFERENCES location(location_id),
7 FOREIGN KEY(route_id) REFERENCES route(route_id),
8 PRIMARY KEY(bus_no)
9 );
    
```

Fig 9 SQL query: bus.sql

```

mysql> DESC bus;
+-----+-----+-----+-----+-----+-----+
| Field      | Type          | Null | Key  | Default | Extra |
+-----+-----+-----+-----+-----+-----+
| bus_no     | int(10)       | NO   | PRI  | NULL    |       |
| bus_name   | varchar(50)   | NO   |      |         |       |
| route_id   | int(10)       | YES  | MUL  | NULL    |       |
| location_id | int(20)       | NO   | MUL  | NULL    |       |
+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)
    
```

Fig 10 Description of the Table ‘bus’

- Geoidal separation, the difference between the WGS – 84 earth ellipsoid and mean – sea – level (geoid), “–” means mean – sea – level below ellipsoid
- Units of geoidal separation, meters
- Age of differential GPS data, time in seconds since last SC104 type 1 or 9 update, null field when DGPS is not used
- Differential reference station ID, 0000 – 1023
- Checksum

Other tables are given in Appendices. View of table from phpMyAdmin

The view of all the tables from ‘phpMyAdmin’ database management system is shown below.

The research paper includes Figure 10, showcasing a view of the MySQL tables from phpMyAdmin DBMS, offering a visual representation of the database structure. The section introduces the concept of web services, emphasizing their role as software systems designed for interoperable machine-to-machine interaction over a network. Web services have interfaces described in

machine-processable formats, often utilizing standards like WSDL. Interactions with web services are prescribed by their descriptions, using SOAP messages conveyed through HTTP with XML serialization. The REST API (Representational State Transfer Application Programming Interface) is divided into two sections: ‘v1’ to manage different versions and route requests, and ‘includes’ to handle different services and store common utilities. Constants.php contains connection details for the database, DbConnect.php is responsible for MySQL connection, and DbOperation.php holds SQL queries for GET and POST commands, handling data retrieval and insertion. A special Google API, the Distance Matrix API, is used to estimate time and distance between the current bus location and the passenger’s location. The code segment for this calculation is included in the DbOperation.php file. This section provides a comprehensive overview of the web service and REST API implementation, outlining the structure and functionality of the backend system. The inclusion of specific PHP code segments and API utilization adds depth to the technical understanding of the Bus Tracking and Arrival Prediction System.

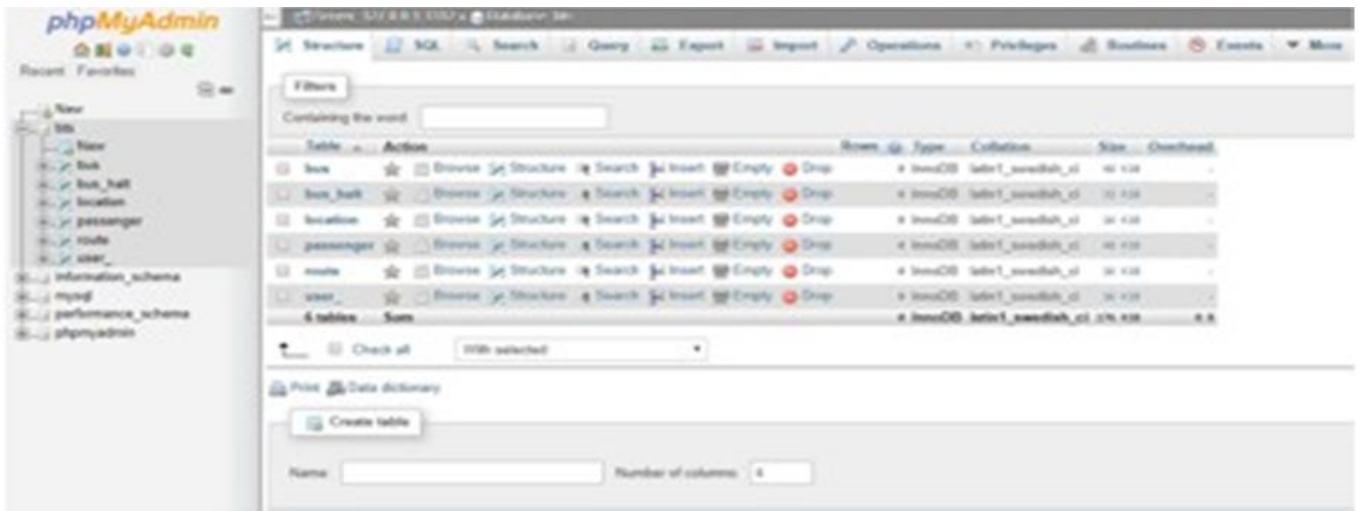


Fig 11 View of the MySQL tables from phpMyAdmin DBMS

```
// Generate the string of google maps distance matrix url
$url = "https://maps.googleapis.com/maps/api/distancematrix/json?units=metric&origins=";

// Origin is the current location of the bus
// Traffic model is by default 'best_guess' which accounts historic data and live traffic
$stmt->fetch();
$url = $url . $latitude . "," . $longitude; // Origin
$url .= "&destinations=";
$url .= $bushalt;
$url .= "&mode=driving&language=en&key=AIzaSy800tg0psb1b8ZPwD2gj6vhJrruQz:4Qt4w";

// Request distance matrix from google maps
$result = file_get_contents($url);
```

Fig 12 Distance Calculation Part

```
{
  "destination_addresses" : [ "Main Bus Stand - Malabe, Malabe, Sri Lanka" ],
  "origin_addresses" : [ "298 Kaduwela Rd, Sri Jayawardenepura Kotte, Sri Lanka" ],
  "rows" : [ {
    "elements" : [ {
      "distance" : {
        "text" : "2.1 km",
        "value" : 2057
      },
      "duration" : {
        "text" : "5 mins",
        "value" : 318
      },
      "status" : "OK"
    } ]
  } ], "status" : "OK" } true
```

Fig 13 Response of Distance and Time Calculation

Distance calculation can get accessing this URL, <http://syngamicexchanges.000webhostapp.com/bts/v1/index.php?op=getdurationbushalt=6.90412,79.95458> (Only want to

change longitude and latitude values of bus halts)

Response is given below, and it is in JSON format

V. CONCLUSION

In conclusion, the implementation of a bus tracking and arrival prediction system marks a significant stride towards enhancing transportation efficiency and passenger experience. By leveraging real-time data, GPS technology, and predictive algorithms, this system not only provides accurate arrival estimations but also empowers commuters with vital information, reducing uncertainty and wait times. Its potential to optimize route planning, improve operational management, and offer a seamless travel experience underscores its value in modernizing public transportation. As technology continues to evolve, further enhancements and integrations can be foreseen, promising a future where commuting becomes more convenient, predictable, and passenger-centric.

REFERENCES

- [1] Ç elan, Marko Lep, Marjan. (2017). Bus arrival time prediction based on network model. *Procedia Computer Science*. 113. 138-145. 10.1016/j.procs.2017.08.331.
- [2] Shanthi N, V E S, Upendra Babu K, Karthikeyan P, Rajendran S, Allayear SM. Analysis on the Bus Arrival Time Prediction Model for Human-Centric Services Using Data Mining Techniques. *Comput Intell Neurosci*. 2022 Sep 26;2022:7094654. doi: 10.1155/2022/7094654. PMID: 36199964; PMCID: PMC9529461.
- [3] S. Vigneshwaran, B. Nithya, K. Raghul, B. Nivas, and V. Kishore, "Design of bus tracking and fuel monitoring system," in 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), 2020, pp. 348-351: IEEE
- [4] R. C. Jisha, A. Jyothindranath and L. S. Kumary, "Iot based school bus tracking and arrival time prediction," 2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Udupi, India, 2017, pp. 509-514, doi: 10.1109/ICACCI.2017.8125890.
- [5] K. Premkumar, P. K., P. J., P. D. and P. P., "College Bus Tracking and Notification System," 2020 International Conference on System, Computation, Automation and Networking (ICSCAN), Pondicherry, India, 2020, pp. 1-4, doi: 10.1109/ICSCAN49426.2020.9262303.
- [6] A. Kumar Sharma, R. Pandey, S. Tarafdar and S. Dubey, "Towards Smart Mobility in Cities - Bus Tracking and Booking System," 2021 9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO), Noida, India, 2021, pp. 1-5, doi: 10.1109/ICRITO51393.2021.9596492.
- [7] Ramdasi, Kunal and Kashid, Rutuja and Patil, Pratik, Real Time Arrival Prediction and Vacancy Detection for Smart City Bus (May 18, 2019). *Proceedings of International Conference on Communication and Information Processing (ICCIP) 2019*, Available at SSRN: <https://ssrn.com/abstract=3422353> or <http://dx.doi.org/10.2139/ssrn.3422353>
- [8] Meiko Jensen, Jorg Sehwenk et al., "On Technical Security Issues in cloud Computing" IEEE Internationalconference on cloud Computing, pp 109-116, 2009
- [9] W.Services,"Implementing Microservices on AWS,"AWS,31072023[Online].Available:<https://docs.aws.amazon.com/whitepapers/latest/microservices-on-aws/microservices-on-aws.html>. [Accessed 02 11 2023].
- [10] M. A. Hafizh Nur, S. Hadiyoso, F. B. Belladina, D. N. Ra- madan and I. Wijayanto, "Tracking, Arrival Time Estimator, and Passenger Information System on Bus Rapid Transit (BRT)," 2020 8th International Conference on Information and Communication Technology (ICoICT), Yogyakarta, Indonesia, 2020, pp. 1-4, doi: 10.1109/ICoICT49345.2020.9166375.
- [11] S. A. E. Yosif, M. M. Abdelwahab, M. Abd Elrahman ALagab and F. Muhammad, "Design of bus tracking and fuel monitoring system," 2017 International Conference on Communication, Control, Computing and Electronics Engineering (ICCCCEE), Khartoum, Sudan, 2017, pp. 1-5, doi: 10.1109/ICCCCEE.2017.7867679.
- [12] A. Badkul and A. Mishra, "Design of High-frequency RFID based Real-Time Bus Tracking System," 2021 International Conference on Emerging Smart Computing and Informatics (ESCI), Pune, India, 2021, pp. 243-247, doi: 10.1109/ESCI50559.2021.9396894.