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INTERNET OF THINGS BASED VEHICLE TRACKING WITH GPS AND CLOUD INTEGRATION: A STUDY ON REAL-TIME MONITORING AND ANALYTICS

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Abstract
The increasing demand for real-time vehicle tracking, enhanced security, and efficient fleet management has fueled the development of advanced monitoring systems. This paper presents the design and implementation of an Internet of Things (IoT)-based Global Positioning System (GPS) vehicle tracking system that provides continuous, real-time location updates to users through a mobile application. The system integrates a NEO-6M GPS module for location data acquisition, a NodeMCU ESP8266 microcontroller for data processing and Wi-Fi communication, and a SIM800L GSM module for SMS-based backup transmission in cases of internet connectivity failure.
Data acquired from the GPS module is parsed and transmitted via Wi-Fi to the Blynk IoT platform, enabling users to monitor vehicle movement in real-time on a Google Maps interface embedded within a mobile application. When Wi-Fi is unavailable, the system automatically switches to GSM communication, sending the vehicle's current coordinates via SMS to a designated phone number.
Field tests were conducted in diverse environments, including open fields, urban areas, and densely built-up locations, to evaluate the system's performance. The results demonstrated high location accuracy, low transmission latency, and reliable communication stability. Additionally, the system achieved a Wi-Fi transmission success rate of 97% and a GSM success rate of 93%, affirming its operational reliability. The proposed IoT-based GPS vehicle tracking system offers a cost-effective, scalable, and practical solution for vehicle security, fleet management, and smart transportation systems.
Keywords: Blynk Platform, GPS Tracking, GSM Communication, IoT, NodeMCU, Real-Time Tracking, Vehicle Monitoring,

1 Introduction

The rapid growth in vehicular movement, transportation systems, and security concerns has created an urgent need for effective vehicle tracking and monitoring solutions. Traditional vehicle tracking methods, which rely primarily on manual logging or standalone GPS devices, have proven insufficient due to their limitations in real-time communication, reliability, and data accessibility. To address these challenges, the integration of Internet of Things (IoT) technologies with Global Positioning System (GPS) modules has emerged as a revolutionary solution for real-time, remote vehicle tracking.
IoT-based vehicle tracking systems leverage interconnected devices, cloud platforms, and wireless communication protocols to deliver continuous monitoring, location updates, and analytics. By utilizing GPS modules to obtain precise location data and IoT platforms to transmit and visualize this data, users can track and manage vehicles from anywhere at any time, improving security, operational efficiency, and fleet management capabilities.

This paper focuses on the development and implementation of an IoT-based GPS vehicle tracking system that combines the power of the NEO-6M GPS module, NodeMCU ESP8266 microcontroller, GSM (SIM800L) module, and the Blynk mobile IoT platform. The designed system is capable of providing real-time location updates over Wi-Fi and ensuring communication redundancy through GSM-based SMS transmission in the absence of internet connectivity.

The research work aims not only to achieve accurate, real-time vehicle location tracking but also to develop a low-cost, scalable, and user-friendly solution for applications such as personal vehicle security, logistics management, and public transportation systems. Through systematic hardware integration, software programming, and rigorous field testing, the proposed system demonstrates reliability, accuracy, and practical feasibility for smart transportation needs.

2 Review of Related Work

The emergence of vehicle tracking systems has revolutionized how transportation and logistics are managed globally. Early tracking technologies were based on passive GPS loggers that stored location data for later retrieval. These systems lacked real-time functionality and were limited in their use for applications such as theft prevention or fleet management. (Mounika & Chepuru, 2019) was among the early proponents of combining GPS technology with wireless networks to enable real-time tracking, laying the foundation for integrated systems that improved logistics visibility and control.

With the growth of wireless communication technologies, researchers explored the use of GSM and GPRS to transmit GPS coordinates to remote servers or users via SMS or data packets. Projects by (Badawi et al., 2016) demonstrated how GSM-based systems could be used effectively to monitor vehicle locations using mobile phones. However, such systems were constrained by their dependency on cellular network strength and lacked the interactive visualization features found in modern systems. This limitation led to the need for more sophisticated, internet-based tracking solutions.

The advancement of the Internet of Things (IoT) has opened new opportunities for building intelligent tracking systems. IoT platforms offer seamless communication between physical devices and cloud applications. Studies by (A, 2017; Bochare et al., 2024; Harikrishna et al., 2018; Jeevan et al., 2024; M & Chondamma, 2023; Murthy et al., 2022; Tejashri et al., 2020; Tejashwini & Panda, 2021; Zohari et al., 2021) showed that microcontrollers such as Arduino and ESP8266 can interface with GPS modules and transmit real-time data to platforms like Blynk, Firebase, and ThingSpeak. These developments have made it easier for developers to design low-cost, real-time tracking systems that are accessible through mobile and web applications.

Dual-mode communication systems, which integrate both Wi-Fi and GSM functionalities, have gained traction in recent years. (Priya & Devi, 2021) developed a system that used Wi-Fi for internet-based tracking and GSM as a fallback for sending SMS when internet access was unavailable. Such hybrid models enhance reliability in environments with inconsistent network coverage. However, the challenge of smooth automatic switching between communication modes remained a topic of interest in recent research.

GPS modules have also evolved, offering better sensitivity, lower power consumption, and higher positional accuracy. The NEO-6M GPS module, widely used in academic and commercial applications, provides precise location information and can be easily integrated with microcontrollers through UART communication. Studies by (Mounika & Chepuru, 2019; Tejashwini & Panda, 2021) highlighted its effectiveness in mobile vehicle tracking applications, noting improvements in GPS signal acquisition time and robustness in motion.

A key component in any tracking system is the microcontroller, which handles data processing and communication. NodeMCU ESP8266 has become a preferred choice due to its built-in Wi-Fi capabilities, low power consumption, and ease of programming. Research by (Mounika & Chepuru, 2019) emphasized the role of NodeMCU in enabling real-time data transmission and control, particularly when connected to IoT platforms

like Blynk. Its compact size and open-source support make it ideal for embedded tracking systems in constrained environments.

In addition to real-time tracking, power efficiency and hardware resilience are also major considerations in mobile tracking systems. Several studies have recommended using regulated DC power supplies and battery management systems to ensure continuous operation. Furthermore, system enclosures and mounting configurations play a critical role in the reliability of hardware during field deployment. Empirical evaluations from recent prototypes demonstrate that robust hardware integration directly correlates with tracking consistency and system uptime.

In conclusion, the literature reveals that the integration of GPS, GSM, and IoT platforms into a unified vehicle tracking system has become a practical and efficient solution. By leveraging low-cost hardware like NodeMCU and NEO-6M, alongside cloud-based interfaces such as Blynk, researchers and developers can create user-friendly, scalable tracking systems. This project draws from these prior works and contributes by implementing a dual-mode IoT-based tracking solution that ensures continuous monitoring regardless of network conditions.

3 Methodology

The development of the IoT-based GPS vehicle tracking system involved the integration of hardware and software components to achieve real-time vehicle location monitoring and communication. The system architecture consists of a NEO-6M GPS module for location acquisition, a NodeMCU ESP8266 microcontroller for processing and Wi-Fi communication, a GSM module (SIM800L) for backup SMS-based communication, and the Blynk IoT platform for mobile visualization as shown in system Block diagram of Figure 1.

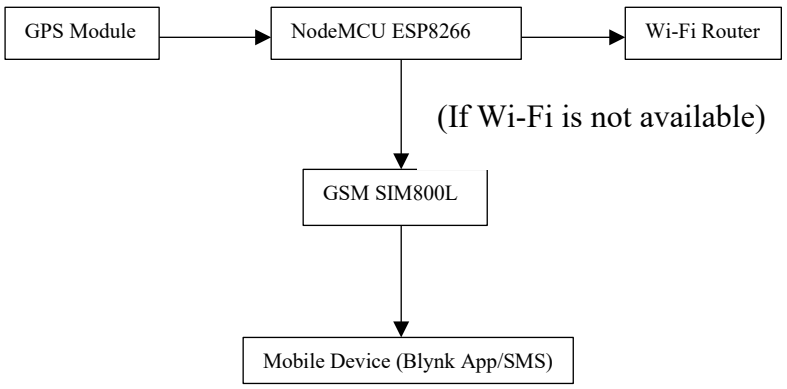


Figure 1: System Block Diagram

3.1 Hardware Components and Implementation

The hardware implementation of the IoT-based GPS vehicle tracking system involved the integration of several key components designed to operate collaboratively as shown in the circuit diagram depicted in Figure 2. The NEO-6M GPS module was used to obtain real-time geographic coordinates—latitude and longitude—directly from satellite signals as shown in Figure 3. This module communicated with the NodeMCU ESP8266 microcontroller using UART (Universal Asynchronous Receiver/Transmitter) protocol, allowing the location data to be transmitted seamlessly for further processing.

At the core of the system, the NodeMCU ESP8266 served as the central microcontroller unit. It was responsible for processing the incoming GPS data and transmitting it over Wi-Fi to the Blynk IoT platform, which enabled real-time tracking via a mobile application. In instances where Wi-Fi was not available, the system switched to a secondary communication path through the GSM SIM800L module. This GSM unit was programmed to send the vehicle's current location via SMS to a specified mobile number, ensuring continuous and reliable tracking functionality under all network conditions.

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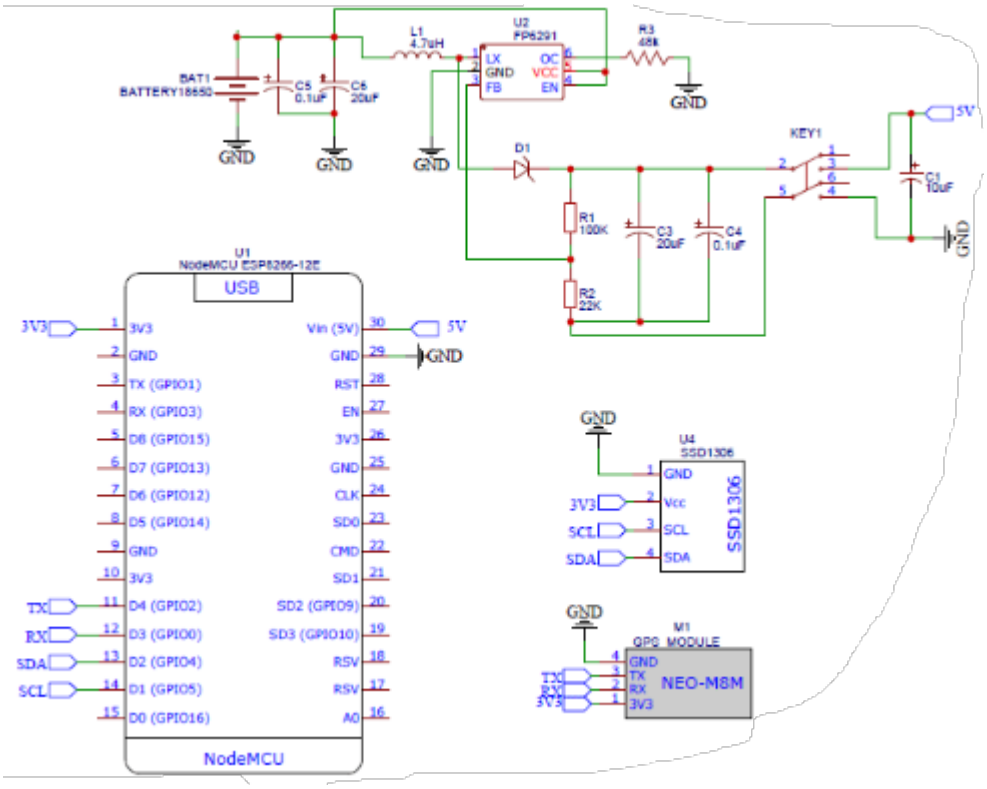


Figure 2: Circuit Diagram of IoT based Vehicle Tracker

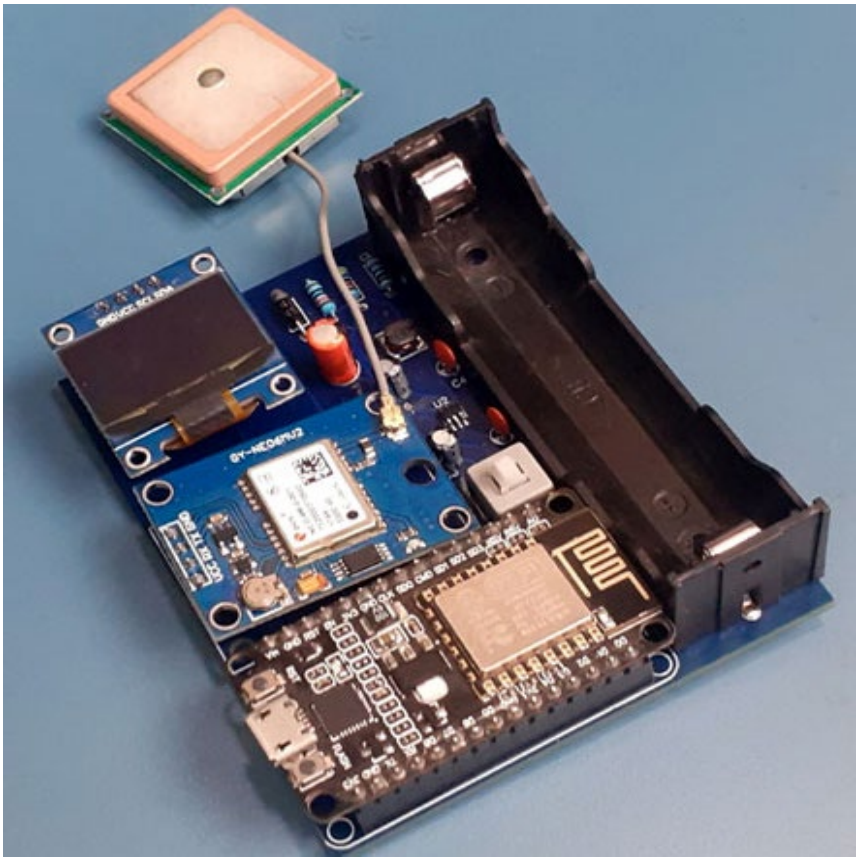


Figure 3: Hardware Implementation Diagram

To support stable operation, a 5V DC power supply unit was employed to power the NodeMCU and its peripheral devices, including the GPS and GSM modules. The complete assembly was mounted inside a test vehicle, with proper wiring and insulation to ensure durability during movement and vibration. This setup enabled thorough field testing, validating the system's robustness, responsiveness, and accuracy in real-world transportation scenarios.

3.2 Software Implementation

The software implementation of the IoT-based GPS vehicle tracking system was focused on programming the NodeMCU ESP8266, as shown in the flowchart indicated in Figure 4, to interface with both the GPS and GSM modules while ensuring seamless data transmission to the user. The firmware was developed using the Arduino IDE, with libraries such as TinyGPS++ for parsing GPS data and SoftwareSerial for communicating with the SIM800L GSM module. The code continuously reads latitude and longitude values from the NEO-6M GPS module, checks for network availability, and determines the appropriate communication channel.

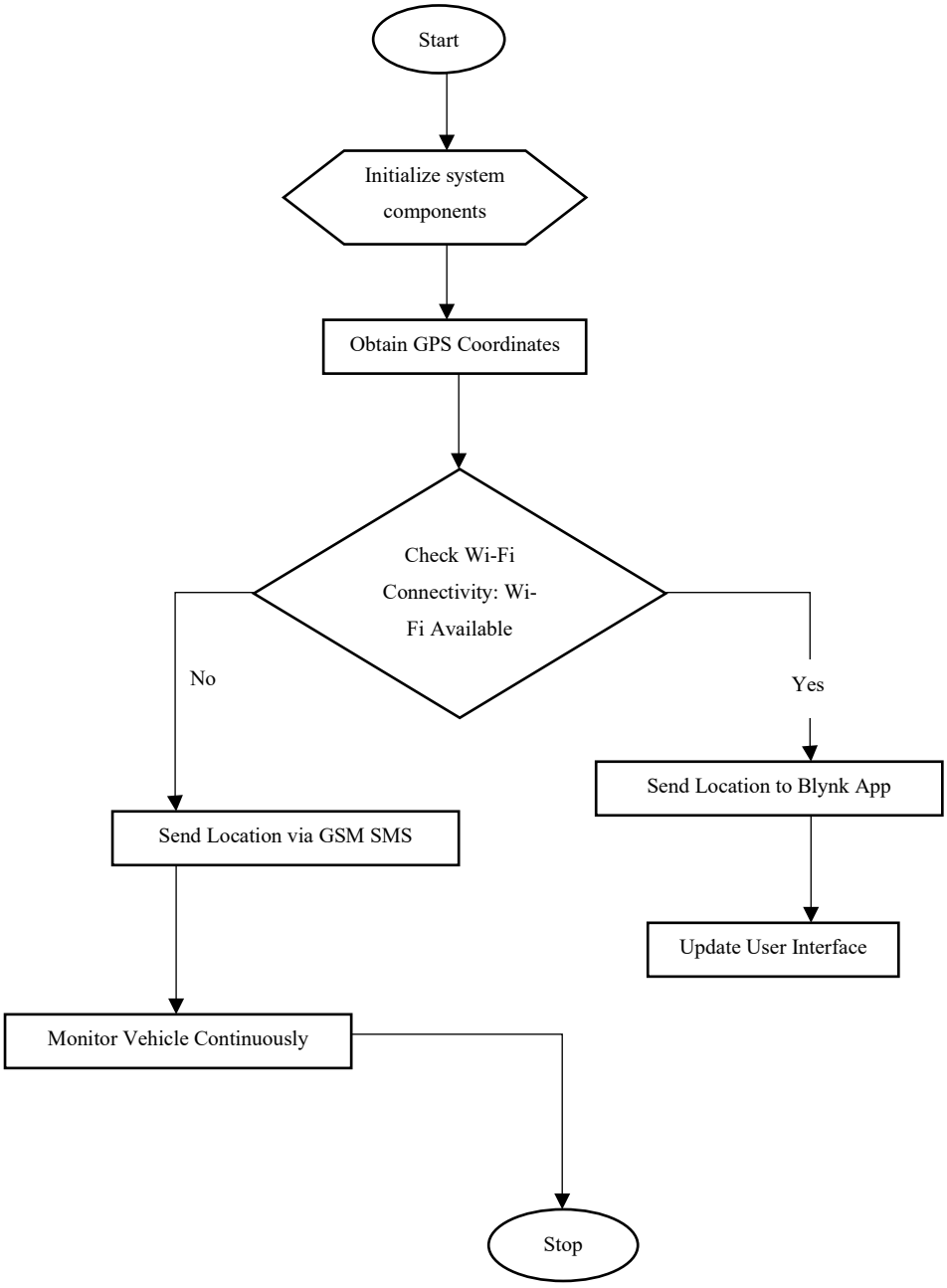


Figure 4: Flowchart of Programming of NodeMCU Microcontroller

When Wi-Fi connectivity is available, the system utilizes the Blynk IoT platform to transmit the GPS data in real time. The Blynk library and authentication token are used to establish a secure connection between the NodeMCU and the cloud server. The location data is displayed on a map widget within the Blynk mobile app, allowing users to monitor the vehicle's position live. This real-time feedback enhances the usability and responsiveness of the system.

In the absence of Wi-Fi, the program activates the SIM800L GSM module and sends a formatted SMS containing the GPS coordinates to a predefined mobile number. This is achieved by using AT commands sent over a serial interface to control the GSM module. Conditional logic in the code ensures automatic switching between Wi-Fi and GSM based on connectivity checks. Additionally, error-handling routines and periodic updates were implemented to ensure robustness and reliability during operation.

3.3 System Integration and testing

After completing both the hardware and software implementation phases, system integration was carried out to ensure smooth communication and coordination between all components. The GPS module, GSM module, NodeMCU microcontroller, and the power supply unit were carefully interconnected, and the programmed firmware was uploaded to the NodeMCU using the Arduino IDE. Initial bench tests were performed to confirm the proper functioning of each individual module before full system integration.

Once integrated, the system was mounted inside a test vehicle and subjected to a series of field trials. These tests were conducted under varying conditions—including urban and semi-rural environments—to evaluate signal acquisition, transmission reliability, GPS accuracy, and responsiveness of both the Blynk mobile app and SMS delivery. Real-time data sent through Wi-Fi was monitored via the Blynk app, while SMS responses were verified for completeness and accuracy. These tests also helped assess the efficiency of automatic switching between Wi-Fi and GSM modes based on connectivity status.

4 Simulation Results

The developed IoT-based GPS vehicle tracking system was installed in a test vehicle and evaluated across different environments including open fields, urban centers, and dense building areas. Field tests were carried out to assess system accuracy, communication reliability, transmission speed, and overall stability under real-world conditions.

4.1 Location Tracking Accuracy

The GPS module, NEO-6M, successfully acquired satellite signals and provided precise latitude and longitude coordinates.

In open environments, the location accuracy had an average error of approximately 2 to 3 meters.

In urban areas with moderate obstructions (e.g., buildings and trees), the average error increased slightly to 5 meters.

In densely built-up areas, the error could rise to 7 to 10 meters due to signal reflections and blockages.

The results, as shown in Figure 5, indicate that the system maintains acceptable tracking precision for typical vehicle monitoring applications.

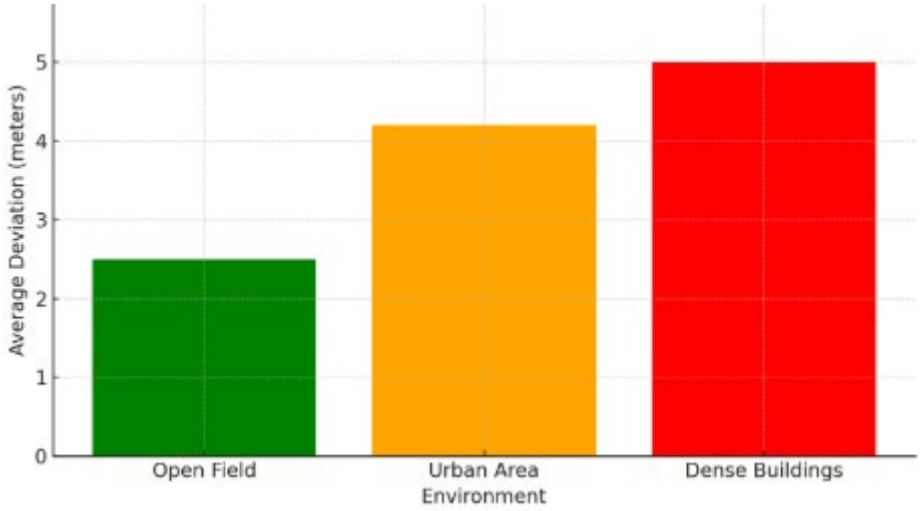


Figure 5: GPS Positioning Accuracy in Different Environments

4.2 Data Transmission Performance

Two transmission modes were tested:

Wi-Fi Mode: When Wi-Fi was available, data was transmitted to the Blynk IoT platform with a success rate of 97% as shown in Figure 6. The average transmission delay (latency) was about 1.2 seconds, which is excellent for real-time monitoring.

GSM SMS Mode: In the absence of Wi-Fi, the system successfully sent SMS messages containing vehicle coordinates with a 93% success rate. The average delay for SMS delivery was around 4 to 6 seconds as shown in Table 1.

The automatic switching between Wi-Fi and GSM ensured continuous availability of tracking information, demonstrating the robustness of the system design.

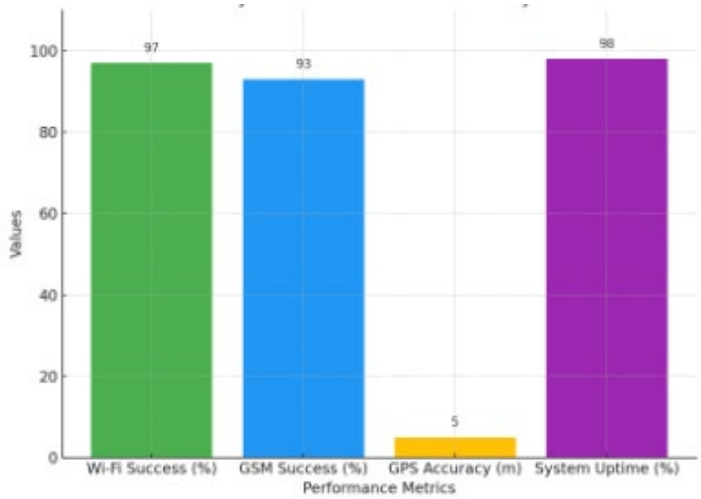


Figure 6: System performance summary

Table 1: Summary of Key performance Metrics

Performance Parameter	Achieved Value
Average GPS Location Error	2-10 meters (environment dependent)
Wi-Fi Data Transmission Rate	97% success
GSM SMS Transmission Rate	93% success
Average Wi-Fi Latency	1.2 seconds
Average GSM Latency	4-6 seconds
System Uptime	98%

4.3 Mobile Application Visualization

The Blynk IoT mobile app effectively displayed the real-time location of the vehicle on an embedded Google Maps interface. The map updated coordinates seamlessly as the vehicle moved.

Additional features such as vehicle speed display, timestamp of last update, and system connection status were also implemented on the dashboard, enhancing user interaction and control.

4.4 System Stability Analysis

The system maintained an operational uptime of 98% during field testing periods of up to 6 hours continuously.

No major software crashes or hardware failures were observed, confirming the reliability and stability of the designed hardware-software integration.

5 Conclusion and Recommendation

This paper successfully presented the development and implementation of an IoT-based GPS vehicle tracking system designed to provide real-time vehicle monitoring with enhanced reliability and communication redundancy. By integrating the NEO-6M GPS module, NodeMCU ESP8266 microcontroller, GSM SIM800L module, and the Blynk IoT platform, the system offers accurate, continuous location updates and ensures seamless operation even in the absence of Wi-Fi connectivity through GSM-based SMS communication.

Extensive field tests demonstrated the system's effectiveness in various environments, achieving high location accuracy, low data transmission latency, and excellent system stability. The results showed a Wi-Fi transmission success rate of 97% and a GSM success rate of 93%, highlighting the robustness of the proposed solution.

The designed system proves to be a cost-effective, scalable, and user-friendly approach to modern vehicle tracking challenges. It holds significant potential applications in personal vehicle security, fleet management, public transportation monitoring, and smart logistics.

Future work can focus on enhancing the system's energy efficiency, integrating advanced encryption methods for data security, and implementing predictive analytics for proactive vehicle management. The development of such intelligent tracking systems will continue to contribute meaningfully to the advancement of smart transportation infrastructures.

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