




# Real-time Monitoring and Controlling of Internal Parameters for Smart Buildings

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**Abstract.** Health risks caused by air contamination have become increasingly worrying, especially when it comes to indoor air quality (IAQ), where there is a lot of concentration of gases such as carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and volatile organic compounds (VOC), and it is where people spend the most part of the day. With that in mind, this article presents a research that is being done in the area of intelligent building automation, which aims to develop an IAQ monitoring and control system using internet of things (IoT) technology. For this, some sensor modules will be connected, such as the BME680 and the AMBIMATE MS4, to the ESP32 microcontroller that will send the collected information to the monitoring and data storage platforms using the Message Queuing Telemetry Transport (MQTT) data exchange protocol through of the Node-RED online tool. With this device, in addition to being able to monitor the internal parameters of the environment where it is installed, it will be possible to detect any adversity that may arise in the place and providing autonomously an output signal that can trigger an actuator capable of stabilizing the system, that is, without the need for any human action.

**Keywords:** internet of things · IAQ (indoor air quality) · environmental monitoring.

## 1 Introduction

The increase of pollution in urban areas has become increasingly worrying. According to the World Health Organization (WHO) it is estimated that more than 90% of the world's population breathes polluted air [12]. People spend most of the time in closed environments, whether at home, at school or at work, where they are often exposed to substances that are harmful to health such as CO, CO<sub>2</sub> and VOC [9], so the control of IAQ is very important.

This article presents a research that is being carried out with the aim of developing a device that is able to monitor and control air quality and safety parameters inside of smart buildings, as well as temperature, humidity, pressure, CO<sub>2</sub>, VOC, among others, in order to promote a better quality of life for people who suffer from health problems caused by poor air quality.

## 2 Related Works

IoT technology and building automation has been important themes in academic research in recent years, in this section, the studies being carried out in the areas of IoT

and smart buildings will be presented and evaluating what has already been done, in order to show the value of this work in relation to this area of research.

In table 1 query results from Google Scholar, IEEE Xplore™ and ScienceDirect using keywords like IoT, Smart Buildings and Monitoring Systems are presented. Only results from 2017 onwards were considered.

Table 1: Results of systematic literature review.

Key words	Google Scholar	IEEE Xplore™	ScienceDirect
IoT	218 000	37 162	20 373
Smart Buildings	409 000	8 969	47 377
Monitoring Systems	959 000	56 128	691 069
IoT and Smart Buildings	16 800	595	6 852
IoT and Monitoring Systems	43 000	6 887	13 097
Smart Buildings and Monitoring Systems	17 600	483	23 943
IoT and Smart Buildings and Monitoring Systems	17 000	187	5 445

The data presented in the table 1 show that there is a large number of research being developed on the keywords, even when looking only for studies that involve the whole set (IoT and Smart Buildings and Monitoring Systems). However, most of this material only develops the monitoring of parameters present in buildings and only a small portion of the studies present an application of control and action on the data collected by the sensors responsible for monitoring. In [10] is presented an Internet of Things (IoT) based smart controlling system to save electricity consumption of air conditioners, including smart meter, smart gateway, and cloud computing modules that is able to realase the monitoring in the real-time. In [6] several arguments are presented for the introduction of IoT systems in order to assess the environmental quality of buildings. The architecture proposed by the authors constitutes a set of integrated sensors, capable of measuring ambient temperature, humidity, atmospheric pressure and detecting volatile organic compounds. This group of sensors was connected to a microcontroller, which periodically sends the sensor data to a server, making it possible to access the collected data from a web portal. The tests performed were in a laboratory environment, similarly to what is being done in this proposed work, however, in the evaluated article, performances in the environment were not demonstrated. As the ability to act in the environment is an essential component of a flexible and robust IoT architecture, in the proposed work, it is expected to present at the end of the work a control system capable of sending output signals to actuators as needed by the system.

### 3 Research proposal

This work aims to develop a module capable of monitoring IAQ and fire, through information stored in a database, apply machine learning techniques in the system so that it can recognize possible adversities present in the parameters that are being measured and in response, emit an output signal that can be routed to an actuator.

The research material developed so far is presented below, as well as the proposal of what is still intended to be developed.

### 3.1 Work development

Figure 1 presents an overview of the system comprising the IoT module, sensors, actuators, communication protocol, cloud storage system and data analysis system. The sensors used for IAQ monitoring will be the BME680, a 4-in-1 digital sensor measuring gas, humidity, pressure and temperature [2], and the AMBIMATE MS4 module, used to detect characteristics of indoor environments, uses a set of sensors capable of measuring temperature, humidity, ambient light, motion, VOC and CO<sub>2</sub> [11]. For fire monitoring, the MQ5 gas sensor for smoke detection [13] and an IR sensor that uses a highly sensitive infrared receiver to detect the flame spectrum will be used.

The parameters measured by the sensors are read by ESP32, a high-performance, low-energy microcontroller that features a low-power microprocessor, 52 kB RAM and built-in flash memory, as well as support for WiFi and Bluetooth networking [4]. The architecture of this device allows it to be programmed independently, without the need for other microcontroller boards like Arduino [1], for example.

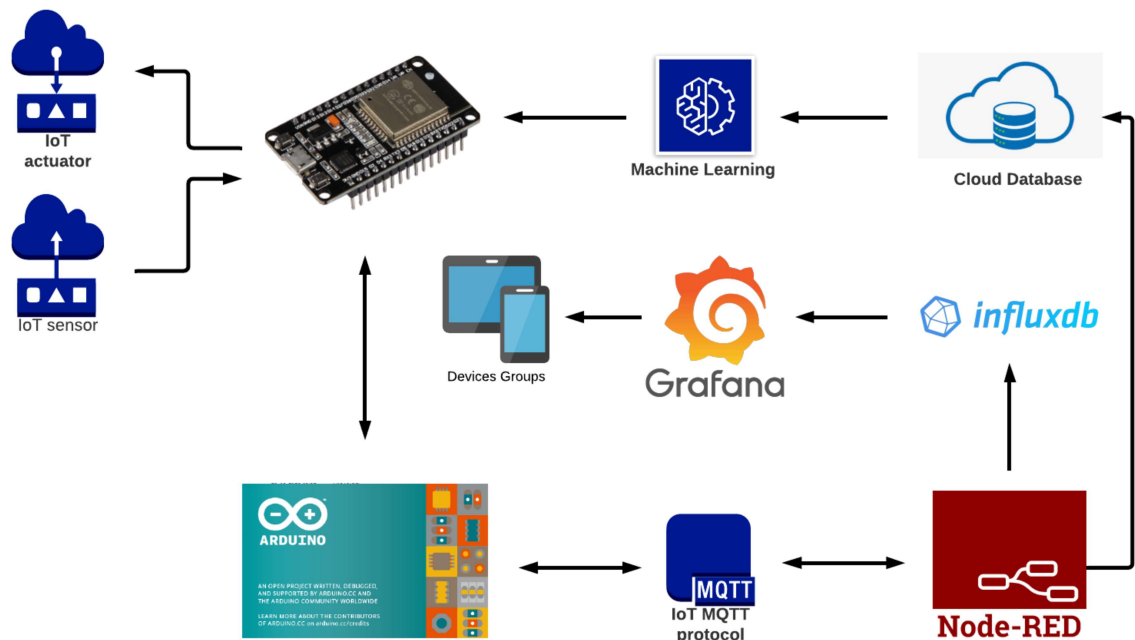


Fig. 1: System architecture.

In figure 1 the communication protocol responsible for the exchange of information between the microcontroller and the monitoring and data storage platforms is the MQTT (Message Queuing Telemetry Transport Protocol), a standard Publisher/Subscriber messaging protocol, widely used for Machine-Machine (M2M) communications in IoT contexts, due to its easy implementation [7]. This protocol was chosen for the development of the work considering that the program used to implement the control rules, Node RED, an open source tool used to connect devices and online services [3], already

had a node referring to the MQTT , semi configured, making it the most practical choice. Information sent to Node-RED via MQTT is stored in InfluxDB, a database optimized for fast storage and availability for retrieving data from IoT sensors and real-time analytics [8].

The monitoring of the parameters being measured is done through Grafana [5], a data analysis web application used to create monitoring panels, often used in combination with time series databases, such as influxDB.

While the database does not have enough information to be used, machine learning methods will be studied in order to obtain a system capable of recognizing any adversity that may arise in the environment being monitored and providing an output signal that can trigger an actuator capable of stabilizing the system.

## 4 Conclusions and future work

As new technologies emerge in the areas of IoT and automation, it is possible to develop monitoring systems that are increasingly cheaper, simpler and more effective. The results of the present study show that many low-cost sensors have the potential to be used to provide a safe indoor environment. Projects like this have increasingly shown the importance of this area of research in people's quality of life.

The work presents a sensor module for monitoring IAQ and fire where the information collected will be stored in a database and later will use machine learning to implement the control part of the system.

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