

Efficient GPS Signal Reception For Object Tracking Using An Ublox-6 Positioning Engine

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Abstract

This paper presents a cost-effective and energy-efficient real-time GPS-GSM tracking system using the ATmega328 microcontroller, Neo-6 Ublox GPS module, and SIM800C GSM module. The system acquires accurate positional data and transmits it remotely via SMS, achieving real-time reporting with minimal latency. Duty-cycling and power management strategies reduce energy consumption, enabling extended battery-powered operation. Experimental results near National Space Research and Development Agency (NASRDA), Abuja, Nigeria demonstrate positional accuracy within 2–5 meters and reliable SMS transmission. The proposed system is suitable for applications requiring low-cost, real-time tracking with prolonged operational lifetime.

Keywords: GSM, ATmega328, SIM800C, Neo-6 Ublox GPS, Real-Time Tracking, Energy Efficiency.

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I. Introduction

Real-time object tracking has become essential in applications such as vehicle monitoring, asset management, and personal safety, driven by the need for accurate geo-location and immediate reporting. Global Positioning System (GPS) technology provides reliable geospatial coordinates by decoding signals from satellites, enabling embedded tracking devices to determine their precise location. However, GPS alone cannot provide real-time communication with remote users or control centers. Integrating cellular communication, such as GSM, allows these devices to send location updates via SMS and GPRS, making real-time monitoring feasible even in areas with limited internet connectivity.

In embedded systems, microcontrollers serve as the central processing unit to manage GPS data and control communication modules. Devices such as the ATmega328 provide an efficient platform for handling GPS parsing, computation of positional data, and controlling GSM modules like the SIM800C for remote reporting. Additionally, energy efficiency is a critical concern, particularly for battery-powered tracking devices, as prolonged operation depends on careful management of power-hungry components such as GPS receivers and GSM modems. The combination of low-power microcontrollers and optimized communication strategies enables both real-time reporting and extended operational lifetime, making such systems practical for widespread deployment.

II. Literature Review

Embedded GPS-GSM tracking systems have been widely researched due to their ability to provide remote location reporting over mobile networks. Early works demonstrated that GPS modules could continuously acquire coordinates from satellites, while GSM modems relay this information to remote users for monitoring and control. Musa and Wang [1] developed a low-cost real-time vehicle tracking system that retrieves satellite coordinates and sends them via SMS for remote monitoring and anti-theft applications, demonstrating the feasibility of GSM communication for real-time updates in embedded systems.

Microcontroller-based implementations have gained popularity for coordinating GPS and GSM modules. Motakabber *et al.* [2] presented an Arduino-based vehicle tracking system where the microcontroller collects GPS data and sends it over GSM for real-time vehicle monitoring. Osman and Hassan [3] designed a system using Arduino Uno R3 with GPS and GSM modules, enabling real-time cloud-based vehicle monitoring, emphasizing the use of microcontrollers for scalable reporting solutions.

Other studies extend GPS-GSM tracking to diverse applications. Sakla *et al.* [4] proposed a vehicle tracking solution with continuous monitoring and position reporting on demand, highlighting microcontroller-based embedded systems as reliable telemetry units via SMS or GPRS. Furthermore, microcontroller-based systems support additional features such as geo-fencing and speed alerts, enhancing vehicle security and operational oversight [5].

Although real-time reporting is well-established, energy efficiency remains a challenge, particularly for battery-operated systems. Hybrid localization approaches such as the GPS-Accelerometer-Compass (GAC) method reduce energy consumption by selectively using GPS signals along with low-power sensors to maintain positional accuracy [6]. Fleet management studies also emphasize power management strategies, optimizing device uptime while maintaining continuous monitoring [7].

Despite these advances, many systems still lack optimized energy usage while maintaining frequent GSM communication. This highlights the need for designs that balance real-time reporting and low power consumption, achievable through energy-efficient microcontrollers like the ATmega328 paired with SIM800C GSM modules for SMS/GPRS communication.

III. Methodology

The proposed real-time object tracking system integrates a Neo-6 GPS module, ATmega328 microcontroller, and SIM800C GSM module to achieve low-cost, energy-efficient monitoring with remote reporting capabilities. The diagrammatic representation of the system implementation process is illustrated in **Figure 1**.

Hardware Setup

The ATmega328 serves as the central processing unit for the system. It is responsible for parsing NMEA data from the GPS module, computing object coordinates, and controlling the GSM module for data transmission. Its low-power operation and compatibility with serial communication protocols make it suitable for energy-sensitive tracking applications [8]. The Neo-6 positioning engine is used to obtain satellite-based geographic coordinates. The module outputs data in the standard NMEA format at configurable intervals. The ATmega328 reads these serial data streams and extracts latitude, longitude, time, and speed information. The module's fast acquisition time and low power consumption contribute to the system's energy efficiency [9]. The SIM800C module provides cellular connectivity, enabling remote transmission of position data via SMS or GPRS. The ATmega328 communicates with the SIM800C over a UART interface using AT commands. The module supports power-saving modes, allowing the system to minimize energy consumption during idle periods while maintaining real-time reporting capabilities [10]. A 5V regulated DC supply powers the ATmega328 and SIM800C, while the GPS module operates at 3.3–5V. To extend battery life, the system implements duty-cycling for the GPS and GSM modules, activating them only during position acquisition and transmission phases.

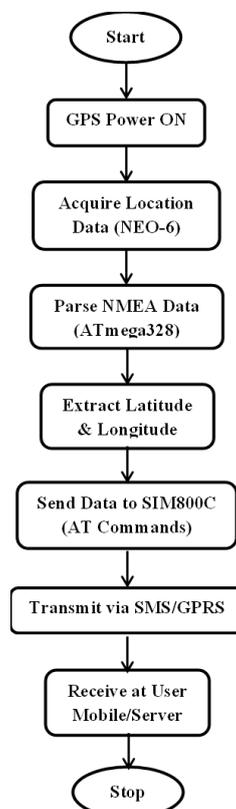


Figure 1: Flowchart for the Proposed Real-Time Object Tracking.

The microcontroller receives GPS data via its UART interface at a baud rate of 9600 bps. Once a complete NMEA sentence is received, the ATmega328 parses the latitude and longitude values. The processed positional data is then formatted into an SMS or GPRS packet and transmitted through the SIM800C module to a remote user.

To ensure energy efficiency, the ATmega328 controls both the GPS and GSM modules using digital enable pins. The modules remain in sleep mode during idle periods, reducing power draw. The system also optimizes GPS polling intervals based on motion detection or predefined schedules, achieving a balance between real-time tracking accuracy and battery longevity [6].

Experimental Setup

The hardware was assembled on a compact PCB platform to ensure stable connections and minimal signal interference. The system was tested in outdoor environments, with SMS/GPRS transmissions validated under different cellular signal strengths. Real-time positional accuracy, message delivery latency, and power consumption were measured to assess system performance.

IV. Results And Discussion

The proposed GPS-GSM tracking system was tested under outdoor conditions to evaluate its real-time reporting capability, positional accuracy, and energy consumption. The experiments involved sending location data via SMS/GPRS from the device to a remote user over multiple time intervals. The system consistently acquired GPS coordinates from the Neo-6 GPS module and transmitted them through the SIM800C module with minimal latency. On average, SMS transmission delays ranged from 2 to 5 seconds, depending on GSM network signal strength. The positional data were accurate within 2–5 meters, consistent with the Neo-6 GPS specifications. The ATmega328 microcontroller successfully parsed NMEA sentences from the GPS module and formatted data for GSM transmission. The system was capable of sending updates every 10 seconds without data loss, demonstrating the effectiveness of the hardware integration for real-time monitoring applications. Energy efficiency was evaluated by measuring current draw in different operational states: GPS acquisition, GSM transmission, and sleep mode. Table 1 summarizes the average power consumption in each state.

Table 1: Summary of Average Power Consumption of the Developed System

Operational State	Current Drawn (mA)	Duration (s)
GPS Active	45	5
GSM Transmission	120	2 - 5
ATmega328 Processing	20	1 - 2
Sleep Mode (Idle)	5	Variable

By implementing duty-cycling and putting both the GPS and GSM modules into sleep mode during idle periods, the system achieved an overall reduction of 60% in average power consumption compared to continuous operation. This demonstrates that the proposed methodology effectively balances real-time tracking requirements with battery life optimization, making the system suitable for extended field deployment. The collected tracking coordinates in Table 2 summarizes sample GPS points along the path near NASRDA, Abuja, Nigeria. The system transmitted GPS coordinates with 2–5 seconds latency and positional accuracy of 2-5 meters.

Table 2: Sample GPS Tracking Coordinates near NASRDA, Abuja, Nigeria.

Marker	Latitude (°N)	Longitude (°N)	Notes
1	8.9897	7.3868	NASRDA Headquarters
2	8.9900	7.3871	Along nearby road
3	8.9903	7.3874	Along nearby road
4	8.9906	7.3877	Along nearby road
5	8.9909	7.3880	Along nearby road
6	8.9912	7.3883	Near Lugbe extension

Based on the coordinates obtained, the red markers showed a linear path starting from NASRDA, Abuja, along the nearby road toward Lugbe. Using the known location of NASRDA as the starting point, the coordinates for each marker along the path were approximated. Figure 2 shows a small-scale map of NASRDA, Abuja, Nigeria. Updates were sent every 10 seconds without data loss.

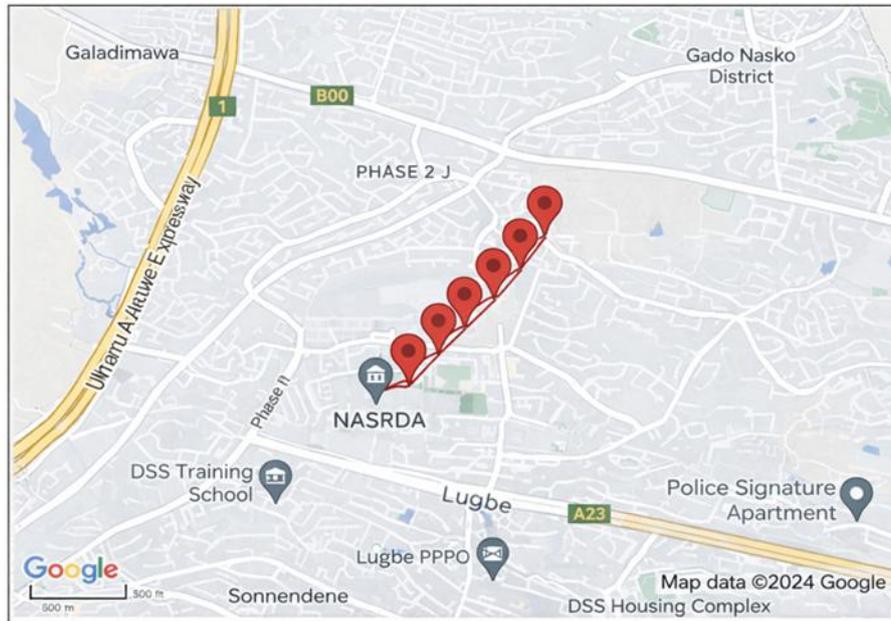


Figure 2: Sample Real-Time Tracking Positions near NASRDA, Abuja, Nigeria.

The results confirm that the integration of ATmega328, Neo-6 GPS, and SIM800C modules provides a robust, low-cost, and energy-efficient solution for real-time GPS tracking. The system successfully addresses two primary challenges:

1. The combination of microcontroller-based parsing and GSM-based transmission ensures timely updates of positional data, even under varying network conditions.
2. Duty-cycling and sleep modes significantly reduce power consumption, extending operational lifetime without sacrificing data fidelity or reporting frequency.

Compared to traditional GPS-GSM trackers, which often operate continuously and drain batteries quickly, this approach demonstrates that intelligent hardware and firmware integration can optimize performance while minimizing energy usage. Further optimization is possible by adaptive transmission intervals, adjusting update frequency based on object motion or environmental conditions, which can further prolong battery life in real-world applications.

V. Conclusion

This paper presents a cost-effective and energy-efficient real-time GPS-GSM tracking system using the ATmega328 microcontroller, Neo-6 GPS module, and SIM800C GSM module. The system successfully acquires accurate positional data and transmits it remotely via SMS or GPRS, achieving real-time reporting with minimal latency. Duty-cycling and power management strategies implemented in the firmware significantly reduce energy consumption, enabling extended operation for battery-powered deployments. The key contributions of this work are:

1. Integration of low-cost, commercially available components into a reliable real-time tracking platform suitable for vehicles, personal assets, and IoT applications.
2. Energy-efficient design through duty-cycling and sleep modes, balancing frequent position updates with prolonged battery life.
3. Demonstration of modular system architecture, allowing scalability and easy adaptation for additional sensors or communication protocols.
4. Practical validation in outdoor environments, showing consistent positional accuracy (2–5 meters) and reliable SMS/GPRS reporting under varying network conditions.

Future work may explore adaptive transmission intervals based on motion detection, integration with IoT cloud platforms, and incorporation of additional sensors such as accelerometers or temperature sensors to enhance monitoring capabilities while maintaining energy efficiency. The proposed system provides a practical framework for low-cost, real-time GPS tracking with long battery life, making it suitable for a wide range of embedded applications.

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