DOI 10.5162/SMSI2020/E5.4

Design and Implementation of Smart Multisensor Monitoring System for Safe Workplaces with LoRaWAN

Sergej Johann[1], Antoine Lapalus[1], Carlo Tiebe[1], Matthias Bartholmai[1]
[1] Bundesanstalt für Materialforschung und -prüfung, Unter den Eichen 87, 12205 Berlin, Germany
Sergej.Johann@bam.de, Antoine.Lapalus@bam.de, Carlo.Tiebe@bam.de,
Matthias.Bartholmai@bam.de

Summary:
This project addresses the application of safe workplaces in offices and chemical laboratories where indoor air quality plays an important role. The LoRaWAN (Long Range Wide Area Network) is used as a communication interface to make important sensor data globally accessible. The goal of the development is to create a sensor node and an online and offline solution that collects the data from the sensor nodes and stores it on a local server or in a cloud. In cooperation with the companies WISTA GmbH and IONOS, a test sensor network is going to be established in the Berlin-Adlershof area.

Keywords: smart sensors, air quality monitoring, LoRaWAN, VOC, multisensor system

Idea

The idea of this project is based on developing a way to create a safe workplace. The implementation is based on the current technology LoRaWAN [1], which allows to cover a large area with a range of up to 15 km. Important parameters should be detected and measured to avoid endangering people. Both in the office and in the laboratory, limits for hazardous volatile gases can be exceeded [2-3]. The sensor network with the low power sensor nodes should continuously record all necessary data and issue a warning if the limit value is exceeded.

Concept and Implementation

The concept envisages the development of several sensor nodes and equipping them with different sensors to determine indoor air quality. Three sensors are implemented as a basis: volatile organic compounds (VOC) gas sensor, temperature and humidity sensor. The network can be operated in two ways to make the collected data available. Online via a cloud and via the associated network infrastructure, that is provided in cooperation with WISTA GmbH and IONOS and is implemented as the primary solution and the offline solution. This assures that the data can be retrieved even if there is no Internet connection. A local computer is configured as a server and provided with a user interface.

Figure 1 shows the overall concept of how the network should look like. The office or laboratory is equipped with sensor nodes, each sensor node contains several sensors to determine the parameters for room air quality measurement.

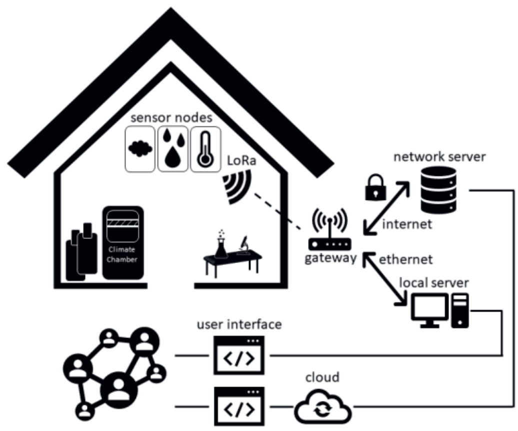

Fig. 1. Concept of the System Network.

Figure 2 shows the individual components of the sensor node. The system is powered by 3xAA batteries to avoid the long charging times that occur with rechargeable batteries, so that the system is ready for use again more quickly. A Cortex M4 microcontroller controls the communication of the LoRa- and the GPS module. The sensors used to measure air quality parameters are commercially available, including the sensors for temperature, humidity, air pressure, and VOC concentrations (BME680 from bosch). The measured data is stored on a SD card as a storage medium. The BME680 was chosen because, unlike other sensors, its measuring range reaches the MAK value of ethanol, which was used as reference gas.

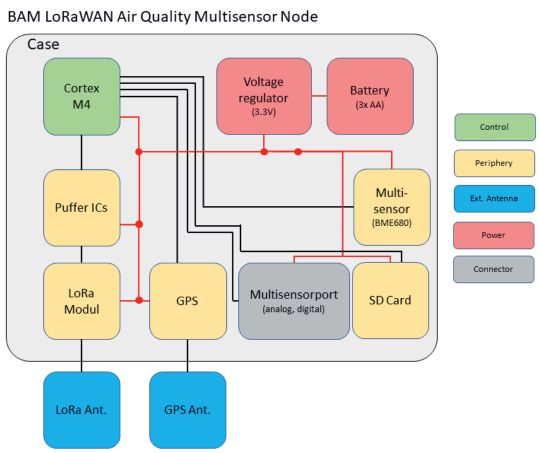

Fig. 2. Block diagram of the sensor node.

Figure 3 shows a 3D model of the electronic structure of the sensor nodes, with the components. Within the scope of a prototype development, the shape of the circuit board was developed for a standard housing.

Fig. 3. First functional model in 3D overview with the electronic components of the sensor node.

Optimization and extensions will be included in the design after the validation phase.

Results

In order to test the suitability of the sensor for this application, a laboratory test was carried out to show how the sensor reacts to different gas exposures. The setup was to validate the sensor under given conditions, the test gas was ethanol in synthetic air.

The validation of the BME680 was carried out in a closed measuring cells, a calibrated gas mixing system has introduced a previously specified ethanol in synthetic air concentration into the measuring cell. The validation was performed in two sequences, the environmental parameters were chosen according to application condidtions, for the first sequence: 10 %rh and 25 °C and for the second sequence: 50 %rh and 25 °C. After a burn-in phase of the sensor (approx. 48 h), ethanol (C_2H_6O) in synthetic air with a concentration of 20 ppm, 40 ppm, 80 ppm, 100 ppm, 200 ppm and 300 ppm and an air flow rate of 1000 ml/min ±1 % was introduced into the measuring cell. Figure 4 shows the signal curves of the sensor response to the varying ethanol concentrations. First results show, that the sensor correlates well with the set concentrations but has a cross-sensitivity to moisture.

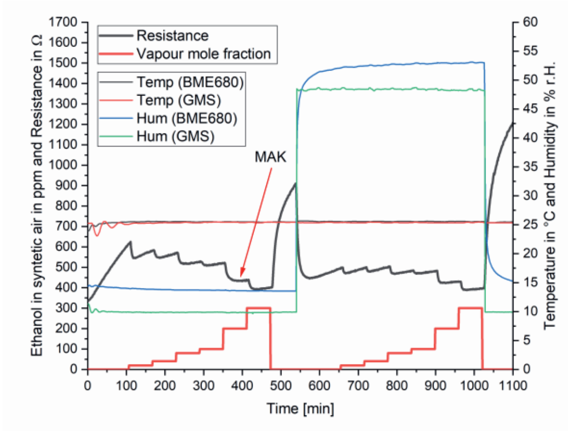

Fig. 4. Validation of the BME680 with ethanol in synthetic air in the climate chamber.

Outlook

The selected sensor shows promising result. Further tests are ongoing, e.g. to validate how robust and reliable the sensor nodes are. Another important aspect that should be investigated is the energy management of the LoRaWAN, where the runtime of the system and signal integrity up to shutdown is examined.

Furthermore, a user interface with sensor and value recognition is being developed for the local solution.

References

Text.

[1] LoRa Alliance Inc., 2017, LoRaWAN Specification 1.1.

[2] Technical instructions for keeping the air clean - TA Luft (in German) https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Luft/taluft.pdf, 2020-01-23.

[3] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, http://data.europa.eu/eli/dir/2016/2284/oj, 2020-01-23.