REAL-TIME ASSET TRACKING AND MONITORING VIA WEBSITE

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ABSTRACT

The Internet of Things (IoT)-based Asset Tracking System is a leading-edge system for monitoring and managing assets in real time. The solution delivers seamless location tracking using IoT-based devices and GPS technology, assuring security and effective use of important resources. This paper describes the use of an ESP32 microcontroller, GSM connection, and a GPS module to gather and communicate asset data to a centralised web platform. Users can access asset information via a web or mobile interface, allowing for more informed decisions and operational transparency. The system is suitable for applications such as personal use, logistics, supply chain management, and industrial asset monitoring. This IoT-based solution improves operational efficiency while lowering the risk of asset loss or mismanagement by providing efficient asset tracking and management.

BACKGROUND

For many companies, being able to track things like vehicles, equipment, or even packages is vital. The standard approaches often require a lot of manual labor, or only basic GPS units that are ineffective since they aren't able to provide timely and informative updates.

The Internet of Things provides an innovative approach to the monitoring of assets and management on a general level. In the simplest terms, IoT provides the ability to devices equipped with sensors to retrieve and transmit information such as where the object is, what the current temperature of that object is, or whether the object is static or in motion. These devices are integrated with Wi-Fi, Bluetooth, mobile data and other similar networks for quick exchange of information even at far distances.

An IoT-enabled asset tracker allows businesses to manage their assets in real-time while preventing their loss or theft and enhancing operations. It integrates technologies including GPS, cloud, and smartphone applications to ensure efficient monitoring of assets. Transport, warehouses, health care and many other industries can use this system.

EVALUATING SOLUTIONS

For robust and scalable real-time asset tracking and monitoring, cloud-based solutions like Google Cloud IoT Core, AWS IoT Core, and Microsoft Azure IoT Hub offer comprehensive platforms for device management, data ingestion, and analysis. These solutions provide reliable and secure communication channels between IoT devices and cloud applications, enabling real-time data streaming, processing, and visualization.

Alternatively, open-source solutions like ThingsBoard and Node-RED offer flexible and cost-effective options for building custom IoT applications. ThingsBoard, in particular, provides a comprehensive data collection, processing, and visualization platform, while Node-RED offers a low-code programming approach for building IoT applications quickly and efficiently.

The choice between cloud-based and open-source solutions depends on various factors, including the scale of the project, the level of customization required, and the desired level of security and reliability. Cloud-based solutions are generally more suitable for large-scale projects with high security and scalability requirements. In contrast, open-source solutions are more appropriate for smaller-scale projects or those requiring specific customizations.

HARDWARE DESCRIPTION

The asset tracking system is built using several key hardware components, each playing a crucial role in its functionality. The *U-Blox NEO-6M GPS Module* provides accurate real-time location data essential for tracking the position of assets. The *6DOF Accelerometer Gyroscope GY-521 MPU-6050* adds motion and orientation sensing, allowing the system to detect movement or sudden changes in position. For wireless communication, the *ESP32 for Wemos D1 Mini WiFi Bluetooth Development Board* offers both WiFi and Bluetooth capabilities, enabling seamless data transmission to connected devices. The *SIM900A Module 5V* allows for GSM/GPRS communication, ensuring that the system can send and receive data via mobile networks, even in areas without WiFi. Powering the entire system is a *Lithium-Ion 3.7 Volt Rechargeable Battery, providing long-lasting energy, while the **L7806Cv Linear Voltage Regulator* ensures that the components receive a stable 6V supply, protecting them from voltage fluctuations. Together, these components form a compact, efficient, and versatile asset tracking solution suitable for real-time monitoring and management of assets in various industries.

SOFTWARE DESCRIPTION

The software for the IoT-based tracking device is designed to process, display, and enhance location data collected by the ESP32 microcontroller. The ESP32 retrieves latitude and longitude coordinates from a GSM module and sends them to a web server via HTTP POST requests. The server-side logic, implemented using PHP, handles incoming POST requests, extracts the location data, and updates a JSON file, which serves as a lightweight database for storing the latest location coordinates. On the client side, the website is developed using HTML, CSS, and JavaScript, with Google Maps API integrated into the front-end interface. JavaScript fetches the updated location data from the JSON file at regular intervals and dynamically updates the map marker on the Google Map interface to display the real-time location of the tracking device. The system also requests the user's location permissions via the browser to calculate the distance between the user and the tracked device. This distance is displayed on the interface in real-time, providing users with additional context. Furthermore, a speed calculation feature is implemented to estimate the velocity of the tracked device by analyzing changes in location over time. This comprehensive integration of features ensures real time tracking, distance measurement, and speed estimation, providing users with a robust and interactive solution for monitoring the movement of the device. The modular and efficient design makes it scalable for various IoT applications.

-- Technologies Used
-Frontend : HTML, CSS, JavaScript
- Backend : PHP
-APIs : Google Maps API, Geolocation API
-Data Format: JSON

Hardware Connection

IoT-based asset tracking system integrates several key components, as shown in the circuit diagram. The ESP32-S2 microcontroller serves as the central unit, responsible for processing and managing the communication between the different modules. The GPS module (U-Blox NEO-6M) is connected to the ESP32 via UART communication. Specifically, the TX pin of the GPS module is connected to the RX pin (GPIO16) of the ESP32, and the RX pin of the GPS is linked to the TX pin (GPIO17) of the ESP32, enabling the retrieval of real-time location data.
The GSM module (SIM900A) is connected to the ESP32 through another UART interface. The TX pin of the GSM module is connected to the RX pin of the ESP32, while the RX pin of the GSM module is connected to the TX pin of the ESP32, allowing two-way communication. This GSM module facilitates data transmission over cellular networks to send GPS coordinates or other tracking data to a cloud server or mobile application.The entire system

is powered by two 18650 lithium-ion batteries, which provide a stable 3.7V supply to the ESP32 and connected modules. These batteries are connected to the VIN and GND pins of the ESP32 to power the microcontroller, while the GSM and GPS modules are powered directly from the 5V output of the ESP32, ensuring sufficient power for all components. This configuration ensures that the system remains efficient, compact, and capable of providing real-time tracking with reliable communication.

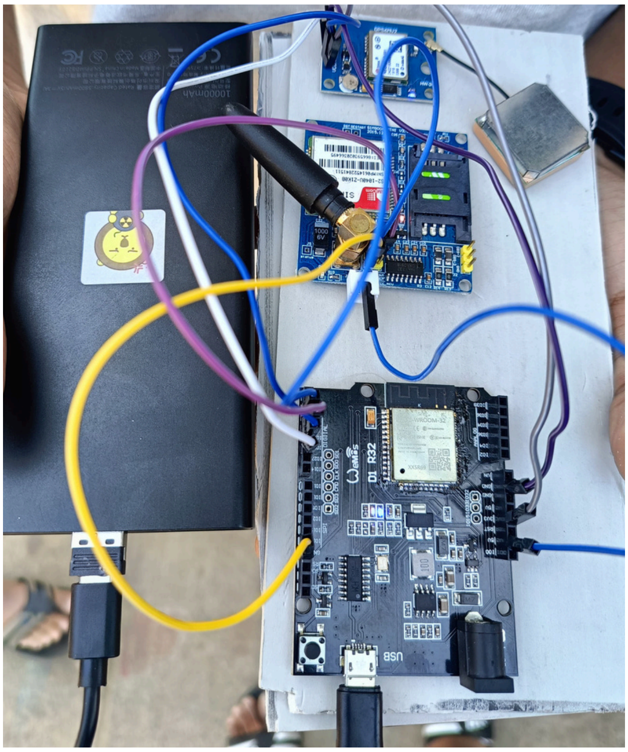


Fig 1: Hardware Outlook

Circuit Diagram

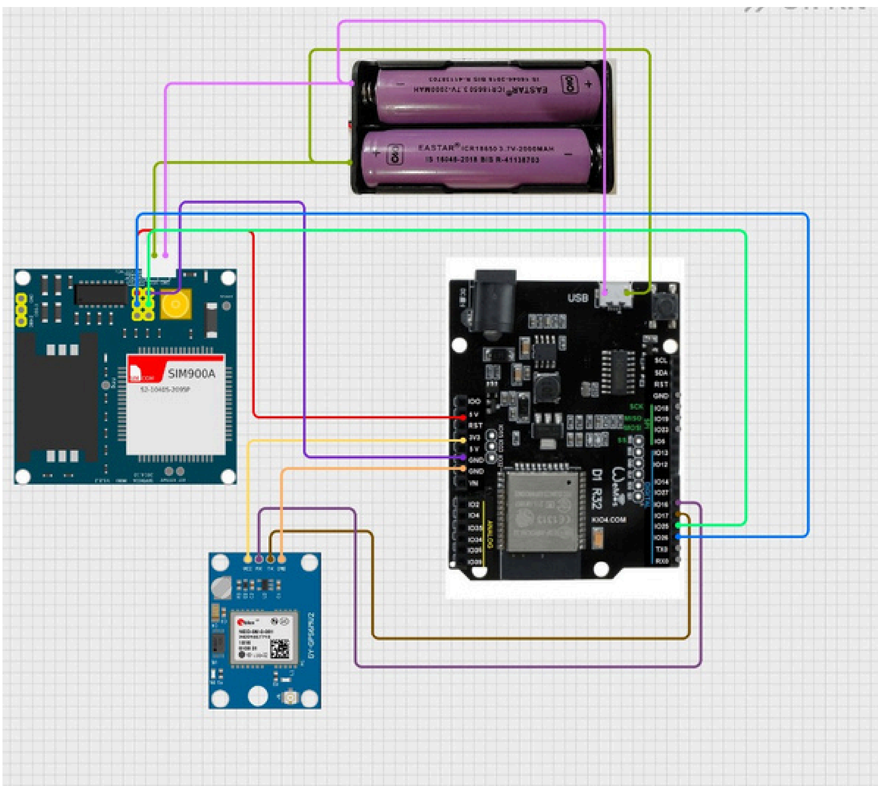
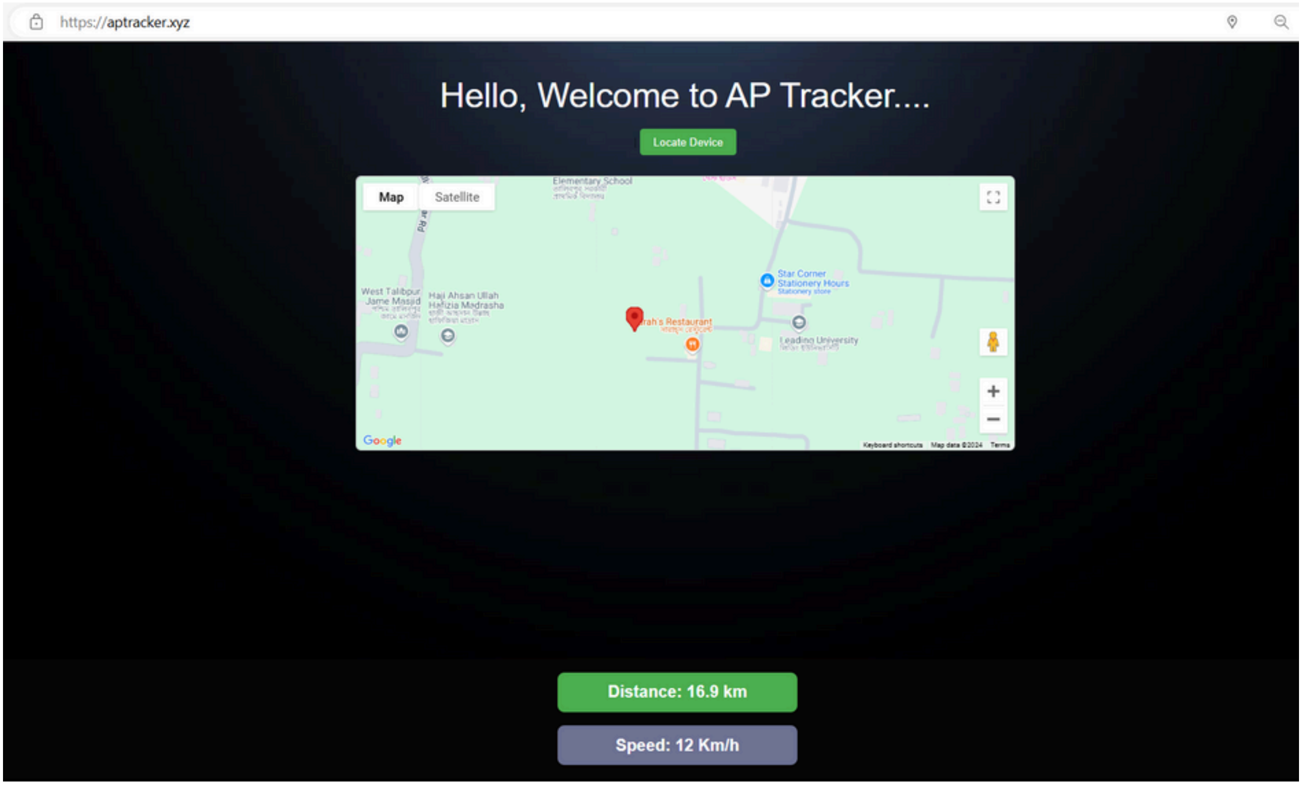


Fig 2: Circuit Diagram

MAP DISPLAY



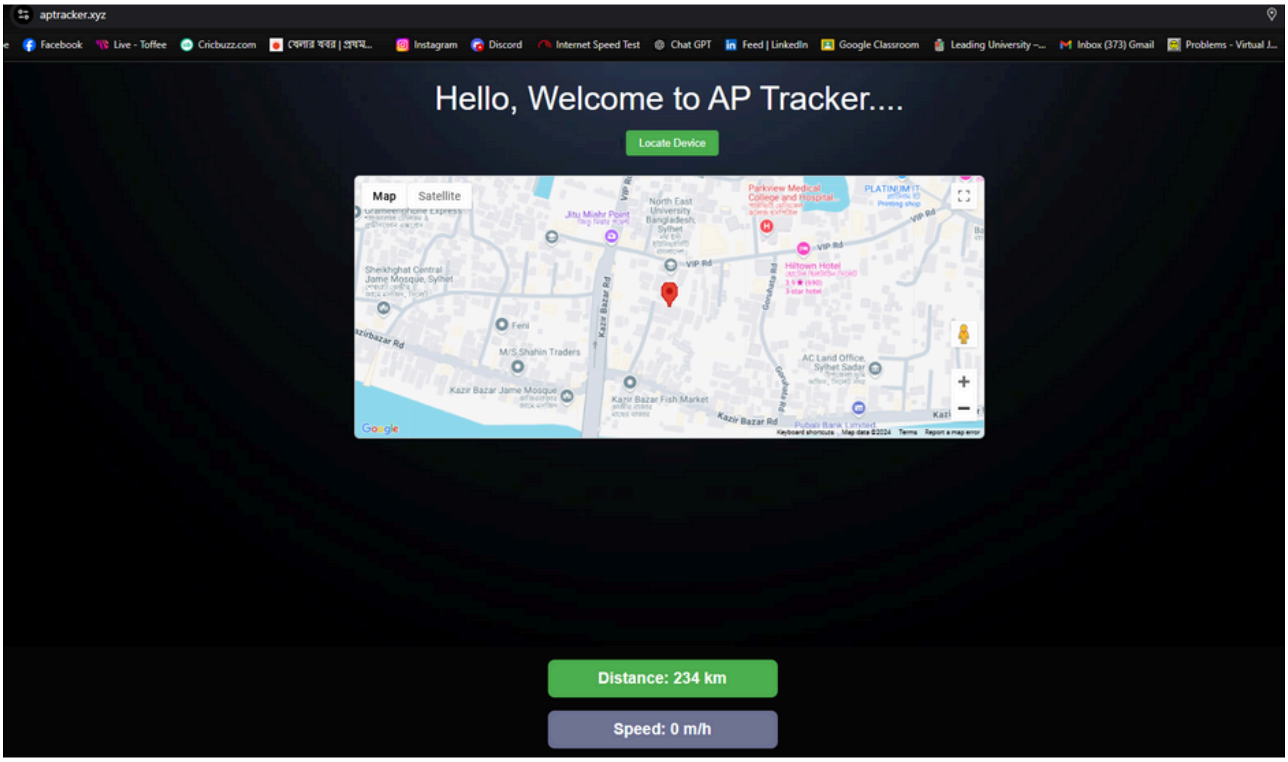


Fig 3: Map Dispaly

System Workflow

Start
Begin the process here,initiating the flow of operations within the IoT Asset Tracker system.

Initialize GPS
Start the NEO-6M GPS module to collect location data.The GPS module locks on satellite for accurate positioning

Collect Location Data
The system gathers real time location data from the GPS module for asset tracking processes.

Send Data to GSM
Use the SIM900A module to transmit location data to a designated server for processing.

Process Data
The server processes the received data, determining the asset’s location & status based on the input.

Display to Website
Utilize the google maps API to visualize the asset’s location on a web interface, making it accesible to users.

SYSTEM DEPLOYMENTS AND COSTS

The IoT-based asset tracking system was developed using a cost-effective combination of hardware components and web services, with a total implementation cost of 3690 BDT, making it accessible for resource-constrained applications. At the core of the system lies the U-Blox NEO-6M GPS module (620 BDT), which accurately captures real-time geographic coordinates, including latitude and longitude, enabling precise location tracking. The ESP32 Wroom DA WiFi Bluetooth Development Board (890 BDT) functions as the central processing unit, efficiently managing data collection from the GPS module while also facilitating communication with the GSM module. For reliable data transmission, the SIM900A Mini GSM Module (1050 BDT) is used to send asset location data securely over mobile networks to the backend server. Powering the entire system is a Lithium-Ion battery (600 BDT), which ensures portability and continuous operation, making the device suitable for field deployment. To streamline hardware connections, jumper wires (50 BDT for 10 pieces) were employed, allowing for seamless integration of components during the system's prototyping and deployment phases.

In addition to the hardware, the system features a web-based tracking platform that provides real-time monitoring capabilities. The platform was built using a custom domain, “aptracker” (230 BDT), and hosting services from XYZ (250 BDT), allowing users to access the dashboard through a browser. This interactive interface, powered by Google Maps API, enables users to monitor the asset’s real-time location, calculate its velocity, and determine its distance from user. By combining affordable hardware with scalable software, the system delivers a reliable and practical solution for real-time asset tracking, with potential applications in logistics, fleet management, and asset security. This cost-efficient architecture demonstrates the viability of IoT-based solutions for addressing asset monitoring challenges in diverse environments.

FUTURE DEVELOPMENTS

IoT-based Asset Tracking Systems possess significant scalability and innovation potential. Future advancements may involve integrating sophisticated machine learning algorithms to enable predictive asset tracking and optimize management. By analyzing historical movement patterns and usage data, the system could anticipate potential issues like misplacement or theft, allowing for proactive interventions. Expanding sensor integration is crucial. Beyond location, sensors could monitor motion, enhancing the system's ability to ensure the safety and functionality of critical assets, particularly valuable in sectors like logistics and healthcare. Battery optimization remains paramount, requiring research into energy-efficient hardware and intelligent power management algorithms to extend operational lifespans. Solar power integration or energy harvesting mechanisms could further minimize reliance on manual recharging or battery replacements. The user interface should evolve to offer more interactive and customizable features, such as dynamic geofencing, AI-driven alerts, and multilingual support. Expanding platform compatibility to include smartwatches and voice assistants would enhance user experience. Finally, robust data security is essential as the system scales. Implementing advanced encryption, blockchain technology for tamper-proof data records, and stringent user authentication protocols will bolster the system's reliability and trustworthiness. These advancements aim to establish the IoT-based Asset Tracking System as a versatile, secure, and future-proof solution for asset management.

Limitation and Challenges

IoT-based asset tracking systems significantly improve real-time monitoring and resource management. They do, however, present a number of limitations and challenges that must be addressed in order for widespread adoption and seamless operation.

Connectivity Issues: Reliable network connectivity is critical for IoT devices. However, in remote or densely populated urban areas, ensuring consistent cellular or Wi-Fi coverage can be difficult, resulting in data transmission delays or loss. Furthermore, in rural areas, the network is poor, resulting in connectivity issues.

Power Consumption: IoT devices rely on batteries to function, particularly in mobile applications. The limited capacity of batteries, combined with the power-intensive nature of GPS and GSM modules, necessitates frequent recharging, which can disrupt operations. GPS and GSM modules require accurate voltage regulation to function properly.

Data Security and Privacy: Asset tracking entails collecting and transmitting sensitive information.

Ensuring the security of this data from cyber threats and unauthorised access is a critical challenge that necessitates encryption and authentication mechanisms.

High initial costs: Implementing IoT-based tracking systems necessitates a significant investment in hardware, software, and infrastructure, which may deter small businesses from adopting.

Environmental Factors: Extreme weather, physical obstructions, and interference from other electronic devices can all have an impact on IoT tracking device performance and accuracy.

Scalability and interoperability: Integrating IoT systems with existing infrastructure or scaling them to accommodate more devices necessitates extensive technical knowledge and resources.

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a guiding light for our endeavors. This project is a testament to the power of teamwork, mentorship, and a shared vision to create innovative solutions. Thank you to everyone who contributed to making this initiative a success.

Conclusion

The proposed asset tracking system presents a cost-effective and reliable solution for efficient asset monitoring and management. By incorporating essential components like a GPS module, GSM/GPRS module, microcontroller, battery, and optional accelerometer, the system can be applied to a range of use cases, including vehicle tracking, equipment monitoring, inventory control, and personal safety. Its affordability makes it an attractive option for a wide array of industries, from logistics and transportation to manufacturing and security. The system's flexibility allows it to be tailored to different operational requirements, while the integration of modern tracking technologies ensures accurate, real-time monitoring of assets. However, to further enhance its performance and usability, future development could focus on key areas such as improving power efficiency to extend battery life, enhancing data security to protect sensitive information, and adding advanced features such as accelerometer and geosensors for specialized applications. Customization options would also enable businesses to adapt the system to their unique needs, providing a higher level of control and visibility. Overall, the asset tracking system offers a versatile, scalable solution capable of addressing the growing demand for efficient asset management in an increasingly connected world.

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