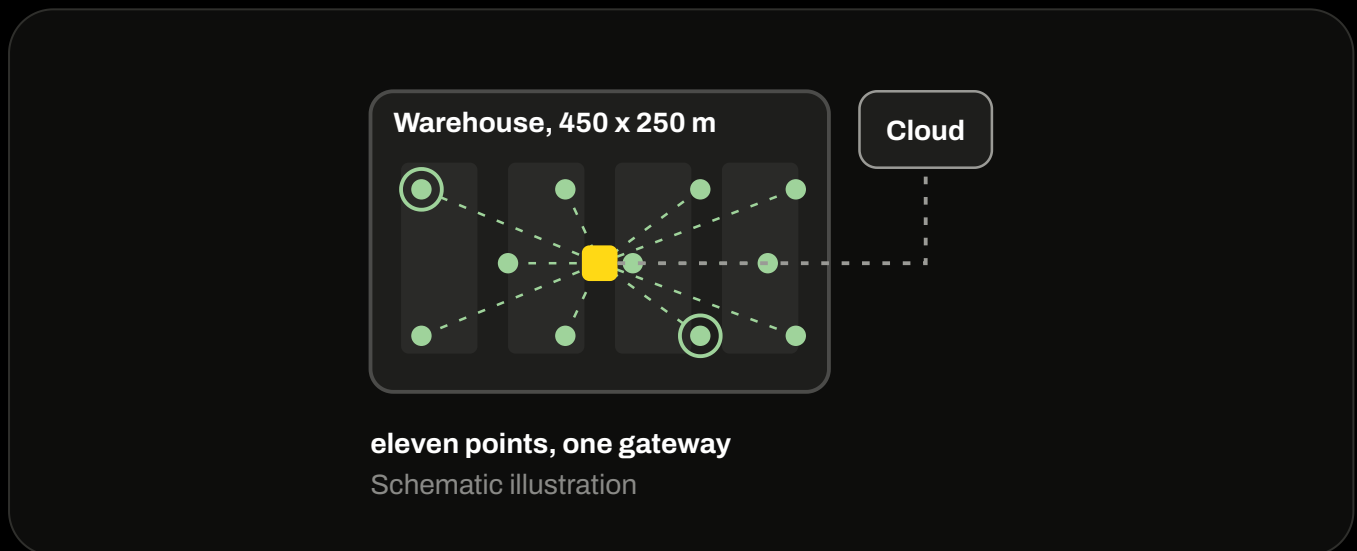


WAREHOUSE · WIRELESS SENSORS

One big warehouse. Eleven radio nodes read the air.

Temperature and humidity every minute, by radio to the cloud.

[Read the interactive case study online ›](#)


11

measuring points across a warehouse of 450 x 250 m

60 s

between two readings of temperature and humidity at each point

2 x AA

cells per node, for more than a year of work as the target

10 min

to install one node; the target was 15 minutes

THE CHALLENGE

A warehouse this size cannot be measured from one spot.

Workplaces must keep temperature and relative humidity inside a comfort zone. In this warehouse the bands are 23 to 27 °C in summer and 17 to 24 °C in winter, with 23 °C as the usual value, and 30 to 70 % relative humidity all year, with 50 % as the usual value. The ranges must be watched automatically, with sensors spread over a floor of 450 x 250 m, more than 100,000 m².

01

Humidity changes at night

In the heat of the day the humidity can be around 30 % or lower. At night it can reach 70 to 80 %.

02

Measure both together

Relative humidity depends on the air temperature: when the temperature goes up, the relative humidity goes down. It tells how close the air is to saturation, so temperature and humidity are read at the same time.

03

No cables across the floor

Each node reads temperature and humidity every minute, with a resolution of 0.1 °C and 1 % RH. Nodes must run more than a year on batteries and install in less than 15 minutes.

04

Know when a node fails

With 11 nodes on a large floor, a silent node must be found quickly. Each node also reports the state of its radio link, so a failure shows which node and what kind of failure.



Why the humidity matters

High humidity helps mould, corrosion and rust grow on stored goods.

HOW IT WORKS

Three jobs: send each reading, map the floor, watch the links.

Job 1 · Send each reading

Wake, measure, send nine frames, sleep.

Every 60 s a node wakes up, reads temperature and humidity and builds one small packet. It sends the packet three times, and each time on three modulations: SUN-FSK, SUN-OQPSK and SUN-OFDM.

- One reading every 60 s, then sleep

Job 2 · Map the floor

Eleven points, one band for each season.

Each point is checked against the band of the case, not only the floor average. In the afternoon the air is warm and dry; at night the same floor can reach 70 to 80 % humidity.

- Temperature: 23 to 27 °C in summer, 17 to 24 °C in winter

Job 3 · Watch the links

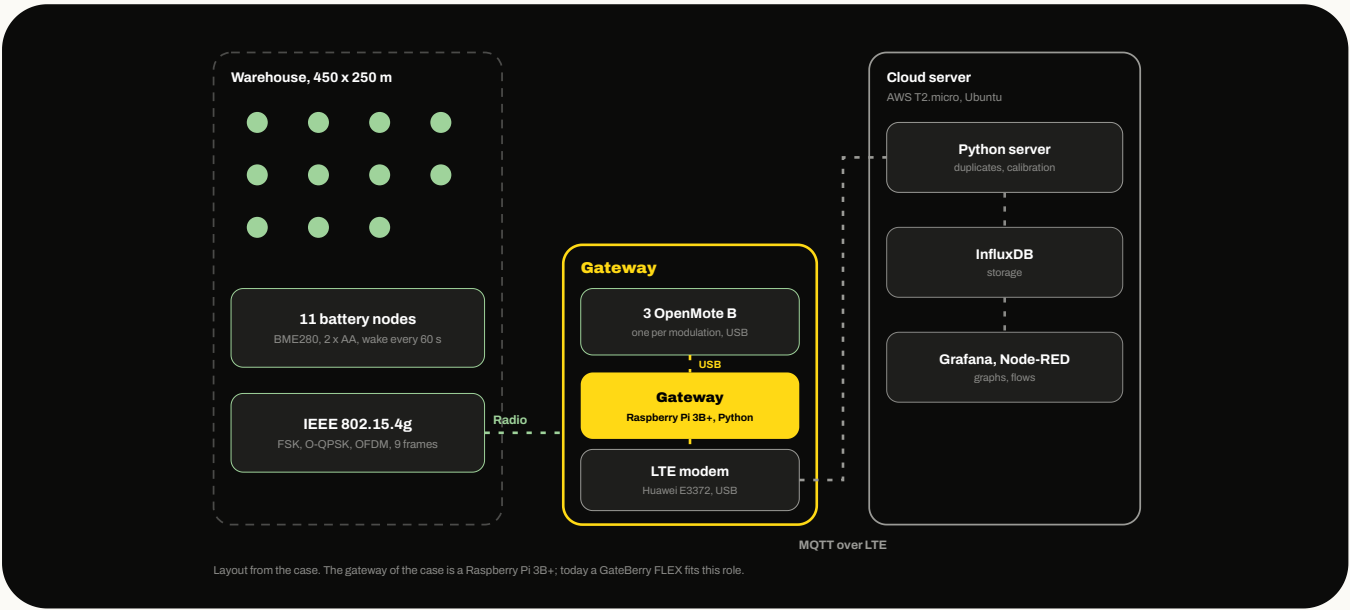
The network reports on itself.

With batteries and radio, a node can go quiet without anyone noticing. Each node sends the strength of the signal (RSSI) and the noise on the channel when it transmits (CCA RSSI).

- RSSI and CCA RSSI from every node

How do you monitor temperature and humidity in a large warehouse without cables?

Eleven battery nodes read temperature and humidity and send them by radio, IEEE 802.15.4g, with three modulations. At the gateway, a Raspberry Pi with three OpenMote B radio boards receives the frames on USB. A Python server on the gateway sends the data with MQTT over an LTE modem to a cloud server on Amazon AWS. There, a second Python server removes the duplicate packets and applies the calibration, InfluxDB stores the data, and Grafana and Node-RED show it.



Signals and data

Signal	Between	Type	Purpose
Temperature and relative humidity	Bosch BME280 → node	On the sensor board	Resolution of 0.1 °C and 1 % RH, every minute. The BME280 also reads pressure
Light	TI OPT3001 → node	On the sensor board	Available on the same sensor board
Reading packet	11 nodes → gateway	SUN-FSK, SUN-OQPSK, SUN-OFDM	21 bytes, AES-128, 32-byte PSDU, 3 repetitions x 3 modulations
Link state	Nodes → gateway	RSSI, CCA RSSI, CSMA retries	Signal strength and channel noise, and retries for each modulation
Packet counter	In every packet	Counter that only goes up	Finds lost packets and node resets
Received frames	3 OpenMote B → Raspberry Pi 3B+	USB serial	The Python gateway server reads the frames
Uplink	Gateway → cloud	MQTT over LTE (Huawei E3372)	Every packet goes to the cloud server
Clean data	Python server on AWS	MQTT in, database out	Removes duplicate packets and applies the calibration
Storage and dashboards	InfluxDB, Grafana, Node-RED	AWS T2.micro, Ubuntu 18.04	Aggregation, storage and graphs of temperature, humidity, RSSI and CCA RSSI

The gateway today. The nodes of the case.



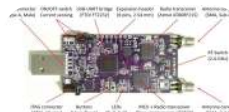
GateBerry FLEX

The gateway of the case was a Raspberry Pi 3B+ with three radio boards and an LTE modem on USB.

Role in this design	Gateway: radio boards on USB, Python server, MQTT to the cloud
Compute	Raspberry Pi 4 (Raspberry Pi 5 option), 2 to 16 GB RAM
Ports	1 x Gigabit Ethernet, 2 x USB 2.0, 2 x USB 3.0, RS-485, I2C, Wi-Fi, Bluetooth LE
Expansion	One board: 4G (LTE-M/NB-IoT or LTE Cat 4), LoRa, CAN, M-Bus or RS-232

The case used a Raspberry Pi 3B+ with Raspbian and a Huawei E3372 USB modem. The GateBerry FLEX is the current Industrial Shields equivalent for the gateway role.

[See the GateBerry FLEX ›](#)



OpenMote B radio board (image from the original case)

Each of the 11 measuring points is an OpenMote B radio board with an OpenMote sensor board and two AA cells.

Radio board	TI CC2538 and Atmel AT86RF215, FreeRTOS
Sensor board	Bosch BME280 (temperature, humidity, pressure), TI OPT3001 (light)
Power	2 x AA, 3 V, 1500 mAh
Radio	IEEE 802.15.4g: SUN-FSK, SUN-OQPSK, SUN-OFDM

OpenMote B is no longer in the Industrial Shields catalogue. The pattern still applies: low-power radio nodes, a Linux gateway and MQTT.

[Ask about the nodes ›](#)

One reading, nine chances

Three repetitions on three modulations give nine frames for each reading. Noise on one modulation or a short burst at one moment does not cost the reading. The cloud server keeps one copy.

A node that sleeps

The node is awake only to read the sensors and send. Then it sleeps until the next minute. This is why two AA cells of 1500 mAh are expected to last more than a year.

Polite on the air

Before each frame the node checks the channel (CCA) and waits if it is busy (CSMA-CA), up to 3 times. The CSMA retries and the CSMA RSSI travel in the packet, so you can see a noisy area.

MONITORING A LARGE FLOOR?

**Tell us about your floor and your limits.
An engineer will answer.**

Tell us the size of the building, the variables and their limits, how many points you want and where the data must go. We will propose the nodes, the radio, the gateway and the software.

READ IT ONLINE

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