

Embedded Systems Super Thesis Project: Outdoor Climate Monitoring Station with Wifi-HaLow

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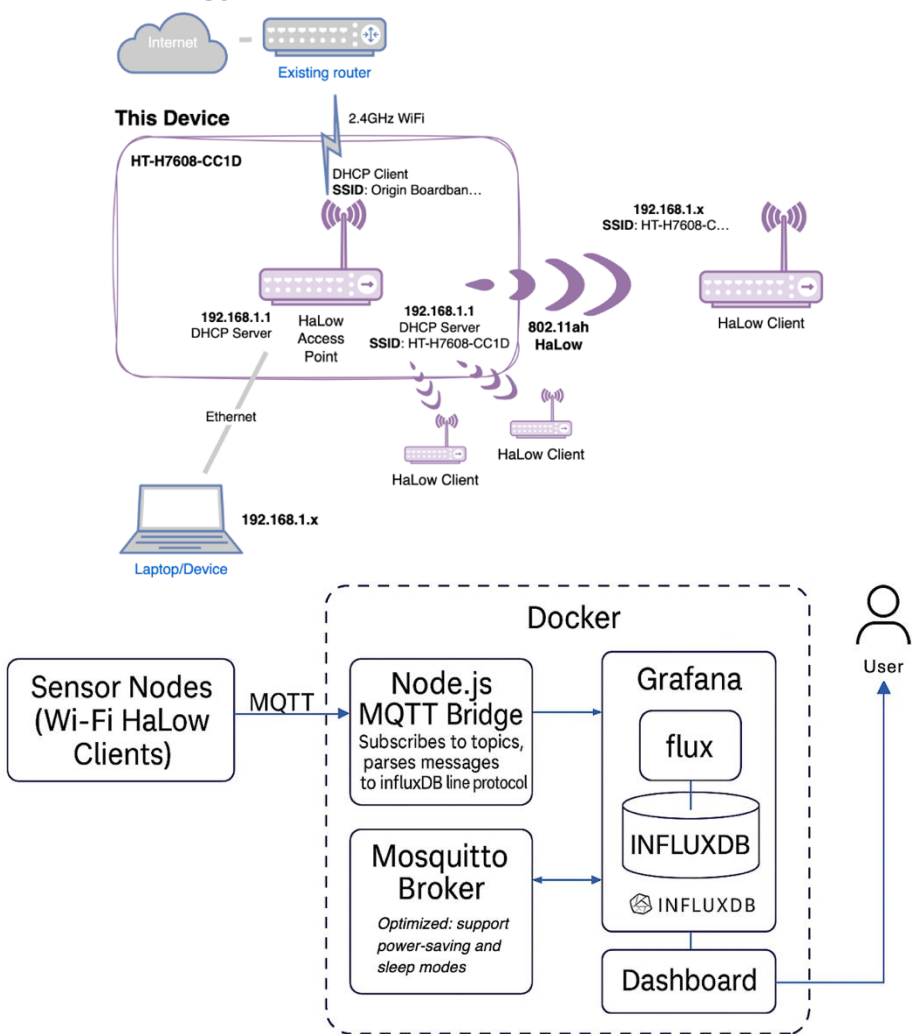
Introduction

This project presents a low-power IoT-based outdoor climate monitoring station using Wi-Fi HaLow (IEEE 802.11ah) for long-range, energy-efficient data transmission. Each solar-powered node measures temperature, humidity, air quality, dust, and wind, transmitting data via MQTT to a cloud-hosted InfluxDB + Grafana dashboard for real-time visualisation.

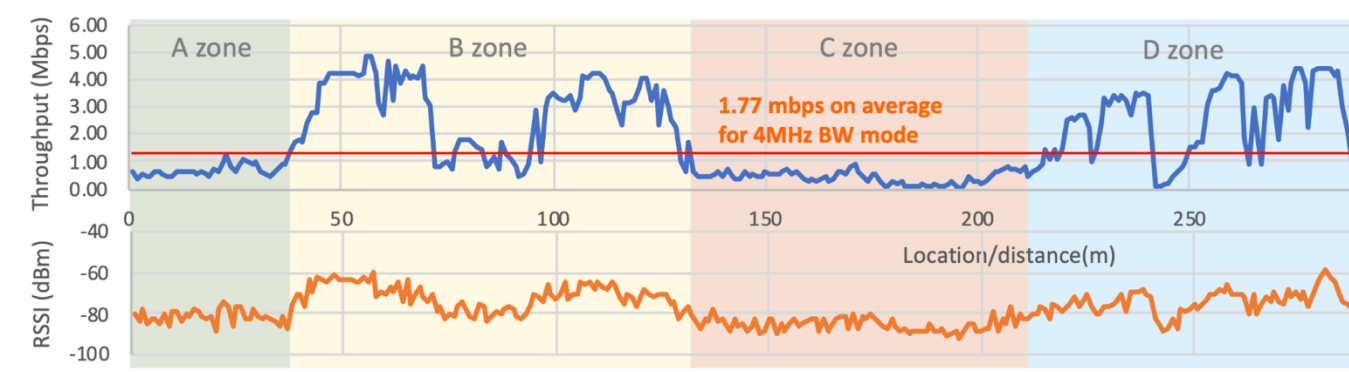
Aim

The aim of this project is to build a sustainable, field-ready platform that reliably collects and visualises environmental data in real time using Wi-Fi HaLow, solar-battery nodes, and a cloud dashboard with power-aware firmware.

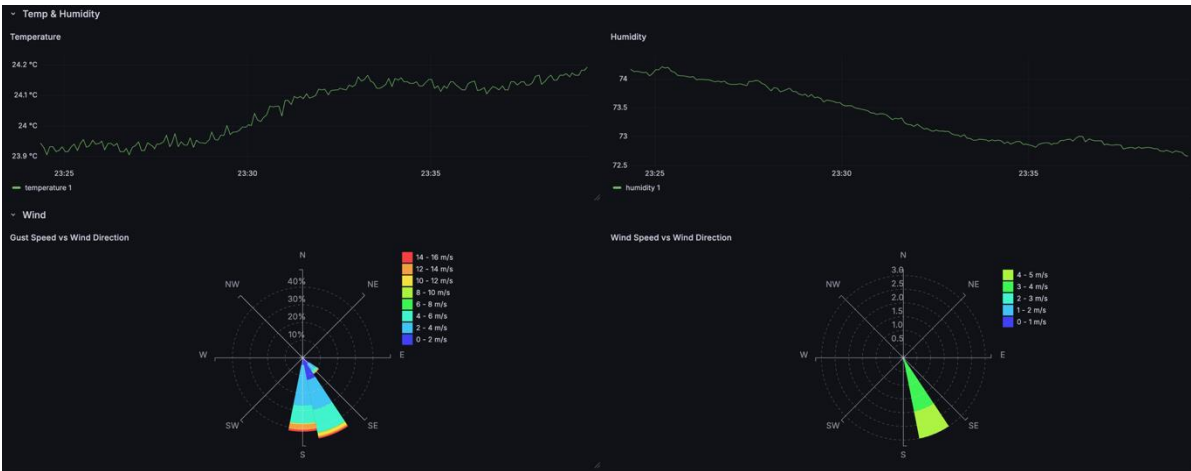
Methodology



Throughput & RSSI



Web Dashboard

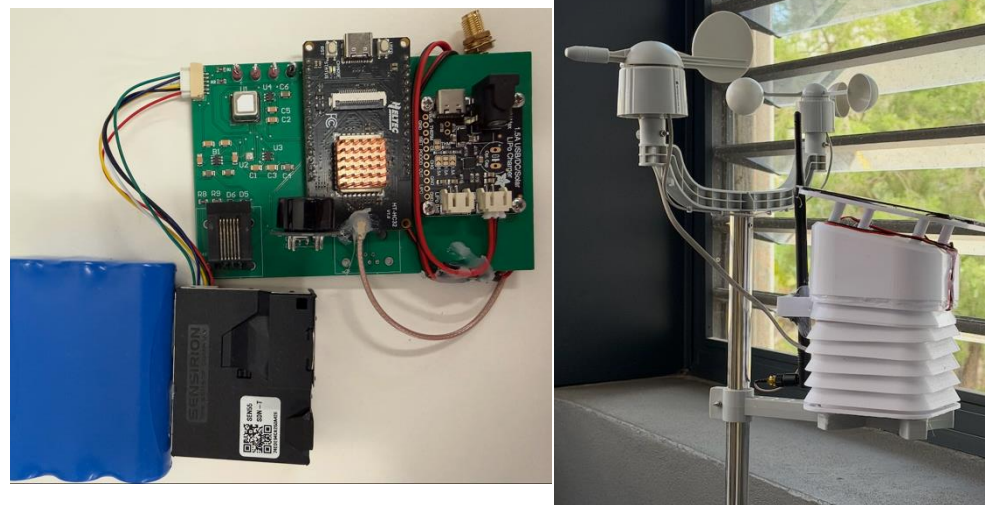


Throughput & RSSI: Walk-test across zones A to D shows RSSI is ranging from about -90 to -60 dBm and TCP throughput peaking ~ 4 to 5 Mb/s with a site-wide average of 1.77 Mb/s, indicating a stable link even through partial NLOS (buildings, trees, etc...).

Web Dashboard: It displays temperature, humidity, CO₂, PM2.5, wind roses (speed & direction), RSSI, OTA, battery/charging status, and more with smooth, rate-limited trends. It supports real-time and historical views with alerts/thresholds.

System Architecture

- Controller:** Custom PCB with a low-power MCU HT-HC32 microcontroller handling processing and power management
- Wi-Fi HaLow:** HT-01 Wi-Fi HaLow backhaul to HT-H7608 AP
- Power system:** Power by 3.7V, 10,050 mAh Li-ion pack, for multi-day runtime with ADC battery sensing and low-power sleep
- Charger/Power-Path:** TI-bq24074 polymer charger (USB/solar-friendly), charge/status pins with thermal regulation
- Sensors:** BME280 (temperature & pressure), SEN55 (PM2.5 & NO_x), wind sensor (speed & direction), MQ-9 (CO & combustibles)
- RTOS/Comms:** FreeRTOS task model; MQTT publish/subscribe (QoS, JSON payloads), offline buffering and OTA-ready



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