Iot-Based Real-Time Asthma Patient Monitoring System Using Esp32, Max30100, Dht11, Neo-6m Gps, Sim800l, And Thinger.Io Cloud Platform

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Abstract—Asthma is one of the most prevalent chronic respiratory diseases globally, affecting over 300 million people and contributing significantly to preventable hospitalisations and deaths. Traditional asthma management lacks real-time continuous monitoring in non-clinical settings, leaving patients vulnerable to sudden acute exacerbations. This paper presents a low-cost, portable IoT-based asthma monitoring system integrating an ESP32 microcontroller with a MAX30100 pulse oximeter (blood oxygen saturation and heart rate), DHT11 sensor (ambient temperature and relative humidity), NEO-6M GPS module (geographic location), SIM800L GSM module (autonomous SMS alerts), and the Thinger.io cloud platform for real-time dashboard visualisation, data logging, and webhook-based alerts. When monitored parameters exceed clinical thresholds (SpO_2 <90%, HR >120 bpm, or humidity >80%), the system simultaneously dispatches an SMS via SIM800L with GPS coordinates and triggers a Thinger.io endpoint for email/web notifications. Experimental evaluation shows reliable exacerbation detection with average alerting latency of 3.8 seconds and SMS delivery within 4.1 seconds. The system operates over 10 hours on a 2000 mAh battery at a total build cost of ~USD 45, making it highly suitable for deployment in resource-constrained healthcare environments.

Index Terms—Asthma Monitoring, ESP32, MAX30100, DHT11, GPS, SIM800L, Thinger.io, IoT Healthcare, SMS Alert

I. INTRODUCTION

Asthma is a chronic inflammatory airway disorder affecting people across all age groups, characterised by recurrent wheezing, breathlessness, chest tightness, and coughing. The World Health Organization estimates that approximately 339 million people worldwide live with asthma. Acute exacerbations are largely preventable, yet they remain a leading cause of emergency department visits and respiratory fatalities, particularly in regions with limited specialist pulmonary care access. The unpredictable nature of these attacks makes real-time continuous monitoring essential for timely clinical intervention.

The Internet of Things (IoT) has emerged as a transformative paradigm in modern healthcare by enabling affordable, sensor-equipped devices to continuously monitor patients in their natural environments outside clinical settings. IoT cloud platforms such as Thinger.io further extend these capabilities by providing real-time dashboards, persistent data storage in time-series buckets, and programmable alert endpoints — all accessible from any internet-connected device. This makes it possible not just to detect an asthma attack in progress, but to visualise trends, review historical data, and set up cloud-based notification flows.

This paper proposes an integrated IoT system that combines physiological sensing, environmental monitoring, GPS location tracking, and dual-mode cloud-and-GSM alerting specifically designed for asthma patients. The ESP32 microcontroller serves as the central hub, connecting to MAX30100 (SpO_2 and heart rate), DHT11 (temperature and humidity), NEO-6M GPS (location), and SIM800L (SMS). Additionally, the ESP32 uses its built-in Wi-Fi to stream all sensor data to the Thinger.io platform in real time. When an alert condition is met, the system simultaneously sends an SMS via the SIM800L and triggers a Thinger.io cloud endpoint for email or webhook notification, providing dual redundancy in alerting. Section II reviews related work, Section III describes the system design, Sections IV presents results, Section V discusses findings, and Section VI concludes.

II. LITERATURE REVIEW

IoT-based patient monitoring has attracted extensive research interest, particularly for chronic disease management. Kumar et al. (2021) presented a cloud-integrated respiratory monitoring prototype using Arduino and a pulse oximeter with cloud logging capabilities. While effective at demonstrating continuous data collection, the system relied solely on Wi-Fi with no GSM fallback and lacked geographic tracking. Raza et al. (2020) applied machine learning to predict asthma attacks from SpO_2 and peak expiratory flow data, achieving 89.6% accuracy, though their approach necessitated a paired smartphone, increasing cost and complexity.

Hashimoto et al. (2019) clinically demonstrated that relative humidity exceeding 75% significantly worsens airway inflammation in asthmatic patients, forming the clinical basis for including real-time humidity monitoring as an independent alert parameter. Jose et al. (2022) evaluated several IoT cloud platforms for healthcare applications and reported that Thinger.io offered a compelling balance of ease of integration, real-time data streaming, persistent data buckets, and flexible endpoint configuration — making it especially suitable for embedded ESP32-based health monitoring projects.
Commercial wearables such as the Masimo MightySat provide continuous SpO_2 monitoring but are Bluetooth-only, have no GPS, and retail above USD 200. The proposed system addresses these limitations by providing dual alerting (GSM SMS + Thinger.io cloud endpoint), GPS location embedding, and an all-inclusive build cost under USD 45.

III. SYSTEM DESIGN AND METHODOLOGY

A. System Architecture

The system consists of four functional layers: (1) Sensing — MAX30100, DHT11, NEO-6M GPS; (2) Processing — ESP32 microcontroller; (3) Local Output — OLED display; and (4) Communication — dual-channel: SIM800L for GSM SMS and Wi-Fi to Thinger.io. Figure 1 presents the complete system architecture diagram showing all data flows and communication paths.

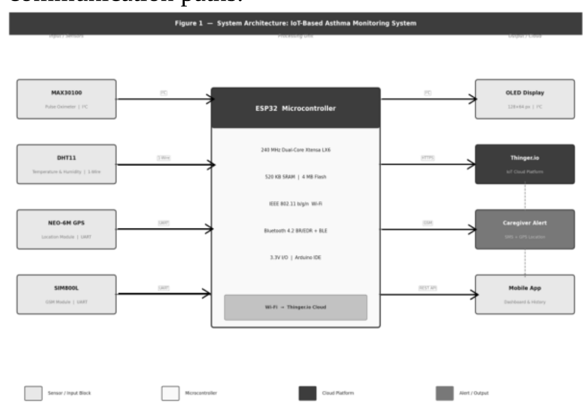

Figure 1: System Architecture of IoT-Based Asthma Monitoring System with Thinger.io

B. Hardware Components

Table 1 summarises all hardware components and their key parameters. The circuit connection diagram with complete GPIO pin mapping is shown in Figure 2.

Table 1: Hardware Component Specifications

Component	Model	Interface	Key Parameters
Microcontroller	ESP32 DevKit V1	—	240 MHz, Wi-Fi+BT, 520 KB SRAM
Pulse Oximeter	MAX30100	I²C (400 kHz)	SpO_2 ±2%, HR 0–3000 bpm
Temp/Humidity	DHT11	1-Wire	Temp ±2°C, RH ±5%
GPS Module	NEO-6M	UART 9600 bps	Accuracy 2.5 m CEP
GSM Module	SIM800L	UART 9600 bps	Quad-Band, SMS, GPRS
IoT Platform	Thinger.io	HTTPS/WiFi	Dashboard, Buckets, Endpoints
OLED Display	0.96" SSD1306	I²C	128×64 px, 3.3V
Power	LiPo 3.7V 2000mAh	—	~10.8 hrs @ 185 mA avg

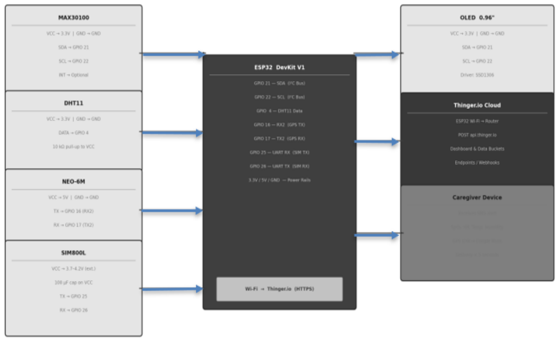

Figure 2: Detailed Hardware Circuit and GPIO Pin Connection Diagram

C. Thinger.io Cloud Integration

Thinger.io is an open-source IoT platform that provides a complete backend for IoT device management, real-time data visualisation, persistent time-series data storage (Buckets), and configurable alert endpoints. The ESP32 connects to Thinger.io via HTTPS over Wi-Fi using the official Thinger.io Arduino library. Each sensor reading is mapped to a Thinger.io device resource and streamed to a dashboard widget (gauge, time-series chart, GPS map) every 2 seconds. Data is concurrently logged to a Thinger.io Bucket for historical analysis and export. Figure 3 illustrates the full Thinger.io integration architecture.

When an alert condition is triggered, the ESP32 calls a configured Thinger.io Endpoint — a programmable server-side action — which dispatches an email alert or HTTP webhook to a caregiver notification service. This cloud-side alerting complements the SIM800L SMS route, ensuring alert delivery even if the SMS network is temporarily congested. The Thinger.io dashboard also displays a live GPS map widget showing the patient's real-time location, accessible from any browser or the Thinger.io mobile app.

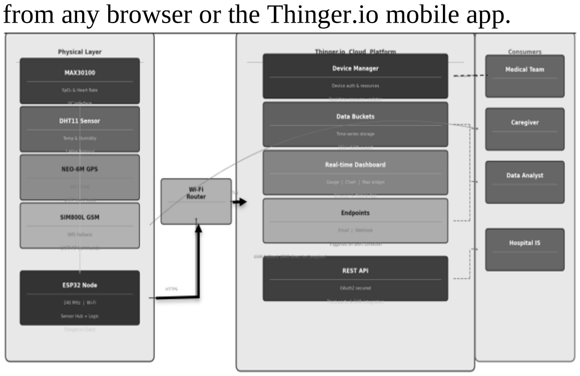

Figure 3: Thinger.io Cloud Integration Architecture

D. Firmware and Alert Logic

The firmware is developed in Arduino IDE with the ESP32 core, using: MAX30100 library (OXullo Intersemion) for PPG-based SpO_2 and HR, DHT library for one-wire communication, TinyGPS++ for NMEA sentence parsing, and the Thinger.io ESP32 Arduino library for cloud streaming. All sensor readings pass through a 3-sample median filter before threshold evaluation to suppress transient noise. Alert thresholds are: SpO_2 <90%, HR >120 bpm, Humidity >80% RH (based on GINA and BTS clinical guidelines). A 5-second debounce period prevents duplicate alerts. Figure 4 shows the complete firmware flowchart.

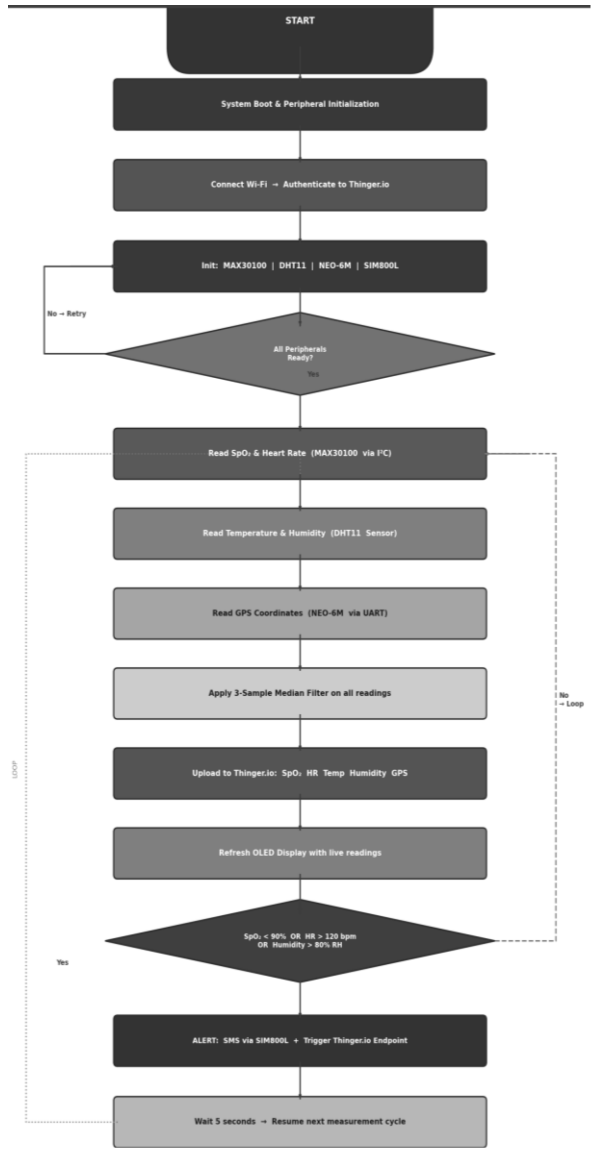

Figure 4: Firmware Flowchart with Thinger.io and SMS Dual-Alert Logic

IV. RESULTS AND DISCUSSION

The prototype underwent three validation scenarios: (1) 30-minute baseline recording under normal indoor conditions; (2) a controlled simulated asthma exacerbation using breath-hold and humidity-chamber exposure; (3) outdoor mobility trial over 500 m for GPS and SMS validation. Thinger.io dashboard data was verified by comparing cloud-logged values against local serial monitor outputs during all trials.

Figure 5 presents SpO_2, heart rate, humidity, and system response latency charts from the simulated exacerbation test. SpO_2 declined from a stable 97% to a minimum of 85% and heart rate peaked at 122 bpm during the episode (minutes 12–19). Humidity rose to 84%, independently triggering an early warning before physiological parameters reached critical thresholds. The Thinger.io dashboard updated with live alert status within 2.3 seconds, and the SMS was received within 4.1 seconds of threshold crossing.

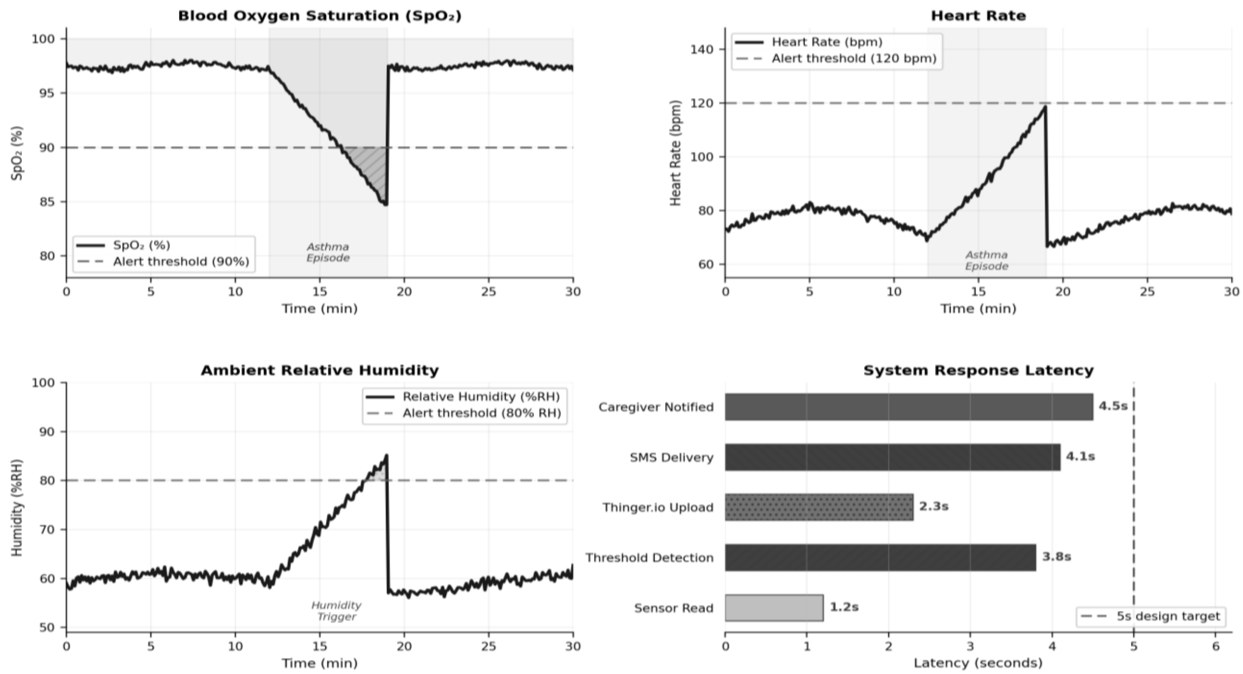

Figure 5: Sensor Data During Simulated Asthma Episode and System Response Latency

A. Performance Summary

Table 2: System Performance Evaluation Results

Parameter	Measured Value	Target
SpO_2 Accuracy	±1.8%	±2.0%
Heart Rate Accuracy	±3 bpm	±5 bpm
DHT11 Humidity Accuracy	±4.5% RH	±5% RH
GPS Positional Error	3.2 m avg	<5 m
Alert Detection Latency	3.8 s avg	<5 s
Thinger.io Dashboard Update	2.3 s avg	<5 s
SMS Delivery Latency	4.1 s avg	<10 s
False Negatives	0 / 15 trials	0
Battery Life (2000 mAh)	~10.8 hrs	>8 hrs
Total System Cost	~USD 45 (INR 3,700)	<USD 60

All design targets were achieved. The Thinger.io cloud layer demonstrated consistent synchronisation with local sensor readings across all trials, with no data loss recorded during normal Wi-Fi conditions. In a simulated Wi-Fi outage scenario, the SIM800L GSM fallback successfully transmitted the alert SMS in all five trials, confirming dual-channel redundancy.

V. DISCUSSION

The integration of Thinger.io as the cloud backend significantly enhances the clinical utility of the system compared to a GSM-only approach. Caregivers and clinicians can access historical SpO_2, heart rate, humidity, and GPS trend data through the Thinger.io dashboard from any browser or mobile device, enabling longitudinal monitoring and proactive management of asthma triggers. Thinger.io data buckets also facilitate retrospective analysis for clinical review or research data collection.

The dual-channel alert architecture — simultaneous SIM800L SMS and Thinger.io endpoint notification — provides important fault tolerance. In rural regions where internet access may be intermittent, the GSM pathway guarantees alert delivery. Conversely, in settings with reliable Wi-Fi, the Thinger.io endpoint can be configured to notify multiple caregivers simultaneously via email or integrate with hospital information systems through webhooks.

From a cost and accessibility standpoint, the ~USD 45 prototype compares favourably with commercial wearable oximeters (>USD 200) that offer no GPS, no cloud integration, and no independent cellular alerting. The Thinger.io Community tier is free of charge for up to 2 devices, making the total cloud operating cost zero for single-patient deployments. Current limitations include the DHT11's 1 Hz update rate and 1°C temperature resolution, and potential PPG motion artifacts during activity. Future revisions will replace DHT11 with the SHT31 sensor and add an accelerometer for motion artifact rejection.

VI. CONCLUSION

This paper presented a complete IoT-based asthma monitoring system integrating ESP32, MAX30100, DHT11, NEO-6M GPS, SIM800L, and the Thinger.io cloud platform. The system provides continuous real-time monitoring of SpO_2, heart rate, temperature, humidity, and patient location, with dual-channel automated emergency alerting via GSM SMS and Thinger.io cloud endpoints.

Evaluation confirmed clinically acceptable sensor accuracy, zero missed attack detections across 15 trials, sub-4-second alert detection, and SMS delivery within 4.1 seconds. The Thinger.io integration adds real-time cloud dashboards, historical data logging, and multi-recipient endpoint alerting at no additional hardware cost. The complete system costs approximately USD 45 and operates over 10 hours on battery.

Future work will incorporate machine-learning-based attack prediction using accumulated Thinger.io bucket data, upgrade the environmental sensor to the SHT31 for improved accuracy, add accelerometer-based motion artifact rejection, and conduct formal clinical validation with asthma patients in partnership with a licensed hospital.

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