# Optimal Monitoring of Server Rooms with Home Assistant Platform

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**Abstract.** High-performance IT systems with high computing power resources, used especially for processing large volumes of data or performing laborious calculations at significant speeds, are installed in special server rooms. Such a room specially built for High-Performance Computing systems, also called HPC, involves soundproofing and fireproofing of the walls, air conditioning equipment, as well as permanent monitoring of the room with a series of sensors, among which can be mentioned: temperature and humidity sensors, smoke sensors, air quality sensors, water and flood sensors, motion sensors, video cameras for real-time remote viewing. Given the wide variety of smart devices on the market equipped with such sensors, it is advisable to choose a suitable software environment, which offers the possibility to integrate, monitor, and control all these smart devices. One of the most popular free, open-source automation applications is Home Assistant. This software platform brings an improvement in the server rooms through the capabilities of monitoring, automation, and notification of events through text messages (email, SMS) or acoustic and video alerts. The paper presents an IoT implementation of a server room monitoring system, applied at INCD INSEMEX headquarters.

## 1 Introduction

In situations where workloads require complex calculations or analysis of large data in a short time, data processing is performed simultaneously using unified servers in a High-Performance Computing (HPC) system (Figure 1).

A High Performance Computing cluster is a scalable system with multiple interconnected components. This system is based on normal commodity hardware, a private network for provisioning, monitoring, and tasking, a high-speed network for application communication, plus a software infrastructure based on protocols, operating systems, file systems, cluster administration, and monitoring tools, and load level management tools, libraries, compilers and, finally, applications.

HPC can be applied in many fields, such as mechanical engineering (design and manufacturing), electronics design, natural sciences (including weather forecasting and

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mapping or natural resource management), medicine, finance and investment (e.g., risk analysis), security and defense, and everything related to scientific research. Today, more and more companies and research institutions are moving towards increasing productivity by providing time-efficient solutions to problems and challenges.

The problem with high complexity modeling is the excessive processing time. This major impediment is particularly characteristic when simulating, for example, fires or explosions occurring in enclosed spaces, civil or industrial buildings, due to the complexity of the simulated phenomenon, generated by multiple factors such as the dimensional and structural complexity of the real geometry, the presence of numerous potentially combustible sources, materials with different fire behavior properties, etc. By using distributed cluster processing, the optimal choice of hardware configuration and efficient parallelization of software application code, the time required to simulate highly complex phenomena can be drastically reduced from months to days or even hours.

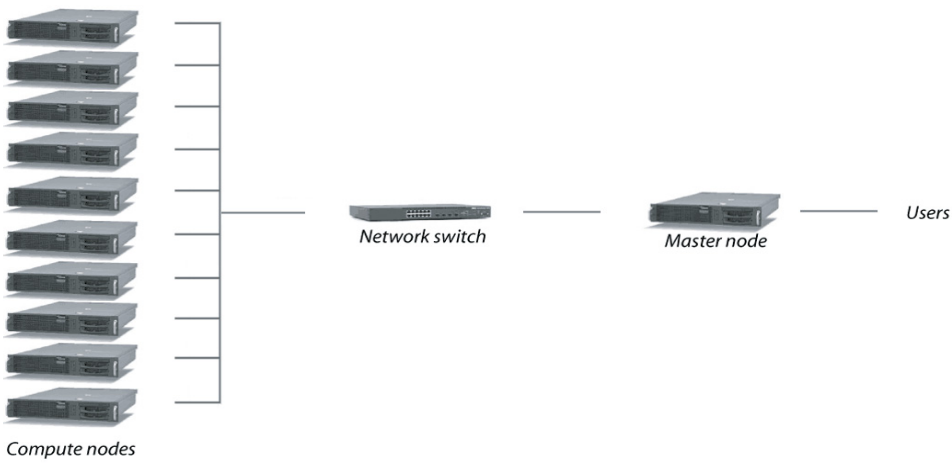


**Fig. 1.** The simplified, general layout of an HPC cluster.

Distributed data processing by performing complex computations requires high-performance hardware resources, which in turn lead to significant power consumption. HPCs and server racks produce heat inside a room, heat that needs to be dissipated, monitored, and controlled by optimal technical cooling solutions [1]. One of the main factors directly affecting energy consumption is the climate through its impact on the room environment [2]. For proper operation of computing systems, the recommended temperature range for the server room is between 18 - 24 °C, the ideal temperature being 20-21.5 °C [3, 4].

The ideal humidity of a room, even for a server room, is between 40-60%. Below this threshold, lower values are known to bring electrostatic charge build-up and above the ideal value, condensation occurs with an impact on the oxidation process of components.

A data center room can be efficiently cooled with the help of air conditioners or HVAC systems. In addition to these air conditioners, rooms are generally equipped with fire protection systems and have soundproofed walls more than a normal working office. Cooling capacity is essential to ensure the reliable operation of computers and other network equipment [5]. Equally important is real-time warning or notification of problems and redundancy of the cooling system [6].

Maintaining microclimate parameters within the recommended range for such applications is mandatory. To achieve this, the server room must be monitored with several temperature and humidity sensors, placed at key points inside the room. In addition, these sensors can also be placed in the vicinity of server racks, as the temperatures in these areas are higher than in the ambient environment. For effective monitoring, these sensors need to operate centrally, forming an ecosystem that allows 24/7 monitoring of the parameters read and can notify specialist staff of any changes or faults in the HVAC system [7]. Today, there are a wide variety of monitoring solutions available on the market, with multiple benefits, but involving significant costs in purchase and implementation, in most cases.

The paper presents a solution developed in-house, using temperature, humidity, and air quality sensors, integrated via the open-source IoT (Internet of Things) platform Home Assistant, a scalable solution, configured according to the actual requirements and the configuration of our server room.

## 1.1 Home Assistant Platform (HA)

IoT represents today one of the fastest growing areas of information technology. It can be defined as a system of interrelated devices (computers, mechanical and digital machines, sensors, objects, users) with a unique identifier (UID), having the ability to communicate and transfer data over a network (or over the internet), often without requiring human interaction [1, 8].

An IoT ecosystem contains smart devices that use embedded systems with processors, different microcontrollers, sensors, and communication hardware, to collect, analyze, send, and act on data they acquire from their working environments. IoT gateways or edge devices collect the sensor data, and either analyze them locally or sent them to the cloud for further processing and decision-making for command and control actions.

The Home Assistant Platform is a free, open-source, global client-server software developed by automation enthusiasts around the world, to unify intelligent equipment from an IoT environment [9].

Any IoT device is composed of one or more sensors with the possibility of connecting to the network via cable or Wi-Fi [10]. Such smart electronic devices can communicate with each other using HA addons. On the website https://www.home-assistant.io/integrations/ there are currently more than 1900 addons (Figure 2).

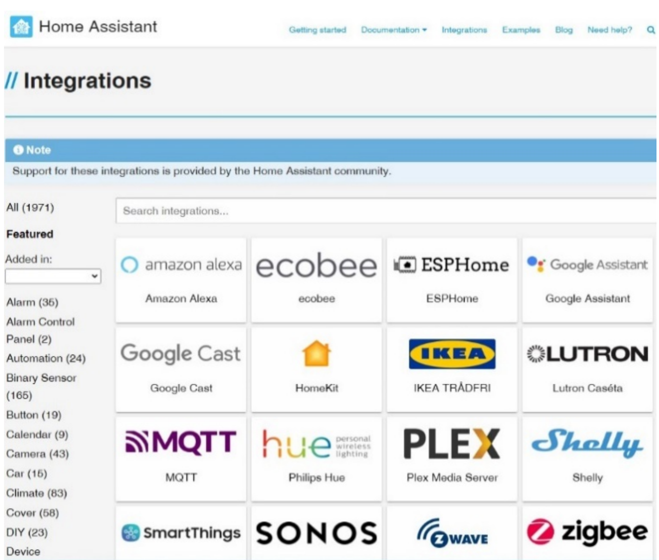


**Fig. 2.** Home Assistant Integrations (add-ons), tested and recommended by the developers.

Interfaces and the main dashboard in Home Assistant can be configured and customized according to everyone's needs.

If the option of purchasing smart devices configured in the manufacturer's specific cloud service is chosen, they can be integrated into the HA using add-ons (Figure 3).

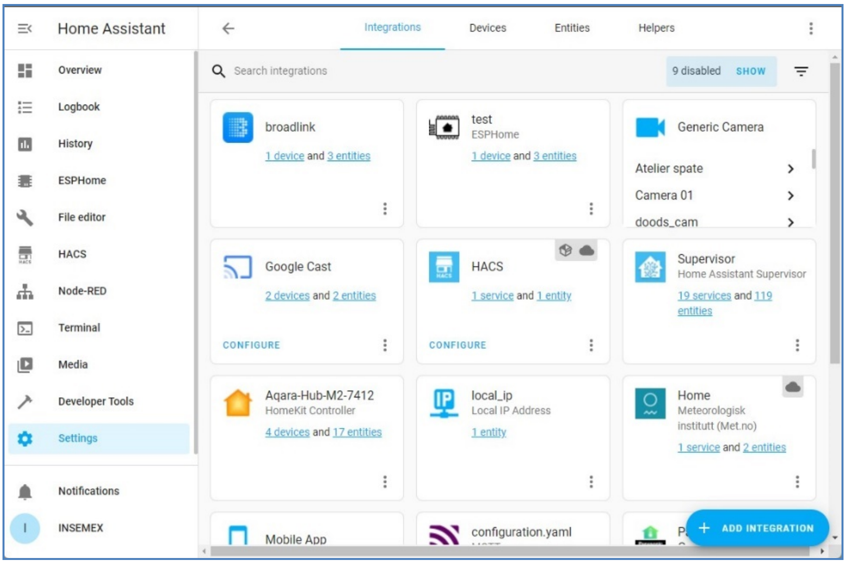


**Fig. 3.** Home Assistant Add-on Store.

Home Assistant integrated devices can trigger automation, and send event notifications, through a variety of methods: email, text messages, and mobile phone notifications with the *notify.events* platform. Any change in the current state of a sensor in the system will trigger an event, which is recorded in the history log.

The immediate response trigger for automation, the customizable interface, and the high degree of security make HA the most popular automation software.

Similar to other automation platforms such as OpenHab or Domoticz, Home Assistant even allows rewriting the proprietary firmware of integrated devices with other monitoring and control software. The most widely used, relatively simple configuration systems are Tasmota and ESPHome, which are extremely flexible and friendly for any compatible smart home application.

## 2 Server room

Our institute is using two HPC cluster system configurations, of different generations, composed of a central management node, computing nodes, network storage, and high-speed, low-latency networking. The two metal cabinets are placed in a well-ventilated room, with soundproof walls and access door, with fireproof properties. The interior climate is assured by two air conditioners dedicated to the server rooms, which can ensure continuous, uninterrupted operation even in low outside temperatures of -20 °C (Figure 4). This room is continuously monitored with temperature and humidity sensors, smoke detection sensors, motion sensors, and remote, real-time visual surveillance.

**Fig. 4.** The placement of air conditioning units.

The current room is intended for the data center and can accommodate INSEMEX's information and telecommunication infrastructure, in the condition of maximum safety and availability. In this specially designed space, acoustic discomfort is significantly reduced, ensuring efficient room cooling and fire safety.

The system consisting of the two air conditioners in the server room is autonomous and cannot be turned off remotely via an IoT platform or app. Through a special interface, redundancy and backup of the two units are ensured, either through its own, integrated algorithm, external, third-party solutions, or dry contact relay management.

## 3 HPC cluster computing system

The technical and scientific fields of fire/explosion safety are nowadays increasingly, based on the knowledge of computational fluid dynamics theory, i.e. fire and explosion models and their consequences, involving multiple physicochemical processes such as combustion, pyrolysis, heat transfer, thermal radiation, turbulence, fluid dynamics, etc. Simulation of complex scenarios of these events with unintended and often severe consequences relies on the use of HPC systems, which allow parallel, distributed processing on multiple computing cores.

The hardware configuration is required to process and store data during computer simulations performed using the ANSYS Multiphysics software suite. The HPC computing system is optimized for clustering (multiserver parallel processing), tested, and certified for the ANSYS Fluent solver. The system also allows running in cluster mode the computer simulation of fires, using the Thunderheadeng Pyrosim software application and the specific CFD (Computational Fluid Dynamics) techniques provided by the open-source FDS (Fire Dynamics Simulator) package.

The two configurations of HPC systems used in our institute are of the blade type. The blade chassis provides support for 10 blade servers, integrating four redundant N+1 3000W hot-swap power supplies, the ventilation system, and the Infiniband FDR 40 / 56 Gbps switch and 1 Gbps Layer 2/3 switch communication equipment and the centralized enclosure management module (Figure 5).

**Fig. 5.** HPC cluster systems in INSEMEX.

The activity of each HPC cluster is controlled by a master server, with superior hardware configuration, and the communication between the two clusters is done by low speed and low latency connection, FDR 40 / 56 Gbps, and the external connection is gigabit (1000 Mbps). The server room also hosts the equipment that provides the external Internet connection, gateway servers, domain and file servers, etc.

## 4 Server room sensors

Continuous monitoring of the server room is carried out by two temperature and humidity sensors, a smoke detection sensor, an air quality monitoring sensor, and two video surveillance cameras with infrared and acoustic motion alerts.

Two smart Wi-Fi sensors are used to detect the temperatures in the room environment: Aqara AAQS-S01 (Figure 6.a) and WSDCGQ11LM (Figure 6.b). In case of possible malfunctions, parallel temperature readings from several sensors highlight differences in sensor readings.

Also, as in our case, a wide variety of sensors can be connected to a single dedicated gateway, using Zigbee 3.0 protocol, which permits up to 128 devices based on the fastest, most stable, and energy-efficient technology. The new Aqara Hub M2 gateway (Figure 6.c) is compatible with Aqara Home, Apple Homekit, and Google Home ecosystems. It is a smart device, with high stability if used in the cloud that can be connected to the network via Wi-Fi or Ethernet cable [11].

Temperature readings are monitored and programmed in Home Assistant for critical condition detection. Such parameters allow automation directly in HA or with the Node-RED programming tool. This is a browser-based flow editor using a wide range of nodes from the built-in palette or library. Through these nodes, data streams are passed between hardware devices in the network [12].


a b c

**Fig. 6. a)** Aqara Hub M2 Gateway; **b)** Aqara AAQS-S01 intelligent air-quality sensor; **c)** Aqara WSDCGQ11LM intelligent sensor.

The Aqara AAQS-S01 smart sensor (Figure 6.a) is used for air quality monitoring. Being a stable triple smart sensor, it can correctly measure air temperature and humidity and is compatible with a wide range of apps such as Google Assistant, Apple HomeKit, and Amazon Alexa [13].

Most of the sensors mounted for temperature and humidity monitoring in the server room are Aqara's smart sensors, model WSDCGQ11LM (Figure 6.b). They work only with an Aqara compatible Hub and provide a very good resolution of +/- 0.3 °C [14].

All sensors used for temperature and humidity monitoring are portable, easy to mount anywhere in the room, and are powered by a standard CR2032 battery with up to 2 years of battery life.

For smoke detection, the chosen device is the MQ-2 sensor, (figure 7) originally designed for Arduino projects, which has high sensitivity and detects several types of gases such as LPG, i-butane, propane, methane, alcohol, hydrogen, and smoke. For collecting and transmitting Wi-Fi data on stale air (smoke), the MQ-2 sensor [15] connects to the popular module in the IoT world called WEMOS D1 Mini MCU (Figure 8), which is based [16] on the ESP-8266EX integrated circuit.

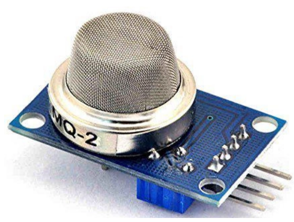


**Fig. 7.** MQ-2 Gas Smoke Sensor Module.

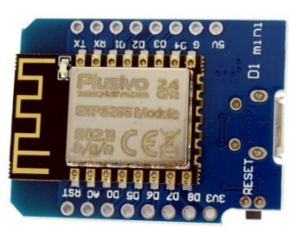


**Fig. 8.** Wemos D1 Mini-Esp8266 development board.

For remote surveillance inside the server room, the Aqara G2H PRO smart camera (Figure 9) is used. The camera is an indoor surveillance camera, which features AI facial recognition technology and is compatible with the European Aqara Home and HomeKit ecosystem [17]. In the monitored premises, two temperature and humidity sensors are connected to this camera, thanks to the built-in gateway with Zigbee technology. Through its smart functions, it can send alerts on a selected area in the field of view, allows real-time conversation thanks to the built-in speaker and microphone, and supports Full-HD resolution with an angle of up to 140 degrees.

**Fig. 9.** Aqara G2H PRO smart camera.

## 5 Server room monitoring and automation with the Home Assistant platform

Most of the smart devices installed in the local network are automatically detected by HA and can be easily integrated.

In the server room, the two air conditioner units, AC1 and AC2 are connected to a custom split programmed interface. Programming consists of reaching the set room temperature threshold, in our case 21 °C with only one unit running (called the Master unit). This is an optimal operation, performed alternately between the two air conditioners (cascade mode, Master/Slave configuration). If the threshold temperature of 21°C is exceeded, the air conditioners will operate at the same time, providing the necessary airflow for the fastest possible cooling (overheating protection of the room air). At the same time, in case of failure or unintentional interruption of the operation of one AC unit, the alarm status is activated, and the other unit automatically starts operating. Switching, i.e. viewing the real-time operation of the two units can be seen in the main HA window (Figure 10).

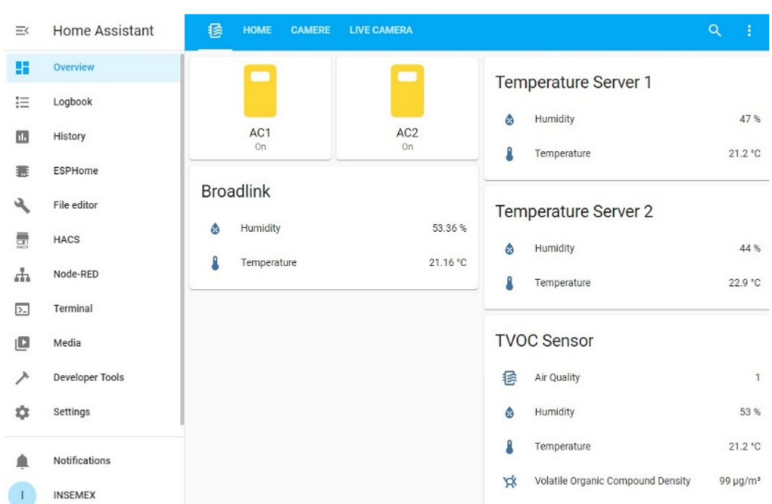


**Fig. 10.** Main window (dashboard) of HA, with the 2 air conditioners, AC1 and AC2.

In the event of a major fault, when both air conditioners are completely switched off, Home Assistant records and sends an alert/notification message, in our case to 3 mobile phones (Figure 11).

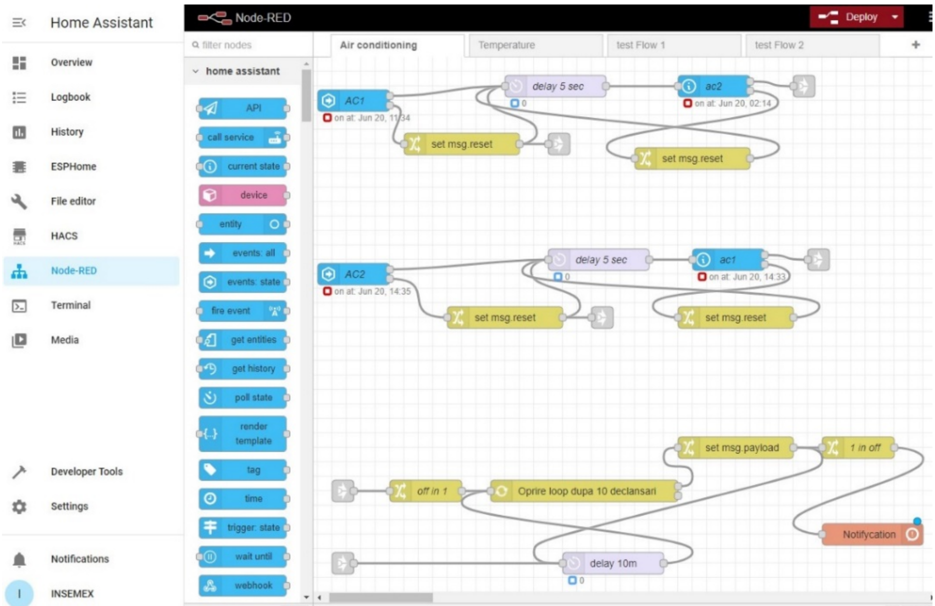


**Fig. 11.** Automation made in Node-RED for checking the operating status of AC1 and AC2.

Similarly, if the ambient temperature in the server room rises above the set value of 26 degrees Celsius, messages are sent to the smartphone (Figure 12).

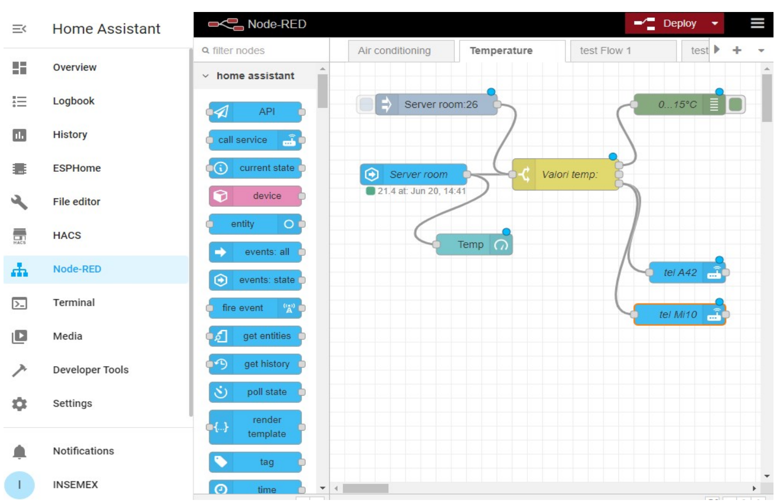


**Fig. 12.** Notification and alarm sent by Node-RED, if the ambient temperature is higher than 26 °C.

Home Assistant allows several connection ways between integrated and monitored sensors: directly from HA, or through other programming tools (addons) such as Node-RED. For message and notification sending, the *notify.events* platform is used (https://notify.events/en). In the absence of this platform, messages and alerts are received only if the HA application is installed on the smartphone. It should be mentioned that this is just a way of sending messages/notifications, there are various other options: by SMS text messages, by email, or through popular applications such as Whatsapp or Telegram.

Video images are received from the Aqara G2H PRO smart cameras, which can be integrated directly into the HA. In the beginning, the option of using the proprietary application from the Aqara manufacturer, called "Aqara Home" was chosen (Figure 13).

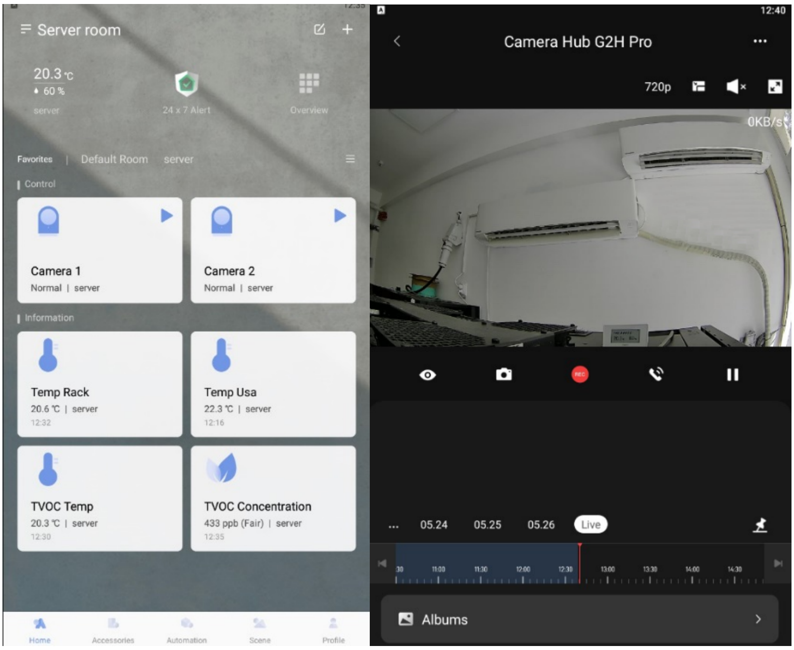


**Fig. 13.** Mobile application for monitoring the two air conditioning units.

## 6 Conclusions

Generally, there is no permanent staff in the server room due to the high noise level of over 80dB and the special temperature and humidity conditions. Special monitoring equipment, tested and periodically verified, is recommended for the permanent checking and supervision of the room.

Both the hardware and software components for smart monitoring devices are a high priority in which the known advantages and disadvantages must be considered, and the connection to the online environment used for remote communication is necessary and depends on several factors. The transmission of sensor data, even if only for informational purposes, must primarily be done in a private environment with a high response speed and simple event identification.

Additionally, a general fire alarm system for offices and adjoining rooms, independent of the Home Assistant infrastructure, is an additional advantage in terms of monitoring conditions in the server room.

No special training is required to create and configure an HA platform. HA software is recommended for users who are passionate about open source automation, offering a high degree of security and safety in operation.

The HA platform can be easily customized and deployed, taking intelligent device automation to the next level, from the simplest switch monitoring and control commands to the most complex automation executed without operator intervention and taking into account multiple sensor states.

The logs containing the values read by the sensors can provide information about the evolution of microclimate parameters over time and can indicate the efficiency of the current air conditioning system or the need to upgrade it as the server infrastructure develops. As a future development, it is planned to implement a controlled access system for the server room, to allow authorized staff only, using modern technology with individual access codes and video identification.

We believe that the implementation of the automated server room monitoring system, in the form presented above, adds value in terms of ensuring the optimal functioning of HPC systems. The possibility of integrating, under a single control and monitoring interface, all sensors and smart devices and easy access, either from the website or from the HA application, is an obvious advantage of using this platform.

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