IoT System for Monitoring Conditions in the Human Environment

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ABSTRACT: *The human health environment is studied with the help of the influence on the quality of the human environment. The significance of the environment on human health and his working and living activities requires the constant tracking of the ecosystem changes. This paper intends to find the reasons for the environmental degradation and act upon them. We have proved that the Internet of Things devices represent the ideal means for monitoring parameters that determine the quality of the environment. The link or synergy between the Internet technologies is well suited for gathering information about the environmental status, as well as the time and place of its changes.*

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I. Introduction

The Development Of Semiconductor technology has enabled the realization of many concepts in the area of computer science and telecommunications. At the same time, the Internet has brought a revolution to human communication. The Internet was preceded by the ARPA network [1]. Since the WWW (World Wide Web) Internet realization, the Internet has become the communication platform as it is used today [2]. Simultaneously, new concepts in computing have emerged. One of them is IoT (Internet of Things) [3][4]. IoT devices revolutionized the ways of data gathering and distribution to the end users. With this concept, it was made possible for different physical devices to become part of the Internet. The IoT devices possess relatively large processing power, small dimensions, and low power consumption.

The emphasis has to be made on the possibility of wireless connections. With this in mind, the IoE (Internet of Everything) concept has become popular [5]. IoE means that every device, including the human itself, can be connected to the Internet. By adding sensors to the IoT devices, they become systems for measurements and data acquisition. On the other hand, by adding actuators, the IoT devices become Internet controlled elements. For these devices to work as intended, it is necessary to have corresponding Internet applications. The IoT devices have made their application in the areas of health care, agriculture, environment protection, and industry [6].

The technological and industrial development also had some negative impact on the human environment [7]. The emission of large quantities of CO2 gas is one of the main causes of the global warming process. The bad management in the application of modern technologies and lack of control have contributed to the high level of environmental pollution. As the consequence of the large industrial activity, the extortion of the natural recourses, such as coil, oil, and wood is happening. In the process of burning off these resources, the large amount of toxic gases and materials is produced. At the same time, by cutting the forests, the possibility of toxic gases absorption is reduced, and the conditions for landfalls and floods are emerging.

The importance of environmental degradation requires making actions on its identification and prevention. With this in mind, the organizational and technical actions can be made. The organizational actions require the change in human behavior, as the most important factor in environment pollution. These would be the cheapest and the most effective actions, but the practice has shown that these changes are very slow. That is why technical actions are necessary. They include the identification of the factors affecting the environment the most, with the places where it is occurring.

IoT devices have shown to be the ideal platform for monitoring support of the parameters that define the environment *quality* [8][9]. The IoT devices characteristics enable the remote usage of these systems. It was made possible by implementing battery power and different communication capabilities. It is of great importance that IoT devices possess the possibility of wireless connection to the Internet.

This paper shows the example of the IoT device project that can be used for monitoring environmental parameters. The proposed system has a great level of generality, because of the possibility of adding different sensors to the same computer platform, without making changes to the device communication subsystem. This IoT device has capabilities for temperature, humidity, and CO_2 levels indoors monitoring.

The remainder of the paper is organized as follows. In the second section, the influence of CO_2 levels on the human environment is described. The main emphasis is given to the indoor conditions, and brief literature review with some conclusions and recommendations regarding allowed CO_2 levels are given. The third section describes the practical implementation of the IoT monitoring system, which is consisted of a Wi-Fi capable module with sensors for measurements of CO_2 levels, and temperature and relative air humidity. The final section brings concluding remarks.

2. The Influence of Co_2 Levels on the Human Environment

The indoor CO_2 concentration has greater value than outdoor concentration since humans directly produce CO_2 in the process of respiration. The ventilation systems require additional power consumption. The CO_2 levels outdoors usually are around 380ppm (parts per million), while in urban surroundings this value is somewhat greater and is around 500ppm [10].

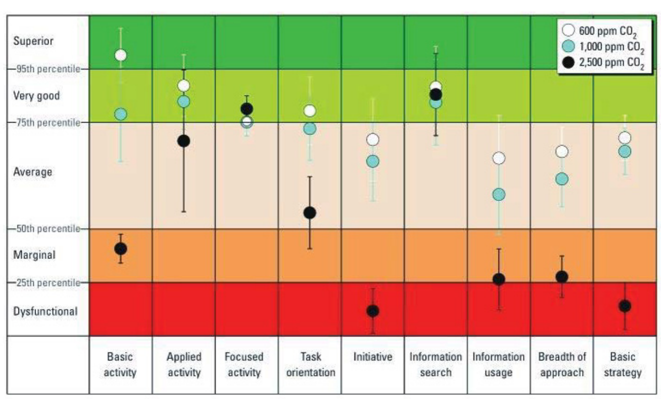

Figure 1. Impact of CO_2 concentrations on human decision-making performance [12]

The indoor CO_2 concentration is beginning at the values for outdoor levels and up to several thousand ppm. The significant importance on human health have concentrations over 20,000ppm. For indoor values, it was common consideration that CO_2 levels up to 5,000ppm do not have significant importance on human health, perception, and working performance. However, the research conducted in Hungary, published in 2003, questioned this hypothesis [11]. These authors presented that controlled exposure to the CO_2 concentrations between 2,000ppm and 5,000ppm had small negative impacts on human activities, but the description lacked details. The aforementioned data have inspired authors of [12] to investigate the influence of the different CO_2 levels on human cognitive behavior.

The results of this research are given in Fig. 1. The cognitive performances of the test subjects were diminished in 6 out of 9 observed parameters, with a CO_2 concentration of 1,000ppm, as opposed to the performance on 600ppm CO_2 levels. With CO_2 concentration of 2,000ppm, the 7 out of 9 parameters were diminished, as opposed to the performance on 600ppm CO_2 levels. The percentages on some parameters were degraded to the dysfunctional levels, shown in red in Fig. 1.

The research in [12] indicates that indoor CO_2 concentration can reach levels that can have a significant impact on human activities and decision-making performance. This is why is of great importance to track CO_2 levels in order to establish proper working and living conditions, and on the other hand, to determine optimal ventilation system support.

Indoor air quality not only affects human health but also human behavior. In [13], the laboratory conditions adapting to the experimental needs were observed. The system for monitoring laboratory conditions was realized with adequate sensors and low-cost microcontrollers, and based on IoT system architecture. The wireless module used was ESP8266. The data acquisition system is supported by web and mobile applications. This system has the capability to notify the users that laboratory conditions have changed and need improvement.

The authors of [14] presented the system for IoT monitoring of CO_2 levels as air quality indicator. The presented system gave satisfactory estimations of the indoor air quality. It also supported the possibility of alarming if the air quality was unsatisfactory.

CO_2 monitoring was used to track elder persons' activity and indoor presence in [15]. Based on the CO_2 values, one can determine if the room is empty. If there is no one in the room, the CO_2 levels are near 650ppm, while if there is one person in the room, the CO_2 levels are around 850ppm. This change in CO_2 levels can be used to determine if a person is present in the room.

Fire prevention is another important factor for measuring indoor CO_2 levels. IoT based system for smart houses is presented in [16] and is based on the wireless sensor networks in order to early detect fire.

3. IoT Monitoring System Description

There are many sensors for CO_2 measurement that use NDIR (nondispersive infrared) principle and that are sufficiently precise. Their price is near $40, while the sensors such as VERNIER CO2-BTA [17] have the price of near $340. Because of its good characteristics and low price, for the presented model, the MH-Z19 [18] sensor is used (Fig. 2). This module has small dimensions and uses NDIR technique for CO_2 air detection.

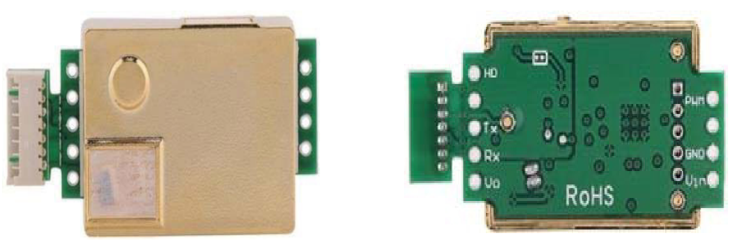

Figure 2. MH-Z19 sensor, frontend and backend

There are two variants of this sensor with different measurement ranges. One has the range from 0ppm to 2,000ppm, while another has the measurement range from 0ppm to 5,000ppm, with adequate temperature compensation. The working voltage of the module is from 4.5V to 5.5V, while the interface voltage level is at 3.3V, but also supporting the 5V levels. The dimensions of the module are 33mm × 20mm × 9mm (L×W×H), which is shown in Fig. 3.1

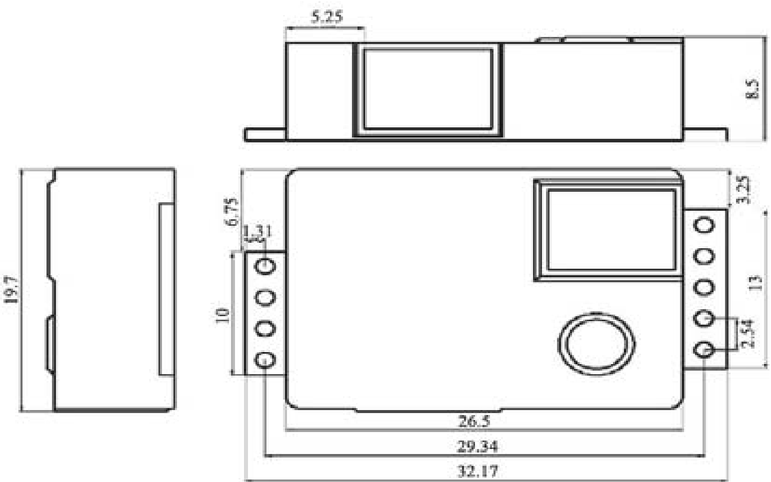

Figure 3. MH-Z19 module dimensions with measures in millimeters

The appearance of an IoT node used for monitoring environmental conditions is shown in Fig. 4. The system is based on ESP8566-12E module that has Wi-Fi connectivity to the Internet. This module is connected with the MH-Z19 CO2 sensor and DHT21 sensor for measuring temperature and relative air humidity.

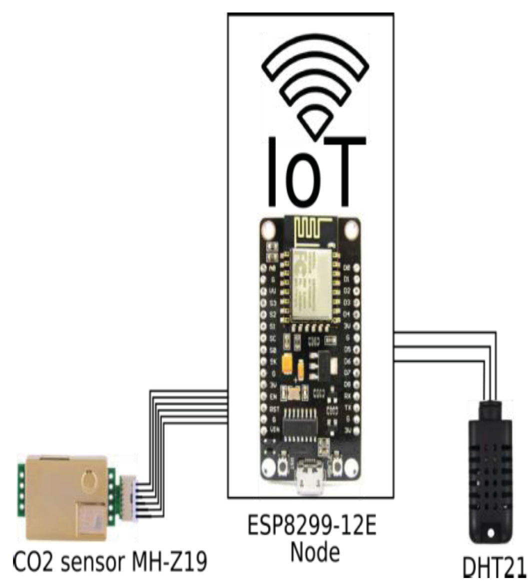

Figure 4. IoT node with ESP8299-12E module, MH-Z19 CO2 sensor, and DHT21 temperature and relative air humidity sensor

The measurements of CO_2 levels, temperature, and relative humidity are taken at certain time intervals and distributed to the server on the Cloud. The data can be accessed with a corresponding web application where users can view chronological measurement data. Based on these data, users can take appropriate actions and recommendations. Depending on the type of the room, a number of persons in it and time spend indoor, the CO_2 concentration levels can be used to improve air quality in the room.

The acquired data from the system indicated that in ventilated rooms CO_2 concentration is near 640ppm, while if there are persons present in the room, the CO_2 levels can reach 1,200ppm. The goal of the realized system is to monitor the environmental conditions and gather information especially in cases where CO_2 levels reach 2,000ppm. This is the case when several persons are present in the nonventilated room for some time.

The realized system can give clear indicators of the indoor air quality. This should be enough for users to take actions upon these results to ventilate the room. In this way, the optimal ambient conditions can be achieved, which may lead to a positive influence on working and living surrounding.

4. Conclusion

The technological development has both positive and negative impact on human life. It is especially seen in environment quality degradation. Global warming and toxic gases emission are just some of the consequences of modern technologies usage. The monitoring of the parameters that identify the degradation of the environment has become practically imperative. Likewise, the possibility of locating the place where the environmental changes occurred is also very important.

The development of the intelligent sensors has greatly impacted on the environmental quality monitoring. The possibility of wireless communication can be here emphasized. The IoT systems further support environmental quality monitoring by being able to send raw data and make them publicly accessible on the Internet. With this in mind, the conditions have developed that lead to the open data system, for access by all the interested parties.

The realized example of IoT device, shown in this paper, has specifically emphasized the role of CO_2 monitoring, beside the temperature and relative air humidity. The CO_2 concentration levels are very important in determining the conditions in which people can live and work, without any hazards on their health and cognitive behavior. This IoT system is modular, with the possibility to add many other sensors in the future. This means that computing and communication subsystems rest the same, and only thing that is left to adjust is the software support for new sensors.

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