Environment measuring system sensors analysis and database design

[1]Sebastián HORVÁTH, [2]Tibor VINCE

[1,2] Department of Theoretical and Industrial Electricial Engineering, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Slovenská Republic

[1]sebastian.horvath@student.tuke.sk, [2]tibor.vince@tuke.sk

Abstract — **This article described the design of a system for measuring environment and analyzing possible usable sensors for an implementation monitoring station. Such a station, implemented later, will be able to measure environment and send these data to database in regular intervals.**

Keywords — **Environment, ESP-32, Sensors, Measurement, Monitoring system**

I. INTRODUCTION

Monitoring of environment is important task, which we collected actual information about measuring environment. State of the environment sometimes can be dangerous for people. Mostly, the presence of various gases in the air can be dangerous, which can endanger lives. Such gases usually do not have color and any even smell. Because of these characteristics, their presence cannot be noticed by a man. The only symptom is the critical state of poisoning. Such monitoring can be used in industrial production or in power plants, which could lead to leakage of gas in the production or increased concentration of dust and radiation, which also endangers human health.

The monitoring system should consist of a control unit and sensors. Such a system should be connected to a central server where the measured data is stored and displayed on the web. This data would be accessible from anywhere in the world where there is an Internet connection. This system should be universal. It should be possible to connect multiple sensors to the measurement node, the entire system could contain multiple measurement nodes and all measuring nodes should communicate via Wi-Fi with the central server.

In a previous article "Analyzing the possibilities of creating a system for measuring the environment" we have mainly dealt with gas sensors. In this article we will deal with sensors as like UV, temperature, humidity and pressure.

II. ANALYZING OF SENSORS FOR MONITORING ENVIRONMENT

The environment can be outdoor or indoor. It can be in offices, homes, manufacturing or in vehicles and in open space at a garden or somewhere in the forest and measure the height of the rivers. The environmental properties are different. We can measure what gases the environment consists and what solid particles are there. It is also possible to measure the temperature conditions in the environment, pressure changes as well as radiation or ultraviolet radiation. All these features affect people who are in the environment, so it is necessary to measure these properties to avoid injuries and harm to the health.

To learn about sensors, we have relied on the technical documentation that is commonly available on the web. On the market are many sensors, so we have only selected those , in this section of the work, that are commercially available and compatible with microcontroller ESP-32.

We become acquainted with sensors of air temperature, relative humidity, barometric pressure and ultraviolet radiation. All these sensors are possible to see in Fig. 1. In their comparison, we focused

mainly on characteristics such as: supply voltage, measuring range, resolution, accuracy, package and interface.

Fig. 1 Compatible sensors for monitoring station

In Table I we can see the comparison of sensors which measure temperature and relative humidity. The most accurate sensors for this selection were those that had a metal probe. However, these sensors are also the most expensive. These sensors are not different only in accuracy of commercial sensors, but also in supply voltage and interface, which can be SDI-12 or RS-232. The commercial sensors with DFN package have only little difference. They use I²C interface and they are supplied by 3,3 V. The difference is in resolution and accuracy, which is not very large. Sensor HDC2080 is more accurate, but HTU21D has resolution in hundredths. The resolution of the sensors depends on the bit rate setting on the sensors [1],[2],[3],[4].

Table I
Table of sensors for monitoring temperature and relative humidity

Temperature			
Type	**HTU21D**	**HDC2080**	**PT100D**
Package	DFN	DFN	metal probe
Range [°C]	-40 ÷ 125	-40 ÷ 125	-40 ÷ 70
Resolution [°C]	0,01	0,1	0,001
Accuracy [°C]	±0,3	±0,2	±0,1
Interface	I²C	I²C	SDI-12 / RS-232
Supply voltage [V]	1,5 - 3,6	1,62 - 3,6	6,0 - 17,0
Relative humidity			
Type	**HTU21D**	**HDC2080**	**RHT175**
Package	DFN	DFN	metal probe
Range [%]	0 ÷ 100	0 ÷ 100	0 ÷ 100
Resolution [%]	0,04	0,1	0,05
Accuracy [%]	±2	±2	±1
Interface	I²C	I²C	SDI-12 / RS-232
Supply voltage [V]	1,5 - 3,6	1,62 - 3,6	5,0 - 30,0

In the next table Table II we compare sensors that measure barometric pressure and ultraviolet radiation. We compare sensors from the same manufacturer, but each sensor also has its predecessor. Sensor measuring ranges have not changed, but sensor accuracy and resolution have changed. The sensors need to be supplied with 3.3 V reference voltage, but the VEML6070 can be supplied by 5 V. For UV sensors, the UV index is the output, but sensors sense the wavelength of light and for that reason

is accuracy in wavelength of light. All sensors communicate with the processor using the I²C interface [5],[6],[7],[8].

Table II
Table of sensors for monitoring ultraviolet radiation and barometric pressure

Ultraviolet radiation		
Type	VEML6070	VEML6075
Package	OPLGA	OPLGA
Range [UV index]	0 ÷ 11 >	0 ÷ 11 >
Resolution [UV index]	0,1	0,1
Accuracy [nm]	±20	±10
Interface	I²C	I²C
Supply voltage [V]	2,7 - 5,5	1,5 - 3,6
Barometric pressure		
Type	BMP180	BME280
Package	LGA	LGA
Range [hPa]	300 ÷ 1100	300 ÷ 1100
Resolution [hPa]	0,1	0,0018
Accuracy [hPa]	±0,12	±0,12
Interface	I²C	I²C
Supply voltage [V]	1,8 - 3,6	1,7 - 3,6

III. DESIGN OF DISTRIBUTED SYSTEM FOR MEASURING ENVIRONMENT

The system design is based on the system requirements which were given in the previous article "Analyzing the possibilities of creating a system for measuring the environment".

A. Design of system

The individual measuring nodes, the number of which is not limited, consists of sensors and the control unit ESP32S-NodeMCU. This module is connected to a central Web server using an available Wi-Fi network. Subsequently, the measuring node communicates with the database using phpMyAdmin, not directly with the MySQL database. From the outside then come the requirements to Web server which processes request, the necessary data are read from the database and the results are sent back to the applicant [9].

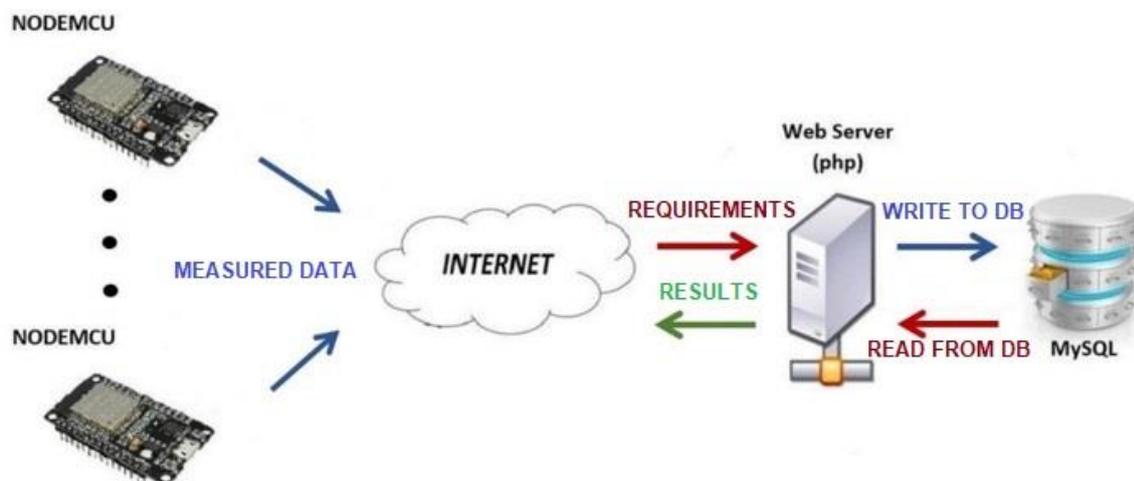The visual design of the distributed system can be seen in Fig. *2*.

Fig. 2 Design of distributed system for measuring environment

B. Design of database

The database consists of 4 tables, Fig. 3, specifically, the tables *monitorovacia_stanica, namerany_udaj, velicina a veliciny_monitorovacej_stanice.*

The table *monitorovacia_stanica* is used to store all available measurement nodes, monitoring stations. To add a new monitoring station, it is not necessary to take action in the database structure, but the station is simply added to this table. The appropriate row of the table will contain the ESP32 MAC address, the station name, where and at which altitude the station is located. These rows of table *monitorovacia_stanica* are defined as text with a limited number of characters. Row *id_monitorovacia_stanica* is the identifier of each measurement nodes. Last 2 rows of table are used for stored information about status of monitoring station. Row *cas_poslednej_aktivity* is defined as TIMESTAMP and is used for information, when was monitoring station active for the last time. Row of table *stav_pripojenia* is defined as TINYINT and is used as pointer, if is station active or no.

The table *namerany_udaj* is used for writing measuring data of all monitoring stations, which measure more than 1 quantity. This table consists of rows: *id_udaj*, *id_monitorovacia_stanica*, *cas_merania*, *id_velicina* and *hodnota*.

Next table is *velicina*, into which are written all measured quantity. It contains the row *id_velicina*, which is identifier of individual quantity. Rows *nazov* and *jednotka* are used for named quantities and assigning the unit, in which the quantity is measured.

Last table is *veliciny_monitorovacej_stanice*. This table is used for assigning individual quantities to monitoring stations, so this table allows each monitoring station has more than one measured quantity and one measured quantity can be measured with more than one monitoring station. Row *id* is primary key of the table and rows *id_monitorovacia_stanica* and *id_velicina* are foreign keys of the table referring to tables *monitorovacia_stanica* and *velicina*, which are used for connection between individual tables. Next row is *popis*, which is used to describe the quantity. Last rows of the table are *pin_pripojenia* and *interval_merania*. Row *pin_pripojenia* is used to determine pin of GPIO, on which is connected sensor, which measure given quantity and row *interval_merania* is used for setting interval, how often the quantity is to be measured [10].
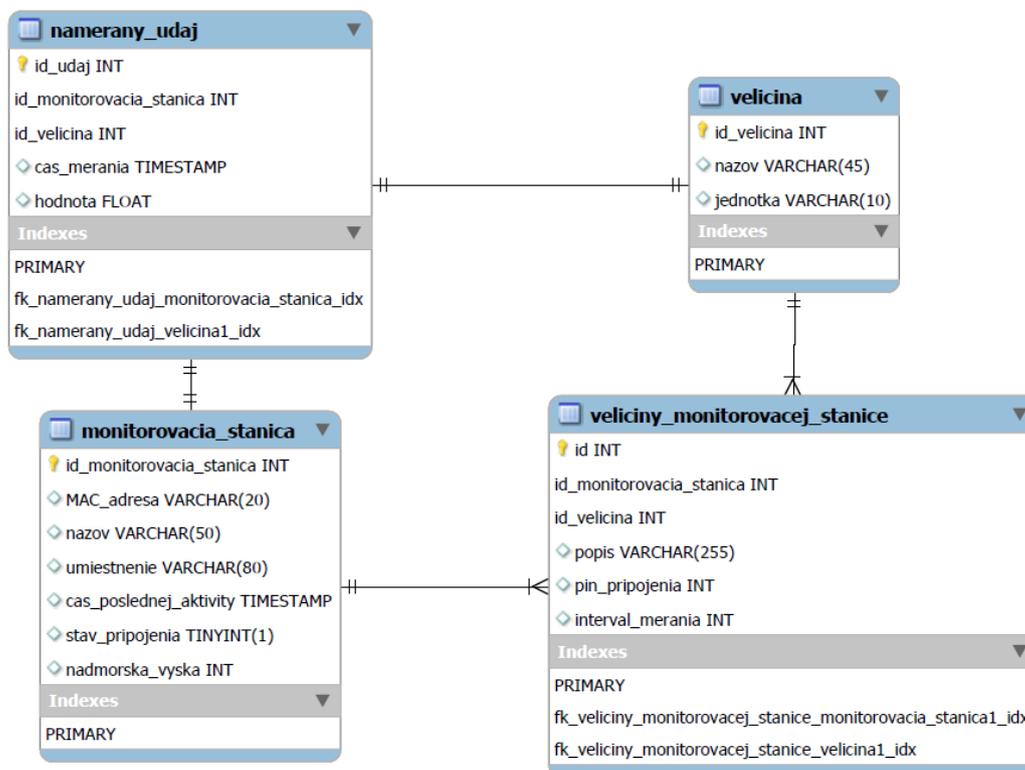
Fig. 3 Table model of database

IV. CONCLUSION

There are many environmental measurement systems on the market, but such systems are pre-defined what they must measure. Because of this problem, it is advisable to create our own systems, which can also be universal, so they can measure multiple quantities at the same time. Customary measurement systems that can store data, the user can make his own evaluation of measured data or create his own warning system.

REFERENCES

[1] Measurement Specialties. HTU21D Datasheet. [Online] [Date: 05. 03. 2019] https://cdn-shop.adafruit.com/datasheets/1899_HTU21D.pdf

[2] Texas Instruments. HDC2080 Low-Power Humidity and Temperature Digital Sensor. [Online] [Date: 05. 03. 2019] http://www.ti.com/lit/ds/symlink/hdc2080.pdf

[3] MicroStep – MIS. PT100D Digital Temperature Probe. [Online] [Date: 20. 03. 2019] https://www.microstep-mis.com/drupal/web/sites/default/files/2018-09/PT100D_product_sheet_0.pdf

[4] MicroStep – MIS. RHT175 Relative Humidity and Temperature Probe [Online] [Date: 20. 03. 2019] https://www.microstep-mis.com/drupal/web/sites/default/files/2019-01/RHT175_product_sheet.pdf

[5] Vishay Semiconductors. VEML6070 UVA Light Sensor with I2C Interface. [Online] [Date: 15. 03. 2019] https://www.vishay.com/docs/84277/veml6070.pdf

[6] Vishay Semiconductors. VEML6075 UVA / UVB Light Sensor with I2C Interface. [Online] [Date: 15. 03. 2019] https://www.vishay.com/docs/84339/designingveml6075.pdf

[7] Bosch. BMP180 Digital pressure sensor. [Online] [Date: 09. 03. 2019] https://ae-bst.resource.bosch.com/media/_tech/media/datasheets/BST-BMP180-DS000.pdf

[8] Bosch. BME280 Datasheet. [Online] [Date: 09. 03. 2019] https://cdn.sparkfun.com/assets/learn_tutorials/4/1/9/BST-BME280_DS001-10.pdf

[9] Shenzhen Anxinke Technology CO, LTD. ESP-32S Datasheet. [Online] [Date: 04. 04. 2019] http://www.es.co.th/Schemetic/PDF/ESP32.PDF

[10] Oracle. MySQL Documentation. [Online] [Dátum: 12. 05. 2019] https://dev.mysql.com/doc/