UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Artificial Intelligence and Data Engineering

Smart Management of Stress conditions in the Workplace

Project Documentation

Martina Marino

Roberta Matrella

Academic Year: 2021/2022

Contents

1 Introduction

Workplace stress can be significantly influenced by environmental factors, including lighting and temperature. Suboptimal conditions not only affect physical comfort but also impact mental well-being and overall productivity. Designing a solution for workplace management using IoT technology is the primary objective of this project. The goal is to develop an application capable of autonomously regulating workplace conditions, specifically focusing on brightness, humidity, and temperature. This innovative system aims to enhance the overall working environment by automating procedures and ensuring optimal working conditions for employees.
The project can be visited at the following link:
https://github.com/martimarino/Workplace-Stress-Monitoring-System

2 Design

The IoT nodes considered for this solutions are implemented on nRF52840 Dongle devices using Contiki-NG operating system.

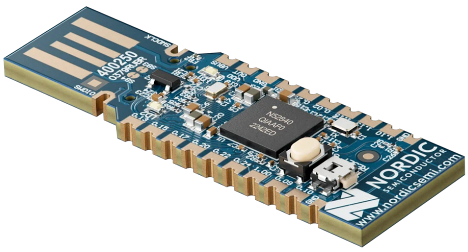

Figure 1: nRF52840 Dongle

The devices are organized in the following architecture:

- an **IoT network**, connecting devices serving as sensors or actuators. Some devices use CoAP, while others use MQTT as their communication protocol.
- a **border router**, providing access to the Internet;
- a **Java collector** responsible for receiving all sensed data, communicating actions to actuators, and storing data in a MySQL database.

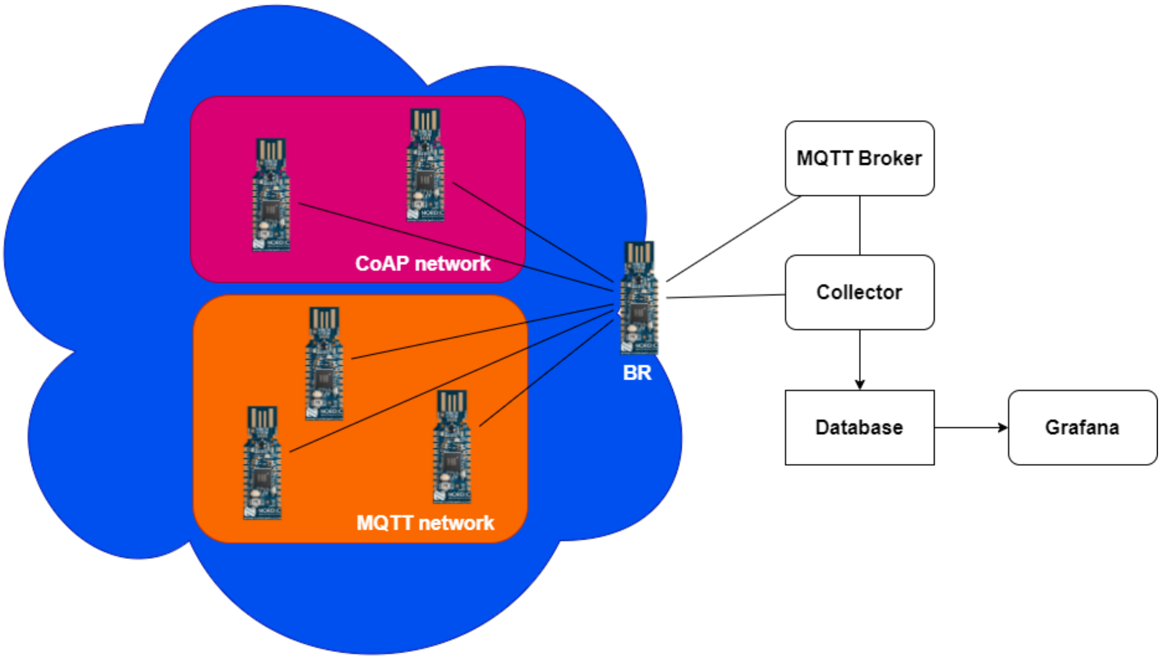

Figure 2: nRF52840 Dongle

The MQTT devices are responsible for monitoring humidity and brightness, whereas those using CoAP are tasked with temperature management. All these devices are implemented on real sensors connected externally through a border router. In MQTT, one sensor detects humidity and serves as an actuator as humidifier/dehumidifier. Additionally, there are two sensors that measure brightness and two actuators (light-bulbs). There are also two sensors that monitor the temperature and two actuators (air conditioners). There is also a collector that collects data from both COAP and MQTT sensors and stores them in a MySQL database. The data collected in this way can be visualized using Grafana. Moreover, the automatic handle of the environment can be enabled/disabled pressing the button on the sensor.

2.1 MQTT

The brightness within a workspace can vary based on the dimensions of the area. Factors such as the size of windows, placement of workstations, and the presence of any obstructions can influence how natural light permeates the space. However, the humidity within a room tends to remain relatively stable, provided there are no significant external influences or sources of moisture. For this reason more than one brightness sensor is necessary to measure the brightness depending on the room size while for the humidity is required at least one.

2.1.1 Humidity

One humidity sensor and one actuator (humidifier/dehumidifier) have been used to handle the humidity level inside the workplace. When the humidifier is turned on the humidity decreases while, when the dehumidifier is turned on, the humidity increases. In case the humidity is not in the optimal range for a workplace, setted between 40% and 60% [1], the led turns red and the humidifier or the dehumidifier is turned on, depending on the actual humidity value. The humidity samples collected by the sensor are sent to the MQTT broker, while the actuator waits for commands from the collector. The sensor publishes the sample to the topic `humidity_sample` as follows: $\{"node" : nodeID, "value" : value, "mode" : mode\}$, where mode is 0 if the automatic mode is on, 1 if the manual mode is active. The actuator subscribes to the topic `humidity_nodeid`. At the beginning the automatic mode is set and the single yellow led is switched on. The actuator can receive one of the following commands:

- **inc**: the humidifier is turned on in order to increment the humidity level and a red led is shown.
- **dec**: the dehumidifier is switched on in order to reduce the humidity level and the led is turned to red.
- **good**: the humidity level is in the range so the led is put to green.
- **off**: the humidity is handled manually, the single yellow led is turned off.

The *off* message is sent to the actuator when the button on the sensor is pressed. In this case the switching on of the humidifier/dehumidifier is leaved to the user. Switching back to the automatic mode, the single led is turned on.

2.1.2 Brightness

Two sensors sense data regarding the brightness in the room. The natural brightness data has been approximated using a Gaussian distribution that associates higher brightness values during the central hours of the day. Specifically, the peak of the Gaussian is considered at 1:00 PM, where the Gaussian takes on its maximum value, while the standard deviation has been set to 3.

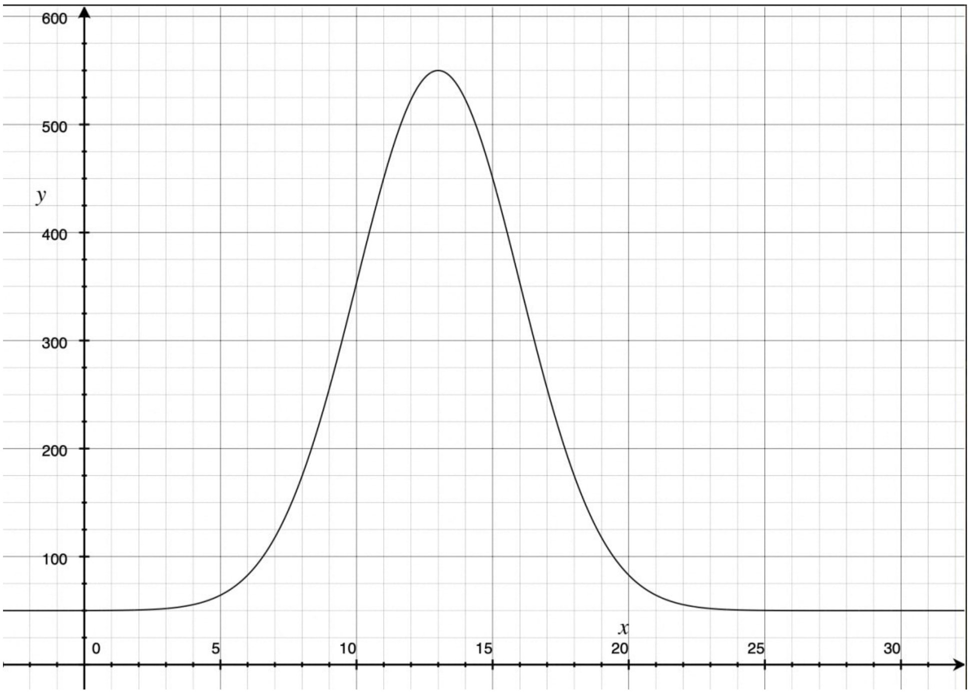

Figure 3: Brightness approximation with Gaussian

Basing on the data collected, the collector assesses if is necessary or not to turn the light on or switch it off. The sufficient brightness level is reached at 300 lux considering operative offices [2]. At the beginning the automatic mode is set and the single yellow led is switched on. The sensor publishes the sensed data with the topic `brightness_sample` as follows: $\{"node" : nodeID, "value" : value, "mode" : mode\}$, where mode is 0 if the light is off, 1 if it is on and 2 if the manual mode has been activated. The actuator waits for the commands subscribing at the topic `brightness_nodeid`. As in the humidity case, the actuators can receive different messages:

- **inc**: the light is tuned on in order to increment the brightness level. All the leds are turned on.
- **dec**: the light is switched off in order to reduce the brightness level. The leds are turned off.
- **off**: the brightness is handled manually. The single yellow led is tuned off.

The single led tunes back on while passing from manual to automatic mode.

2.2 COAP

Environmental factors, such as temperature, play a crucial role in shaping the overall workplace experience. Designed for constrained devices and low-power networks, CoAP facilitates the exchange of information in a resource-efficient manner. In this project, this protocol is employed as a communication protocol for devices that serve dual roles as both sensors and actuators in the temperature management system. Let's focus now on the design and functionality of CoAP-enabled devices, highlighting their role in ensuring a comfortable and adaptive thermal environment for optimal workplace conditions.

2.2.1 Temperature

Regarding temperature control, two devices serve both as sensors and actuators because in today's context, modern climate control solutions integrate advanced climate management functionalities. These devices, implemented with CoAP (Constrained Application Protocol) technology, are designed to monitor ambient temperature and, simultaneously, automatically adjust it based on occupants' needs. CoAP devices send temperature data to the Java collector for storage and analysis. The collector can communicate with CoAP actuators to regulate the temperature according to desired parameters [3]. Additionally, the manual management feature can be activated or deactivated through the button on the CoAP sensors, providing users with direct control over the climate system. The message sent from a sensor has the following format: $\{"node" : nodeID, "value" : value, "isAuto" : [0|1]\}$. The field `isAuto` is related to a global variable representing the manual or automatic mode.

The actuators can receive:

- **color=**`[r|g|b]`, that implicitly instructs the actuator about the current temperature status. If the color is red (r), it indicates that the temperature is too high; if it is blue (b), the temperature is too low, and if green (g), the temperature has returned to a comfortable level. The actuator responds by setting the LED to the corresponding color and appropriately adjusting the `recoverLevel` variable, signifying that the climate control system has been activated to either heat or cool the working environment.
- **mode=**`[auto|man]`, indicating that a the mode button has been pressed and so specifying whether the climate control system should operate in automatic (auto) or manual (man) mode.

2.3 Data Encoding

The choosen data encoding is JSON; all the data generated by the sensors have been sent to the collector as JSON objects. Indeed, due to the limited resources of the sensors, XML was too complex for the application needs. However, JSON is text-based, flexible and less verbose.

2.4 Database

The data collected from the sensors is stored in the database and analyzed through Grafana. The database is composed by two tables, one in which are present the sensors node id and their correspondent data collected, and one which contains all the observations of the different sensors. Both for temperature and brightness there are more than one device so, for this reason, in the observation table is stored also the node that has sent the sample.

Field	Type
id	int(11)
timestamp	datetime
value	int(11)
sensor	varchar(255)

Figure 4: Observation table

Field	Type
nodeId	varchar(255)
dataType	varchar(255)

Figure 5: Sensor table

2.5 Grafana

The Grafana web-based user interface has been developed to visualize the data stored in the database by the collector node. Each node has a dedicated section, featuring individual panels for each measured metric. In particular, this tool has been used to plot data collected during a typical working day in an office. The goal is to gain a visual understanding of how sensors and actuators operate to maintain the environment as stress-free as possible and manage any potential discomfort situations.

Figure 6: Humidity monitoring

Figure 7: Temperature monitoring

As depicted in Figures 6 and 7, the temperature and humidity can vary significantly. However, when they surpass the respective upper or lower thresholds, the actuators are promptly activated, and the values are adjusted to fall within the green comfort zone.

Figure 8: Light monitoring

Regarding light, Figure 8 displays the values of natural light that are sensed. When the natural light exceeds the specified maximum value, the lights automatically turn off as they are no longer necessary.

In conclusion, this project strives to create a sophisticated workplace environment that dynamically adapts to environmental conditions, prioritizing the well-being and productivity of employees. The implemented IoT system effectively monitors and regulates humidity, brightness, and temperature, providing a comprehensive solution for workplace stress management.

References

[1] Humidity in office. https://www.alitec.it/microclima-ambienti-di-lavoro-temperatura-aria-umidita/#:~:text=L%20umidit%C3%A0%20ideale%20in%20ufficio,degli%20ambienti%20lavoro%20in%20estate.

[2] Lux in office. https://www.luxi.lighting/la-normativa-uni-en-12464-1-per-lilluminazione-degli-uffici/.

[3] Temperature in office. https://www.bruneau.it/it/mag/freddo-in-ufficio#:~:text=Tuttavia%2C%20in%20generale%2C%20la%20temperatura,40%25%20e%20il%2060%25.