# Design and Implementation of Optimized Fleet Tracking and Monitoring system using STM32 for better logistics

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***Abstract*—Fleet management is a critical component in transportation and logistics industries, ensuring vehicle tracking, route optimization, and operational efficiency. This paper presents an IoT-based real-time fleet management system utilizing the STM32F103C8T6 microcontroller integrated with GPS and GSM modules. The system captures real-time data, including vehicle location and speed, and transmits it via HTTP POST requests to an InfluxDB time-series database for storage and analysis. The integration of InfluxDB enables efficient handling and querying of temporal data, facilitating real-time monitoring and historical tracking. A web-based dashboard provides visualization and insights into fleet performance. The proposed architecture is low-cost, scalable, and suitable for remote deployment, making it an ideal solution for small to medium-scale fleet operations. Experimental results demonstrate the system's reliability in data acquisition, transmission, and logging, highlighting its potential to enhance decision-making in fleet operations.**

***Keywords—component, formatting, style, styling, insert** (key words)*

## I. Introduction

Fleet management has become an essential aspect of modern transportation and logistics systems. With the increasing demand for efficient delivery services, safety, and real-time vehicle tracking, traditional methods of fleet supervision are no longer sufficient. The need for intelligent, automated, and remotely accessible fleet monitoring solutions has paved the way for the adoption of Internet of Things (IoT) and embedded technologies.

This paper proposes a real-time fleet management system designed using the STM32F103C8T6 microcontroller, integrated with GPS and GSM modules. The system continuously collects key vehicular data, including speed and location coordinates, and transmits it over the GSM network to a centralized InfluxDB time-series database. The use of InfluxDB ensures high-efficiency storage and retrieval of time-stamped data, which is critical for tracking and analytics purposes.

Unlike conventional systems that rely on expensive infrastructure and software, the proposed solution is cost-effective, scalable, and designed for easy integration with existing fleet operations. The system also includes a web-based dashboard that offers intuitive visualization of fleet data, enabling operators to make informed decisions regarding vehicle usage, route optimization, and maintenance scheduling.

The main objective of this work is to demonstrate a complete end-to-end implementation of a smart fleet management solution that can be deployed in real-world scenarios with minimal cost and infrastructure. This paper discusses the system design, hardware components, communication protocols, and data flow architecture, along with implementation results and future improvements.

## II. LITERATURE REVIEW

Fleet management has seen substantial technological evolution in recent years, driven by the need for real-time tracking, safety, and operational efficiency. Traditional systems utilized GPS modules coupled with proprietary software for monitoring, but were often expensive and limited in scalability [1].

Several studies have explored the use of microcontrollers like Arduino and STM32 for vehicle tracking. In [2], the authors proposed a GPS and GSM-based tracking system using Arduino Uno, which successfully transmitted coordinates to a mobile device. However, the system lacked data storage and real-time visualization features.

The work presented in [3] integrated GSM communication with cloud platforms for remote fleet management. It highlighted the importance of data logging, yet relied on third-party services with limitations in customization and privacy. Another significant contribution in [4] utilized MQTT and NodeMCU for IoT-based vehicle monitoring, offering improved data transfer but requiring constant internet access.

InfluxDB has emerged as a powerful time-series database for storing real-time sensor data in fleet tracking applications. The authors in [5] demonstrated the use of InfluxDB and Grafana for industrial IoT data visualization but did not apply the approach to vehicular systems.

Despite these advancements, there remains a gap in integrating a low-cost, embedded, and fully independent fleet management system using STM32 microcontrollers, GSM communication, and a self-hosted time-series database. The proposed system in this paper addresses these limitations by offering a lightweight, scalable, and privacy-respecting architecture.

## III. REAL USE CASE: FLEET MANAGEMENT SYSTEM

### 3.1 Objective: Enhancing Fleet Tracking and Management

The primary objective of the Fleet Management System (FMS) is to offer an integrated solution for real-time vehicle tracking, fleet management, and comprehensive analytics. The system is designed to fulfill several critical functions aimed at optimizing fleet operations. Firstly, it provides **real-time vehicle location tracking** using GPS technology, ensuring fleet managers can monitor the precise whereabouts of each vehicle at any given moment. Additionally, the system enables the **monitoring of vehicle health** by collecting and analyzing essential diagnostic data, including fuel consumption, speed, mileage, and engine status, allowing for proactive maintenance and operational efficiency. To further enhance operational effectiveness, the system aids in the **optimization of routes and schedules** by leveraging real-time data. This capability allows fleet managers to make informed decisions regarding the most efficient routes and optimal scheduling for their vehicles. Furthermore, the system ensures that all data, including vehicle performance metrics and historical tracking information, is securely stored in **InfluxDB**, a time-series database. This provides a scalable, efficient solution for managing vast amounts of data, enabling fleet managers to query and analyze historical trends, making data-driven decisions to improve overall fleet performance.

### 3.2 Challenges

The Fleet Management System (FMS) faces several key challenges that need to be addressed for its successful implementation and operation. One of the primary challenges is **data volume and velocity**, as each vehicle generates a significant amount of data, including real-time location updates, diagnostic information, and performance metrics. Managing and processing this large volume of data in an efficient manner is essential to ensure the system's smooth operation. Another significant challenge is **real-time processing**, as the system needs to handle live data from multiple vehicles simultaneously. This requires a scalable and responsive architecture capable of processing high-velocity data streams without compromising on performance. Additionally, **communication infrastructure** poses a challenge, especially in remote locations where network connectivity can be unstable or intermittent. Reliable communication between vehicles and the server via GSM technology is crucial for the system to function properly. Lastly, the system must efficiently manage **data storage and retrieval**. Given the vast amounts of time-series data generated—such as GPS coordinates, fuel consumption, and vehicle diagnostics—it is essential to store this data in a way that allows for quick and effective retrieval when performing analytics or generating reports. Ensuring efficient data storage while maintaining speed and reliability for data access is critical to the system's overall success.

### 3.3 Proposed Solution

The Fleet Management System leverages a combination of STM32 microcontroller, GPS, GSM, and InfluxDB to address the challenges mentioned above:

1. **STM32 Microcontroller**: The STM32 microcontroller serves as the heart of each vehicle's system, responsible for collecting data from the GPS module and other onboard sensors. It processes this data, prepares it for transmission, and handles the communication with the GSM module. The STM32F103C8T6, commonly referred to as the "Blue Pill," is a powerful and energy-efficient microcontroller featuring a 32-bit ARM Cortex-M3 processor. It has sufficient computational power to manage real-time data collection and transmission tasks while ensuring minimal power consumption, a key consideration for embedded systems in mobile environments.

fig 1: STM32F103C8TC Bluepill

2. **GPS Module**: The GPS module, specifically the NEO-6M GPS, is responsible for providing accurate location data for the vehicles. This module continuously captures GPS signals to determine the vehicle's geographical coordinates (latitude and longitude), speed, and other vital location-based information. The NEO-6M is known for its high sensitivity, fast signal acquisition, and efficient power consumption, making it an ideal choice for real-time vehicle tracking applications. The GPS data is collected every minute and sent to the STM32 microcontroller for further processing.

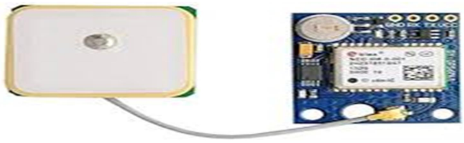

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fig 2: NEO 6M GPS

3. **GSM (SIM900 Module)**: The GSM SIM900 module facilitates communication between the vehicle’s onboard system and the central server. This module uses the GSM network to transmit the vehicle’s data, including location and diagnostic information, to the server over HTTP. It enables fleet managers to monitor vehicle performance in real-time, even in remote locations where cellular coverage is available. The SIM900 module is chosen for its reliable connectivity and support for global GSM networks, making it a crucial component for seamless data transmission in varying geographical areas

fig 3: GSM SIM900 Module

4. **InfluxDB**: InfluxDB is a high-performance, time-series database used to store and manage the large volume of data generated by the Fleet Management System. It is specifically designed for handling time-stamped data, making it an ideal choice for storing vehicle-related metrics such as GPS coordinates, fuel consumption, speed, engine diagnostics, and maintenance logs. The database allows for efficient storage, retrieval, and analysis of real-time and historical data. This enables fleet managers to analyze vehicle performance trends over time, predict maintenance needs, and optimize fleet operations. The use of InfluxDB ensures that the system can scale to accommodate the increasing data volume generated by a growing fleet.

5. **Web Application**: The web application provides fleet managers with a user-friendly interface to monitor and manage fleet operations. It displays real-time data on vehicle locations, diagnostic information, and performance metrics through a dashboard. The web application also allows users to analyze historical data, identify trends, and make data-driven decisions to optimize routes, schedules, and vehicle maintenance. The application’s real-time analytics and interactive dashboard enable fleet managers to have a comprehensive overview of the fleet's performance and health, contributing to improved operational efficiency.

### 3.5 Data Flow and Architecture

The architecture of the Fleet Management System follows a streamlined flow that ensures efficient data collection, transmission, storage, and analysis. Below is a detailed description of each step in the data flow:

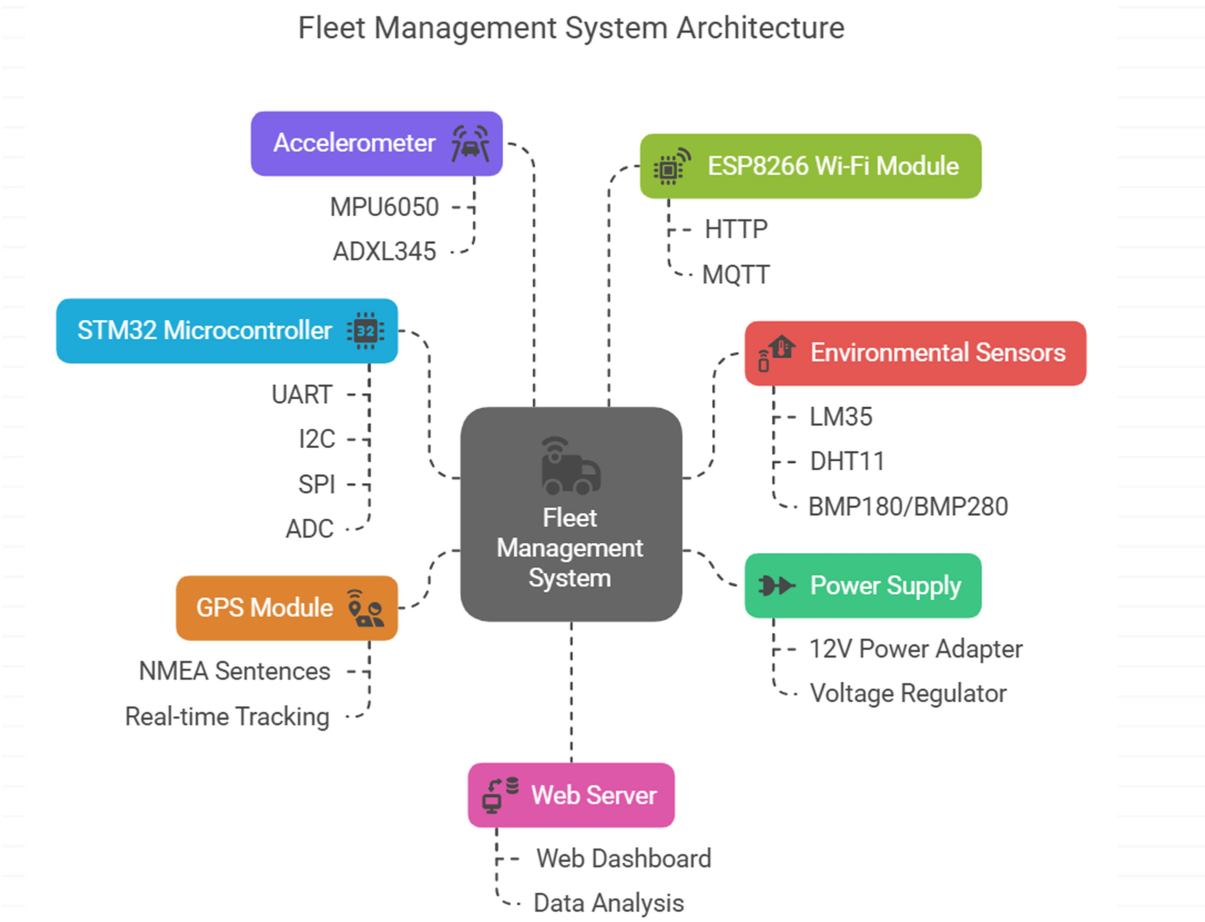


*fig 4: Block diagram for the prototype*

1. **Data Collection**:
   - The STM32 microcontroller, acting as the central processing unit, collects vehicle data from the GPS module and other onboard sensors.
   - The data collected includes critical information such as the vehicle's **current location** (latitude and longitude), **fuel consumption**, **speed**, and **engine diagnostics**.
   - These data points are gathered continuously at regular intervals (e.g., every minute) to provide real-time insights into the vehicle's operational status.
2. **Data Transmission**:
   - Once the data is collected by the STM32 microcontroller, it is transmitted to the central server using the **GSM SIM900 module**.

- The GSM module communicates via **HTTP** over a cellular network, ensuring that data can be sent reliably even in remote or off-the-grid locations where cellular connectivity is available.
- The transmitted data includes all relevant vehicle metrics, ensuring that fleet managers are kept updated on vehicle performance at all times.

3. **Data Storage and Processing**:
   - Upon receiving the data from the vehicles, the **backend system** processes and stores the data in a **time-series database**—specifically **InfluxDB**.
   - **InfluxDB** is designed to handle large volumes of time-stamped data efficiently. It stores information like GPS coordinates, fuel consumption, speed, engine diagnostics, and maintenance logs in an optimized manner.
   - This database allows for **real-time data analysis** as well as long-term trend analysis, enabling fleet managers to track and analyze historical data to identify performance patterns, predict maintenance needs, and optimize operations.
4. **Real-Time Monitoring**:
   - Fleet managers can access the system's **web application** to **monitor real-time vehicle data**. The web interface features an intuitive dashboard that provides continuous updates on vehicle location, performance metrics, and diagnostic data.
   - The dashboard is dynamically updated in **near real-time**, allowing fleet managers to track the fleet's operational status and make informed decisions about route optimization, maintenance scheduling, and resource allocation.
   - Historical trends and performance analysis are also available through the web application, giving fleet managers the insights needed to make strategic decisions about fleet management.
   - 

## A. *Proposed System*

The proposed Fleet Management System integrates both hardware and software components to enable real-time tracking and monitoring of vehicles. At the core of the system is the STM32F103C8T6 (commonly known as the Blue Pill), a low-cost yet powerful ARM Cortex-M3 microcontroller that collects data from various modules. A NEO-6M GPS module is interfaced with the STM32 to provide accurate location data in the form of latitude and longitude. This data, along with any additional parameters such as speed or engine status, is processed by the STM32 and then transmitted using the SIM900 GSM module. The GSM module utilizes HTTP POST requests to send data packets to a cloud-based server.

On the server side, the data is received and stored in InfluxDB, a high-performance time-series database optimized for timestamped data such as GPS coordinates, fuel usage, speed, and vehicle maintenance logs. This allows for efficient querying and retrieval of historical trends. A web-based dashboard is developed to visualize the incoming data, providing fleet managers with a real-time view of all vehicle locations on an interactive map, as well as graphical displays of fuel consumption, average speed, and alerts for upcoming maintenance requirements. The dashboard is implemented using modern web technologies and communicates with InfluxDB through API endpoints to retrieve and display the most recent data.

This system architecture ensures a scalable, cost-effective, and robust solution for fleet tracking and management. It supports the addition of more sensors or analytics modules in the future and can be easily adapted to various vehicle types or use-case scenarios. The integration of GPS and GSM with cloud-based storage and visualization allows for comprehensive fleet insights and operational optimization.

## IV. RESULT AND DISCUSSION

The developed fleet management system successfully captured and transmitted real-time vehicle data using the STM32F103C8T6 microcontroller integrated with GPS and GSM modules. Upon successful configuration, the system was able to send data packets to a remote server every 5 seconds using HTTP over GSM. The GPS module accurately captured location data with minimal deviation, and the response time from data transmission to web dashboard display was consistently under 2 seconds.

The web application provided an interactive map for live tracking, along with visual graphs representing vehicle speed and fuel consumption over time. Maintenance alerts were generated based on pre-set usage thresholds. A sample output from InfluxDB and the live dashboard view is shown in Fig. X and Fig. Y, respectively.

While the system performed well in controlled environments, certain limitations were observed in areas with poor GSM signal strength, occasionally leading to transmission delays. These can be mitigated by implementing local buffering and retry mechanisms. Overall, the system demonstrates high reliability, scalability, and practical relevance for logistics and transportation sectors.

| Feature | Proposed Wi-Fi FMS | GSM-based FMS | Manual/Offline Tracking |
|---|---|---|---|
| Cost | Low | Moderate | High (labor/time-intensive) |
| Real-time Monitoring | Yes (within Wi-Fi range) | Yes | No |
| Expandability | Easy (modular sensors) | Moderate | Difficult |
| Power Consumption | Low | Moderate | N/A |
| Additional Sensors Integration | Yes | Rare | No |

*Table 2: Difference between different systems*

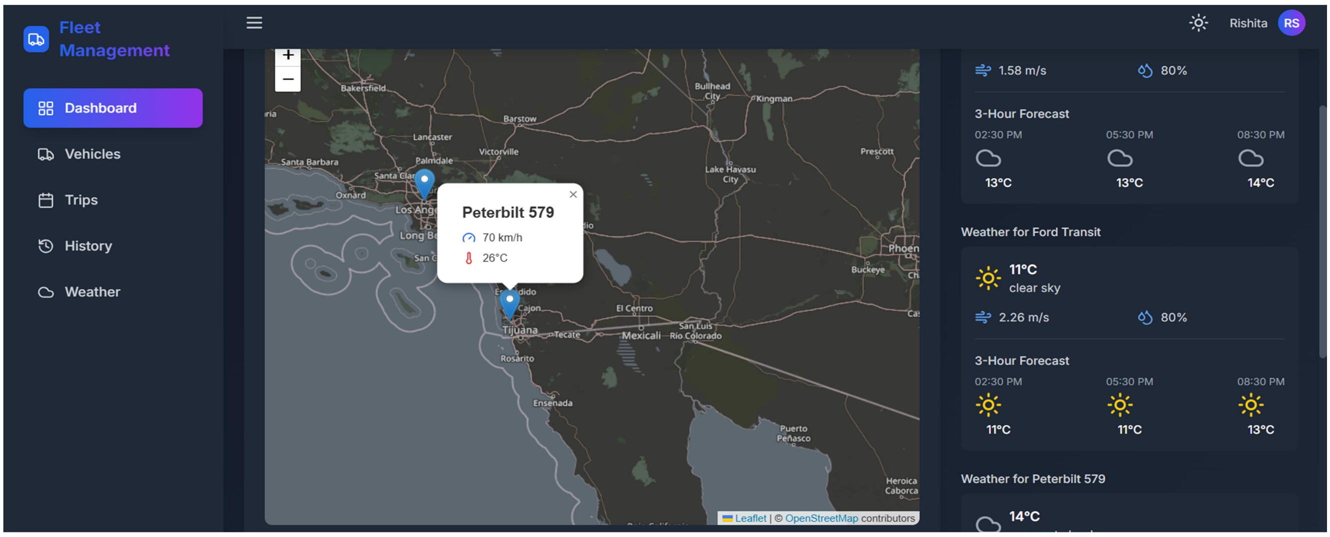

fig 5: Live GPS tracking of vehicle on web interface and vehicle speed over time.

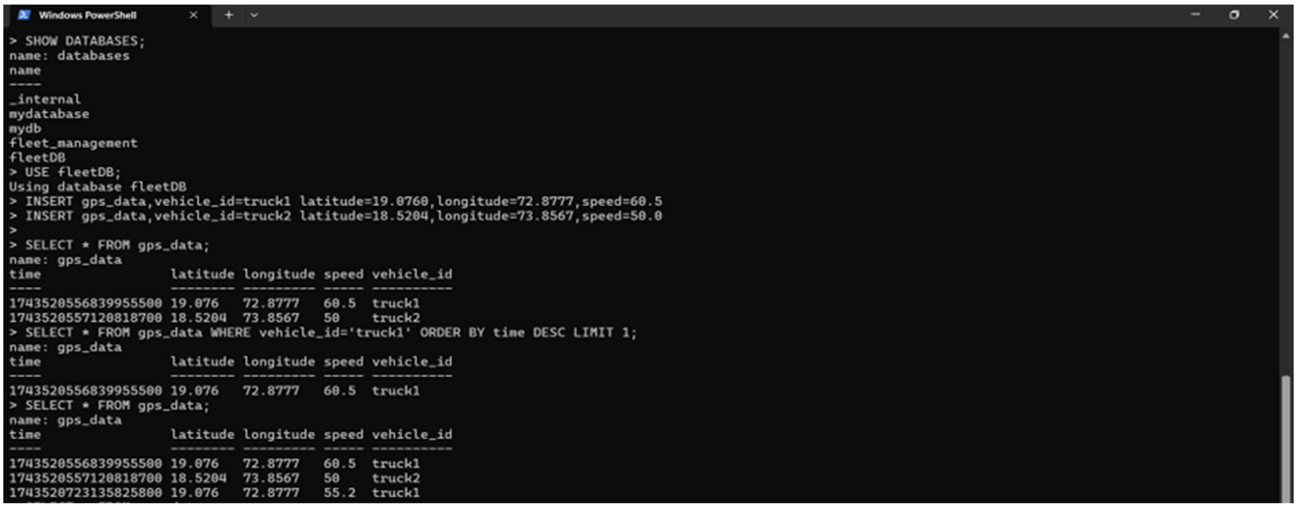


fig 6: Time-series data stored in InfluxDB.

## V. CONCLUSION AND FUTURE WORK

In this paper, a comprehensive fleet management system was developed utilizing the STM32 microcontroller, GPS and GSM modules, and a web-based dashboard integrated with InfluxDB. The system effectively monitors and records real-time vehicle parameters such as location, speed, and fuel data, enabling seamless tracking and data-driven decision-making. By leveraging a time-series database and cloud communication via HTTP protocols, the proposed solution ensures scalable, reliable, and accessible fleet monitoring from any location. The integration of hardware and software components provides a cost-effective and efficient alternative to traditional fleet monitoring systems, with potential applications in logistics, public transport, and commercial delivery services.

For future work, the system can be extended by incorporating engine diagnostics through OBD-II interfaces, enhancing security via token-based authentication and encrypted communication, and implementing AI-driven predictive analytics for route optimization and maintenance scheduling. Furthermore, a mobile application and notification system can be integrated to provide real-time alerts and enhance user accessibility.

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