

IoT Sensor Node for Environmental Safety Applications via LoRa

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ABSTRACT: Internet of Things sensor node aimed at monitoring harmful environment conditions for safety application via LoRa wireless technology. It handles and supports low power consumption and multiple environment monitoring sensors. The LoRaWAN (Long Range Wide Area Network) module is used to connect sensors to the microcontroller which can be connected to the internet. It is mainly focused on monitoring carbon-di-oxide, carbon monoxide, Humidity and some environmental condition parameters. It reports poor environment quality could cause severe health problem to individuals. Therefore, surrounding environmental data is gathered by the wearable node in a real time manner and then transmitted to a remote cloud server. The data can then be displayed to authorized users through web-site application located in the cloud server and the device will give alert to the users via mobile when an emergency occurs in the environment. The results indicate that the safety monitoring network can work reliably with low power.

KEYWORDS: Internet of Things, Wireless sensor networks, Sensor nodes, Environment Monitoring.

I. INTRODUCTION

There are some air pollutants in both indoor and outdoor environments, such as carbon dioxide, carbon monoxide and particulate matter. Carbon dioxide is a common indicator used for ventilation systems. High carbon dioxide levels can cause headaches, dizziness and a range of detrimental systems. The sources of carbon monoxide are produced from the partial oxidations of carbon-containing compounds present in the environment. Gases like Carbon-di-oxide and Carbon monoxide are mixtures of small particles found in the air. Small particles with a diameter of 10µm or less can be inhaled, causing serious health issues to lungs. Particles with a diameter less than 2.5µm can go deeper into our lungs and they can be more dangerous than bigger particles ranging between 2.5µm and 10µm. The particle sources are formed from forest fires, power plants, automobiles, organic compounds and also some metals that dissolved in the air.

Wireless sensor network is a prominent solution for a number of monitoring applications including health monitoring, environmental monitoring, indoor air quality monitoring and fire monitoring using WSN and can cut costs in wiring and related infrastructures. WSN usually have stringent power requirements to maintain continuous monitoring. [1] Therefore, an efficient power management and energy sources should be selected. Different harmful environmental parameters are measured in each system. For instance, reference presents a WSN system that monitors volatile organic compounds and CO in a building. Work measures methane and temperature in working environment. Reference measures VOC, humidity, temperature and Wind in an industrial site. Finally, work measures CO₂ concentrations. Wearable sensor nodes are essential elements in wireless body area network in monitoring the human body. In addition to medical signals, they can be used to collect environmental conditions around the human body as well, such as in safety applications. Reference provides a wearable wireless sensor system for toxic volatile organic compounds monitoring with Bluetooth wireless interface. Some non-cellular wireless technologies available for IoT applications are compared in table. It can be seen that LoRa can provide longest cover distance and highest receiver sensitivity with lower power consumption. [2][9]

II. LITERATURE SURVEY

It is difficult task to implement a wearable node for safety application. It has Hardware and Software implementation which includes Power management, Sensor nodes. The power management system includes in coin battery, for buck boost converter and a quick output discharge switch. LTC 3130-1 is a high efficiency (95%) buck boost converter which regulates the input voltage to a constant 3.3V for the entire circuit. TPS22918 is a single channel switch with low on-resistance of 50 MHz load switch. With quick output discharge function, the switch can quickly discharge the output pin when the device is or disabled instead of leaving the electronic devices in a floating state. The switch is controlled by a digital pin of MCU. ATMEGA 328P is used as MCU in this work. It collects the data form different sensors and interfaces with LoRa module. It also controls the power consumption of the entire node. This MCU has low power consumption, low cost and high performance features. It has six 10-bit analog to digital converters and fourteen digital pins which can support the various functions required by the sensor board. The nominal voltage for the MCU is 3.3V when the clock pad is 8MHz. A RFM95 module is used as the RFM module in this setup.[3]

The module is the low power and long range transceiver module which features high interference immunity whilst minimising current consumption. It has high sensitivity, which can go down to -148 dbm. The receive current is very low, which is only 10.3 mA. Compared to LoRa, the sensitivity of XBEE dig mesh can only go down to -110 dbm and the receive current is as high as 29 mA. LoRa outweighs XBEE in these features. RFM95's operating voltage is from 1.8 to 3.7 voltage and temperature is from -20 to +70°. The sleep current is only 0.2 μ A. The LoRa chip communicates with MCU via Serial Peripheral Interface bus (SPI). RadioHeadPacketRadioLibrary is used to communicate between LoRa and MCU.

The LoRa module is a type of BEE with version v1.1 in XBee layout from Dragino which is a wireless gateway makes it support fast prototyping. The temperature, humidity and pressure data are measured by using the BME280 sensor as what we did in work [2]. The BME280 is a low-power sensor consuming only 3.6 μ A when operating and 0.1 μ A in sleep mode. It has an accuracy of ± 0.5 °C for temperature and $\pm 3\%$ for relative humidity. The CO₂ sensor chosen is the COZIR CO₂ sensor as in reference [2]. It is an ultra-low power (3.5 mW) and high performance (± 50 ppm) sensor. The warm-up time for the sensor is less than 10 s, which is ideal for a remote sensor node. The measurement is ranged from 0 to 10,000 ppm, which can be used in both indoor and outdoor measurements. The CO sensor chosen is ULPSM-CO 968-001 from SPECSensor. It consumes very low power (< 45 μ W) and provides CO readings via analog output. It operates from 2.7 to 3.3 V. SI1145 from Silicon Labs is chosen as the UV sensor. It measures UV radiation index, proximity of the UV rays and ambient light sensor. It also uses a low power sensor, which consumes less than 500 nA in standby mode and average 9 μ A while measuring the data.

The sensor communicates with MCU via I²C interface, which is a low speed processor and a controller for short range distance with intra-board communication. The nodes are programmed to wake up every minute to keep track of the changing environmental data and monitor the harmful data. It can also be programmed to run in continuous monitoring mode which will update the environmental data according to users' requirements. The software algorithm for wearable sensor node is presented. By using the low power components, low power management techniques, and proper software algorithm, the maximum current consumption while awake is 33 mA, and the minimum current consumption while in sleep mode is measured at 24.71 μ A. From the mobile user interface, user can view the surrounding environmental information directly. This is because warmer the temperature can take up more moisture, which results in lower relative humidity. CO₂ value peaks at 7.5 minute when the user is inside an elevator during that time. UV index peaks at 20 minutes when the user is under sunlight.

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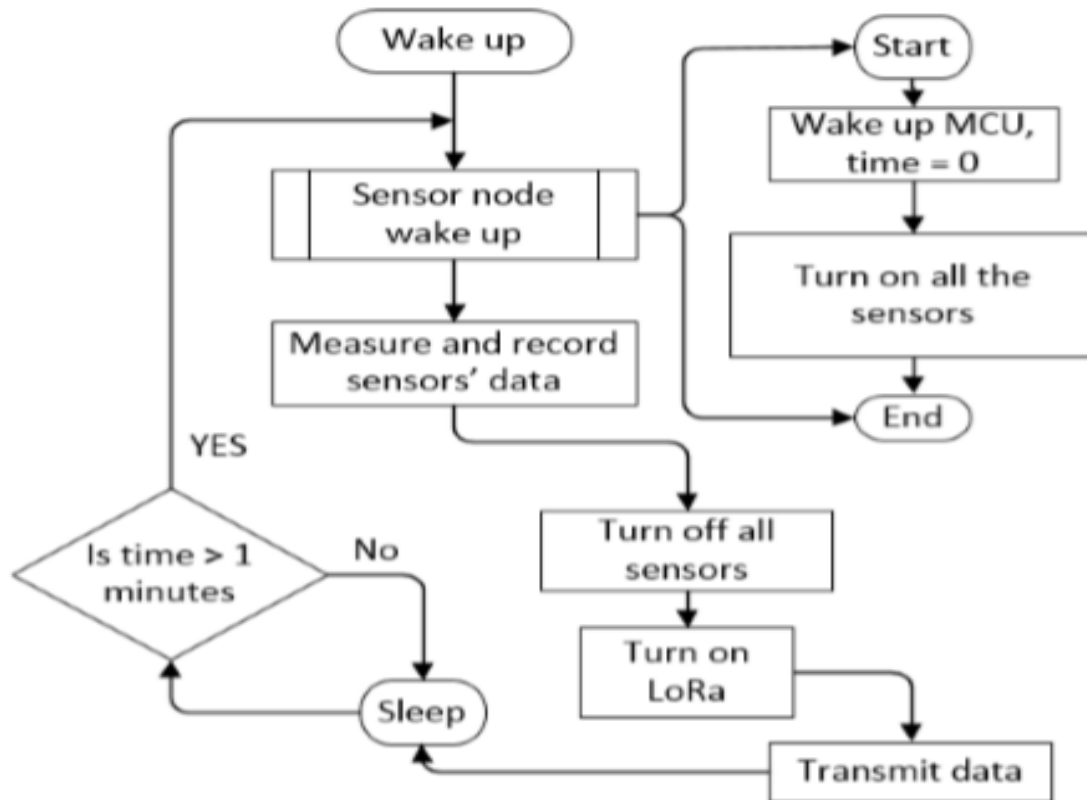


Fig.1: Sensor node Software Algorithm

III. EXPERIMENTAL RESULTS

A. Power Consumption:

By using the low power components, low power management techniques, and proper software algorithm, the maximum current consumption while awake is 33 mA, and the minimum current consumption while in sleep mode is measured at 24.71 μ A.[6]

Stage	Current(mA)	Power(mW)	Mode
1	3.2	10.42	Sense
2	10	73.32	Transmit
3	0.3453	0.9574	Idle
4	8.5	26.33	Sleep

Table.1: Power consumption in different Stages of the LoRa Node

B. Sensors' Preliminary Results:

From the mobile user interface, user can view the surrounding environmental information. The Fig.2 shows directly how some sample readings from the sensor node in continuous mode (one sample every ten seconds) when the subject is walking around the surroundings. The temperature and humidity readings show opposite trends with temperature in Celsius and humidity in percentage. This is because warmer the temperature can take

up more moisture, which results in lower relative humidity. The gas sensors which collect data of CO₂ and CO value peaks at 7.5 minute when the user is inside an elevator during that time. The gas sensor collect the data in ppm (parts per million) range. UV which ranges from 0 to10,the index peaks at 20 minutes when the user is under sunlight.

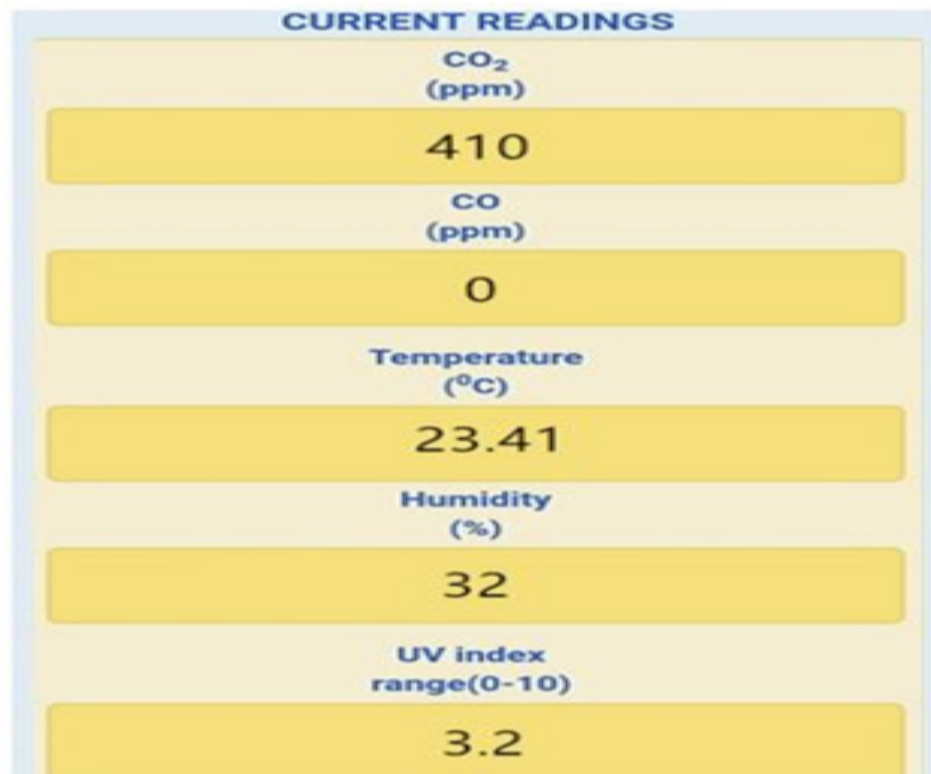


Fig.2 Screenshot of phone application developed for the Safety application.

IV. CONCLUSION

We have implemented IoT sensor node for safety applications called WE-Safe. The Environmental Safety project is to provide early warnings for people working in extreme and harsh environment when they are not in the safe zones. Such an IoT platform will present new opportunities for saving life or preventing health issues etc. Our future work will focus on network performance of LoRa network and more experimental results.

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