



Muhammad Hamza

23-NTU-CS-1186

Hassan Ali

23-NTU-CS-1036

Hafiz M. Zarar

23-NTU-CS-1030

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TrackMate

University Bus Tracking System

Problem Statement

At present, National Textile University (NTU), Faisalabad does not have any automated or digital system to track the real-time location of its university buses. Students rely on estimated timings, manual coordination, or personal judgment to reach bus stops, which often leads to inconvenience, missed buses, and unnecessary waiting, especially during peak hours, traffic congestion, or unexpected delays.

Since there is no centralized system to monitor bus movement, students and university administration have no visibility into whether a bus is moving, stopped, or delayed due to traffic. This lack of real-time information reduces efficiency and affects the overall transportation experience within the university.

Therefore, there is a strong need for a dedicated university bus tracking system for NTU that can provide live bus location, route visualization, and bus status information in a simple and accessible manner.

Objectives

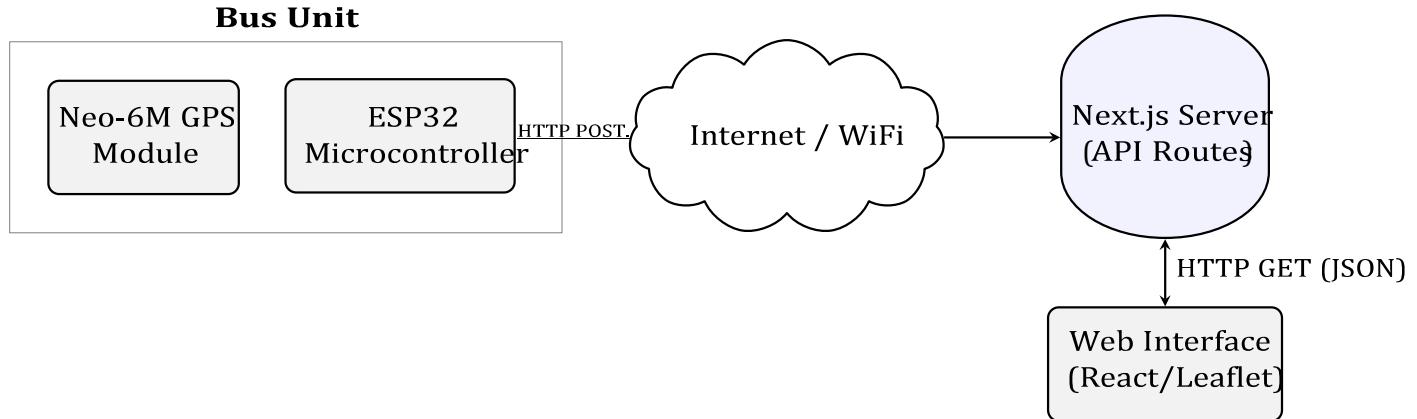
- To design and develop a real-time tracking system specifically for NTU buses
- To track the live location of a university bus using GPS technology
- To visualize NTU bus routes and stops on a digital map
- To determine the real-time status of the bus (moving, stopped, or in traffic)
- To build a scalable system that can later be expanded to include multiple NTU buses

System Architecture / Block Diagram

The TrackMate system follows a client-server architecture. An ESP32 microcontroller connected with a Neo-6M GPS module collects real-time latitude and longitude data. This data is sent to a backend server built using Next.js via HTTP requests. The backend processes and stores the data and exposes APIs. A web-based frontend consumes these APIs to display the bus location, route, and stops on an interactive map.

System Architecture Diagram

The architecture diagram illustrates the hardware-to-software ecosystem, highlighting the transition from NMEA data to web-based JSON visualization.



Main Components

- ESP32 + Neo-6M GPS Module
- Backend Server (Next.js API)
- Web Frontend (Map Interface)
- Internet / Wi-Fi Network

Hardware and Software Description

Hardware Components

ESP32 Microcontroller:

Used for processing GPS data and sending it to the backend server via Wi-Fi.

Neo-6M GPS Module:

Provides real-time geographical coordinates (latitude and longitude) of the bus.

(Currently, only one ESP32 and one GPS module are used, representing one university bus.)

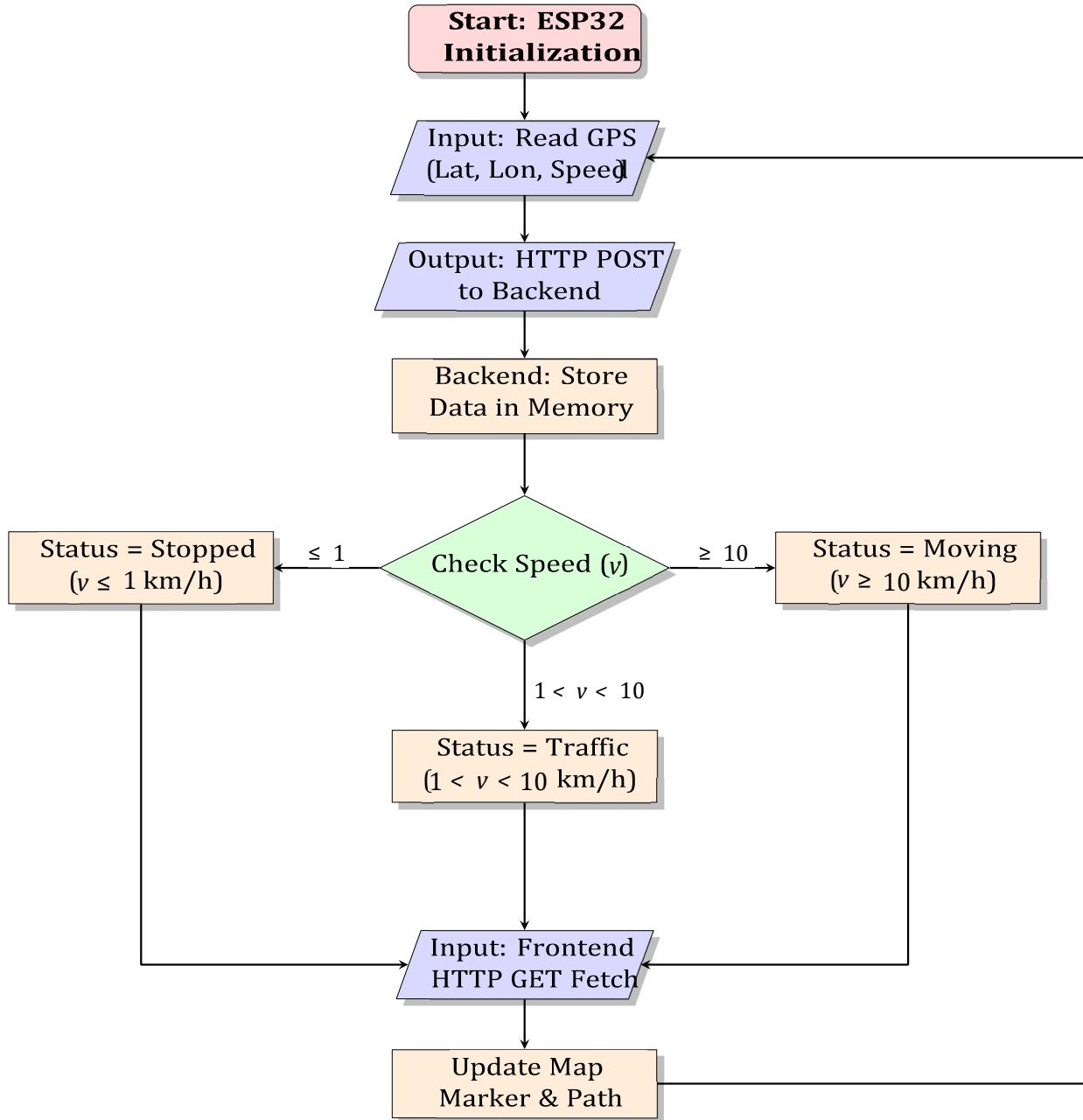
Software Components

- Next.js (JavaScript): Used for backend API development and frontend integration.
- Node.js: Runtime environment for executing the server.
- Leaflet (Map Library): Used for displaying routes, stops, and live bus location on the map.

Methodology and Flowchart

Operational Flowchart

This flowchart details the step-by-step logic of the tracking system, from hardware initialization on the bus to real-time visualization on the web interface.

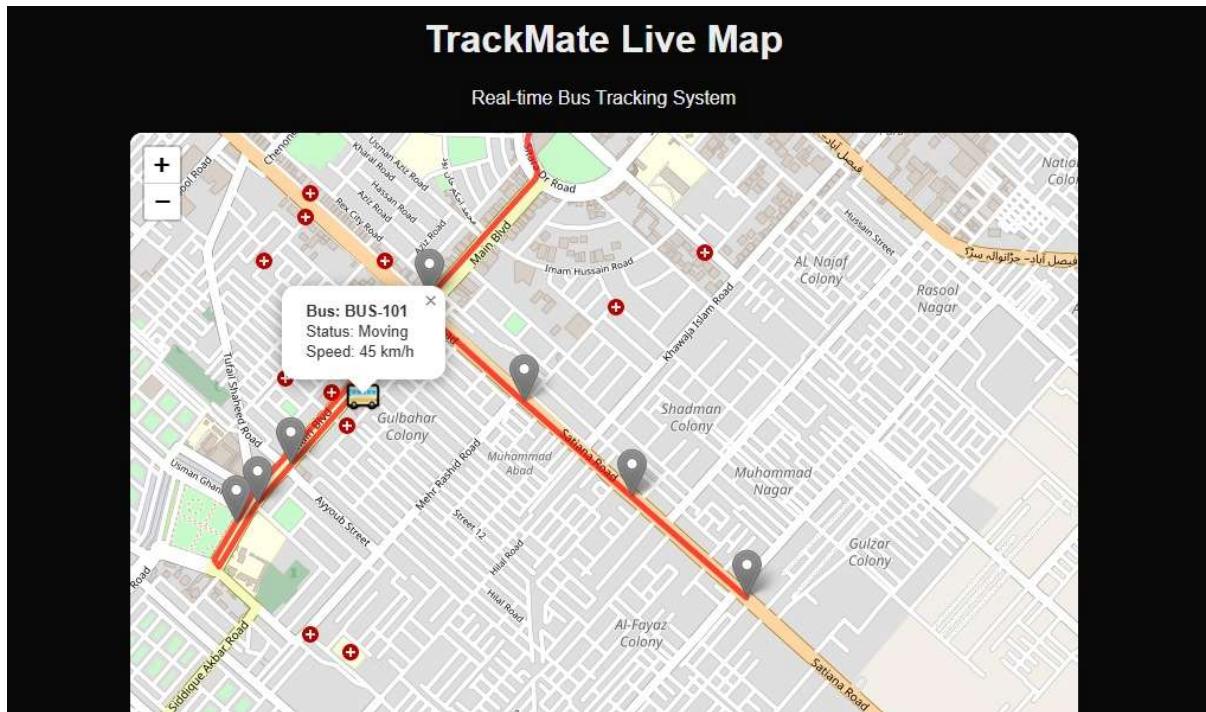


Methodology

- The GPS module continuously reads the bus location.

- ESP32 processes the GPS data and sends it to the backend server using HTTP POST requests.
- The backend stores the received data in memory and calculates the bus status based on speed.
- The frontend fetches the latest bus data using GET requests.
- The live bus location, route, and stops are displayed on the map interface.

Screenshots of Output and Dashboards



Results, Conclusion, and Future Scope

Results

The TrackMate system successfully tracks the real-time location of a university bus and displays it on a digital map. The system accurately identifies the bus status and visualizes routes and stops clearly. The backend APIs function reliably and respond correctly to incoming GPS data.

Conclusion

TrackMate provides an effective solution to the problem of university bus tracking. It eliminates uncertainty for students and demonstrates the practical integration of

IoT, web technologies, and real-time data processing. The project also serves as a strong foundation for building scalable transportation monitoring systems.

Future Scope

- Integration of multiple buses with unique bus IDs
- Addition of GSM module for mobile data communication
- Real-time notifications for students
- Bus arrival time prediction
- Admin dashboard for route and stop management
- Mobile application for Android and iOS