Indoor air quality monitors using IOT sensors and LPWAN

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Abstract— **The effect of air quality on wellbeing and on life comfort is entrenched. Indoor air quality parameters are critical to make a gainful and sound indoor condition anyway by and large the air quality parameters are altogether different from those characterized as solid qualities. Taking into account that we spend about 90% of our lives inside, it is critical to screen the indoor air quality progressively to distinguish issues in the nature of air and plan intercessions in the building, or in the ventilation frameworks so as to enhance air quality. In this paper we are identifying the indoor air quality with the help of internet of things by using the sensors BME680 from bosch,SGP30 and CCS811 and low power wide area network (LPWAN) for the data transfer. Here we are separating the gases CO2 equivalent, Ethanol, TVoC and so on. For transmitting this IOT information, we require high vitality productive sensor hubs that can impart crosswise over long separation. This propels the improvement of some Low-Power Wide Area Networks (LPWAN) advances, for example, LoRa, to satisfy these requirements. The reports are exhibiting the destructiveness of air that we are taking in step by step. Here we are trying to give a social awareness by using this paper.**

Keywords— **BME680, SGP30, CCS811, LPWAN**

I. INTRODUCTION

The expanding interest for better personal satisfaction has enlivened the academician and mechanical networks known as Internet of Things (IoT). The conceivable association between living (for example human, domesticated animals) and non-living things (for example autos, house, and working) through remote system correspondence opens a way to the improvement of new and advance applications. Indoor and open air quality (AQ) is turning into a noteworthy worry for the general population and strategy producers. As of late, Europe and USA have decreased the discharges of a few airborne poisons, for example, carbon monoxide (CO), sulfur dioxide (SO2) and lead (Pb). Nitrogen dioxide (NO2), ozone (O3), particulate issue (PM) and some other natural mixes are additionally considered as a genuine risk to wellbeing. Moreover, a few factual investigations demonstrated that individuals simultaneously from different areas and making it accessible pervasively empowers intrigued clients to be spend up to 90% of their time in encased conditions, for example, workplaces, schools, homes, and shopping centers[12]. For every one of these reasons, continuous indoor air quality observing (IAQ) is required. Gathering information educated about AQ in their picked or arranged spot.

II. WHAT ARE VOCs?

The across the board utilization of new items and building materials has brought about expanded groupings of indoor toxins, specifically unpredictable natural mixes (VOCs). These days, a great many people go through over 20 hours out of each day inside where VOC[11] fixations are in excess of multiple times higher than open air concentrations1. VOCs start from various diverse conceivable sources, such as building materials, tobacco smoke, individuals and their exercises, and indoor substance responses. Especially high VOC levels are normally found in new structures or after redesign. Further, when utilizing items that contain VOCs, for example, deodorizers or cleaning specialists, individuals uncover themselves as well as other people to high toxin levels that can persevere long after the movement has wrapped up. VOCs incorporate a wide scope of synthetic exacerbates, the most well-known of which are cleaning specialists, solvents , beauty care products ,paints, human inhabitants ,covers and deck and so forth. Due to the high VOC concentration the potential health effects are Tactile irritation (dryness and disturbance of the eye, the nose and the throat, migraines, and discombobulation) Intellectual abilities, debilitated building syndrome (migraines, mucous layer aggravation, asthma-like indications, skin bothering and dryness.). To reduce VOC level we can provide good ventilation, air purification and keeping away the things which will increase VOC levels.

III. LPWAN (LOW POWER WIDE AREA NETWORKS)

Low Power Wide Area Network (LPWAN) [6] systems speak to a novel correspondence worldview, which will supplement conventional cell and short range remote advances in tending to assorted prerequisites of IoT applications[7],[8]. LPWAN advances offer exceptional arrangements of highlights including wide-zone network for low power and low information rate gadgets, not given by inheritance remote innovations. Their market is required to be huge. Approximately one fourth of overall 30billion IoT/M2M gadgets are to be associated with the Internet utilizing LPWA[9] systems utilizing either restrictive or cell innovations. LPWA systems are novel since they make unexpected tradeoffs in comparison to the conventional advancements pervasive in IoT scene, for example, short-extend remote systems e.g., ZigBee, Bluetooth, Z-Wave, heritage remote neighborhood (WLANs) e.g., Wi-Fi, and cell systems for example Worldwide System for Mobile Communications (GSM), Long-Term Evolution (LTE) and so on. The inheritance non- cell remote advances are not perfect to interface low power gadgets appropriated over extensive geological zones. The scope of these innovations is constrained to a couple of hundred meters, best case scenario. The gadgets, along these lines, can't be self-assertively conveyed or moved anyplace, a necessity for some applications for savvy city, coordinations and individual wellbeing.

A, DESIGN GOALS AND TECHNIQUES

The accomplishment of LPWAN innovations lies in their capacity to offer low-control network to huge number of gadgets dispersed over expansive land territories at a remarkable minimal effort. This segment portrays the procedures LPWA innovations used to accomplish these regularly conflicting objectives.

LONG RANGE

LPWA advances are intended for wide territory inclusion and magnificent flag proliferation. Quantitatively, a +20 dB increase over heritage cell frameworks is focused on. This permits the end-gadgets to associate with the base stations at a separation extending from a couple to several kilometers relying upon their arrangement condition (provincial, urban, and so on.).

ULTRA LOW POWER ACTIVITY

Ultra-low power activity is a key necessity to take advantage of the colossal business opportunity given by battery-controlled IoT/M2M gadgets. A battery lifetime of 10 years or more with AA or coin cell batteries is alluring to cut the support cost down.

LOW COST

The business accomplishment of LPWA[10] systems is attached to associating countless gadgets, while keeping the cost of equipment underneath $5 [33]– [35] and the availability membership per unit as low as $1. This reasonableness empowers LPWA innovations to address a wide-scope of uses, yet in addition contend positively inside the areas where the short-run remote advancements and the cell systems are as of now settled.

IV. IOT SENSORS

A. BME680 [2]

The BME sensor family has been intended to empower pressure, temperature, humidity and gas measurements (BME680). The sensors can be worked in various modes determined in provided header files. . For example, ULP mode offers output data at slow rate thereby minimizing power consumption. As a rule, higher information rate relates to higher power utilization.

Fig. 1. BME 680

TEMPERATURE SENSOR

So as to ensure quick reaction times, the temperature sensor inside BME280/680 is relied upon to be mounted at an area in the gadget that empowers great air and temperature trade. The coordinated temperature sensor has been streamlined for extremely low clamor and high goals. It is basically utilized for assessing encompassing temperature and for temperature pay of alternate sensors present. The temperature estimation precision is determined in the comparing information sheet of the utilized equipment.

WEIGHT SENSOR

The weight sensor inside BME280/680 is a flat out barometric weight sensor including especially high precision and goals at extremely low commotion. The weight estimation precision is indicated in the comparing information sheet of the utilized equipment.

RELATIVE HUMIDITY SENSOR

The moistness sensor inside BME280/680 estimates relative mugginess from 0 to 100 percent over a temperature extend from - 40 degrees centigrade to +85 degrees centigrade. The stickiness estimation exactness is determined in the relating information sheet of the utilized equipment.

GAS SENSOR

The gas sensor inside BME680 can identify an expansive scope of gases to gauge indoor air quality for individual prosperity. Gases that can be distinguished by the BME680 incorporate unpredictable natural mixes (VOC) from paints, (for example, formaldehyde), veneers, paint strippers, cleaning supplies, goods, office gear, pastes, glues and liquor. The gas estimation precision is determined in the comparing information sheet of the utilized equipment.

B. SGP30 [3]

The SGP30 is a computerized multi-pixel gas sensor intended for simple coordination into air purifier, request controlled ventilation, and IoT applications. Sensirion's CMOSens® innovation offers a total sensor framework on a solitary chip highlighting an advanced I^2C interface, a temperature controlled smaller scale hotplate, and two preprocessed indoor air quality signals.

Fig. 2. SGP 30

AIR QUALITY SIGNALS

To provide two complementary air quality signals, the SGP30 uses a dynamic baseline compensation algorithm and on chip c alibration parameters. The total VOC signal (TVOC) and the e quivalent CO2 signal (CO2eq) are calculated on the basis of th e sensor signals.

SENSOR RAW SIGNALS

There are two raw signals are there, Ethanol signal and H_2 signal.

HUMIDITY COMPENSATION

An absolute humidity value from an external humidity sensor such as the SHTxx is required to use the on-chip humidity compensation. A new humidity value can be written to the SGP30 using the "Set_humidity" command.

C. CS811 [4]

CCS811 is a ultra-low power gas sensor solution that integrates a gas sensor for metal oxide(MOX) to detect a wide range of volatile organic compounds(VOCs) for indoor air quality monitoring with a microcontroller unit (MCU), wh ich includes an analog to digital converter (ADC), and an I^2C interface. The integrated MCU detects VOCs by managing the sensor drive modes and measured raw sensor data. The digital I^2C interface simplifies hardware and software design significantly, enabling faster marketing time. CCS811 supports intelligent algorithms to measure raw sensors to produce a TVOC value or equivalent levels of CO2 (eCO2), where the main cause of VOCs is human. CCS811 supports several measurement modes optimized for low power consumption during active sensor measurement and idle mode to extend battery life in portable applications.

Fig. 3. CCS811

V. PROPOSED WORK

The proposed system consist of BME 680, SGP 30, CCS811 and UV sensor connected parallel in arduino board with LORA connectivity through I^2C bus. Each of this single unit is connected to a gateway and from the gateway we will get the data.

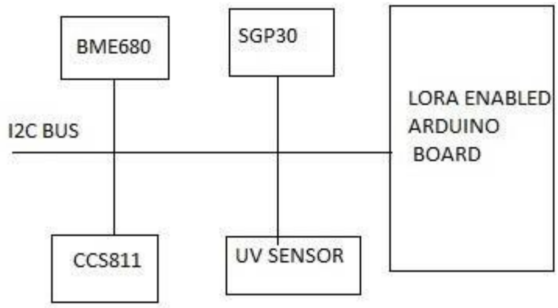

Fig.4. Architecture

Here we are taking data from 3 sensors for more accuracy. Fig. 4 shows the overall architecture diagram. In addition to BME 680,SGP30 and CCS 811 we are adding UV sensor to detect the amount of UV light. Here the four sensors , BME 680, SGP 30, CCS811 and UV sensor are connected parallel in LORA[1] enabled arduino board by using an I2C bus. Here the sensors BME 680, SGP 30, CCS811 are used for calculating indoor air quality levels. For getting more accuracy we are using these three sensors together. The above architecture is a single unit .Like that many single units connected together through a gateway. From the gateway we will get the gas levels. By using this data we can analyses the indoor air quality (IAQ).

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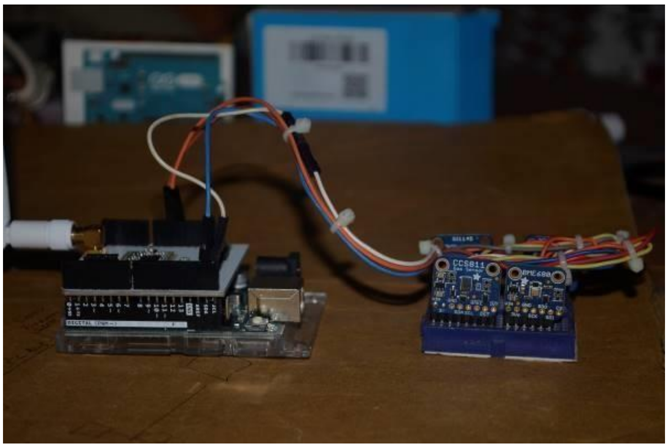

Fig. 5. Experimental setup

Fig. 6. Sensors connected

Fig. 7. Sensors connected

Figure 5 shows the experimental setup for the single unit. Here the sensors are connected to LORA enabled arduino board. Figure 6 and 7 shows the sensors connected to it. From the above experimental set up we will get the following data. This is shown in Figure 8. It contains the sample data. Here indoor air quality levels ,equivalent CO2, VOC and gas levels are shown.

Time and Date							
TimeZone adjustment							
iaq	c02	voc	gas	Date	Time (GMT)	Raw Local Time	Local Time
27.8054118	400	4.125	223.691812	11/26/2018	10:32:00 AM	1.54324E+12	5:50:00 PM
25.12975	408.4	5.75	236.5162	11/26/2018	10:37:00 AM	1.54324E+12	5:55:00 PM
33.59375	401	7.5	234.6165	11/26/2018	10:38:00 AM	1.54324E+12	5:56:00 PM
40.4334	400.9	7.6	233.0275	11/26/2018	10:39:00 AM	1.54324E+12	5:57:00 PM
56.5979	400.6	9	229.5985	11/26/2018	10:40:00 AM	1.54324E+12	5:58:00 PM
62.874	400.9	6.55	228.58895	11/26/2018	10:41:00 AM	1.54324E+12	5:59:00 PM
71.519	400.5	6.9	227.08835	11/26/2018	10:42:00 AM	1.54324E+12	6:00:00 PM
75.34915	400	6.47368421	226.450684	11/26/2018	10:43:00 AM	1.54324E+12	6:01:00 PM
80.1822105	401.05	7.9	225.357	11/26/2018	10:44:00 AM	1.54324E+12	6:02:00 PM
84.4948	400.7	7.15	224.4815	11/26/2018	10:45:00 AM	1.54324E+12	6:03:00 PM
89.76555	400.95	7.25	223.18805	11/26/2018	10:46:00 AM	1.54324E+12	6:04:00 PM
97.94235	400.05	5.9	221.75385	11/26/2018	10:47:00 AM	1.54324E+12	6:05:00 PM
99.6853	401.6	6.65	221.76725	11/26/2018	10:48:00 AM	1.54324E+12	6:06:00 PM
101.6484	400.05	6.8	221.7843	11/26/2018	10:49:00 AM	1.54324E+12	6:07:00 PM
101.4388	402	10.5	222.22515	11/26/2018	10:50:00 AM	1.54324E+12	6:08:00 PM
110.0718	401.25	7.15	220.79675	11/26/2018	10:51:00 AM	1.54324E+12	6:09:00 PM
117.5915	400.052632	6.6	219.22215	11/26/2018	10:52:00 AM	1.54324E+12	6:10:00 PM
123.22485	401.333333	7.6	218.08905	11/26/2018	10:53:00 AM	1.54324E+12	6:11:00 PM
126.367	400.45	16.3	215.5501	11/26/2018	10:54:00 AM	1.54324E+12	6:12:00 PM
146.5199	403.210526	55.4210526	204.892421	11/26/2018	10:55:00 AM	1.54324E+12	6:13:00 PM
173.694579	402.5	36	197.89115	11/26/2018	10:56:00 AM	1.54324E+12	6:14:00 PM
187.61485	400	18.15	196.76725	11/26/2018	10:57:00 AM	1.54324E+12	6:15:00 PM
164.96375	400	4.45	205.77205	11/26/2018	10:58:00 AM	1.54324E+12	6:16:00 PM
141.53155	400	5	211.6064	11/26/2018	10:59:00 AM	1.54324E+12	6:17:00 PM
138.8847	400.3	5.4	212.5487	11/26/2018	11:00:00 AM	1.54324E+12	6:18:00 PM
134.8011	401.2	8.55	213.33035	11/26/2018	11:01:00 AM	1.54324E+12	6:19:00 PM
149.5194	400.8	5.55	206.07205	11/26/2018	11:02:00 AM	1.54324E+12	6:20:00 PM
191.98415	400.8	8.95	195.5298	11/26/2018	11:03:00 AM	1.54324E+12	6:21:00 PM
212.035526	400.052632	8.05263158	191.768211	11/26/2018	11:04:00 AM	1.54324E+12	6:22:00 PM

Fig. 8. Sample data

VI. RESULTS AND CONCLUSION

According to guidelines issued by German Federal Environmental Agency, exceeding 25 mg/m3 of total VOC leads to headaches and further neurotoxic impact on health[2]. The color coding is shown below in figure 9. By using this standard we can predict the quality of air we taken every day.

IAQ index	Air Quality
0-50	Good
51-100	Average
101-150	Little Bad
151-200	Bad
201-300	Worse
301-500	Very Bad

Fig. 9 Indoor air quality classification and color coding[2]

From the above data we can generate graphs to show the IAQ and gas levels like equivalent CO2, VOC, and other gas levels.

After collecting the data from above experimental setup we can represent this data in graphical format as shown in figure 10 and 11.

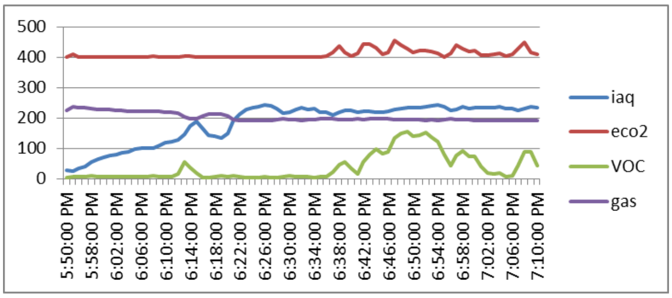

Fig. 10 Gas levels.

From the above diagram the CO_2 equivalent gas levels are very high. The equivalent CO2 levels exceed 400. The VOC levels are more than 150.from the above table we can conclude that the air quality is bad. The following table shows the IAQ levels.

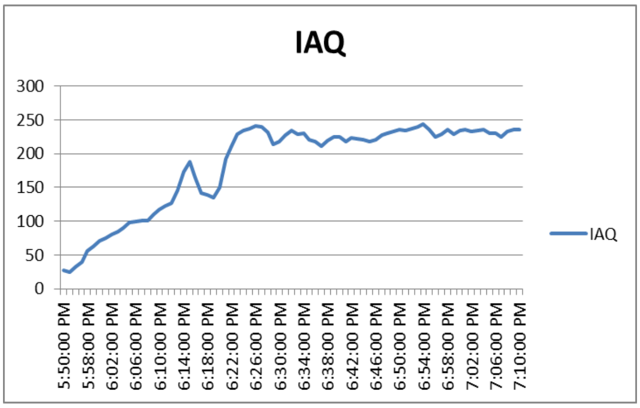

Fig.11 Indoor Air Quality Levels

Indoor Air Quality (IAQ) is about more than 150. From the following table it is clear that above 150 it is very bad.
From the above results it is clear that the air we are taken step by step is killing us. Now it is the time for thinking how to improve the air quality. The plants and trees can reduce air pollution in some levels. How we will improve the air quality inside our house? It is the time for taking this issue very seriously. The simple things we can do are provide more ventilation. Because the closed room air quality and air circulated room air quality have far difference. Air circulated room will provide better air quality. Plant more tees. If outside air quality is better then it will improve indoor air quality automatically. Even air purifiers can improve air quality. So for the better future improve the air quality.

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