RESEARCH ARTICLE OPEN ACCESS

Edge Computing Based Air Pollution Monitoring System

Sujith Krishna B [1], Janardhan Guptha S [2]

Department of ECE (Specialization in internet of things and sensors), Vellore Institute of Technology, Vellore, Tamil Nadu - India

ABSTRACT
The acquisition of biological changes by releasing various types of toxics (Chemicals) into our surrounding is called Air contamination(pollution). The main objective is to estimate the rate of Air pollution. Air pollution is a tremendous natural medical problem, executing 10,000 individuals consistently in London alone. In this modern society Air Pollution Monitoring System plays a curial role. Existing systems are not able to provide proper information and solutions. In this paper we explained about the conditions, procedures and designing of the Air Pollution Monitoring System. To overcome the existing monitoring devices and to lower the price of the device, this paper formulated a way to deal with the air quality monitoring system, utilizing the edge-computing based Internet-of-Things (IoT). In the proposed technique, sensors accumulate the air quality information continuously and transmit it to the edge computing device, in which analysis is done.
Keywords: - Edge Computing, Internet of Things.

I. INTRODUCTION

Air pollution is one the worst thing we are facing on our greatest planet called earth. It's a greatest deal for every researcher to find a solution on how to measure the quality of air in our atmosphere. Due to these air pollutions many people around us are facing many hazardous diseases like respiratory problems etc., Though there are many precautions and solutions to reduce the pollution. Still we are in need of some effective solutions to be developed.

Mainly, we focus on outdoor environment i.e... breathing a fresh air from atmosphere. But now the situation was worst. We can't even breath the fresh air in our so called developing urban areas... There are many states of affairs to be verified to check the quality of air. One major problem we face is the quality of air changes on daily basis i.e. in fraction of seconds.... The state of affairs includes wind density, pollutant distribution etc... Typically, there are many stations to verify the quality of air but they are of larger size and mainly there are very expensive which cannot be afforded by common people for the purpose of installation and maintenance.

Any how these stations provide precise results. But still many more attempts have been made to develop an alternative solution and also cost-effective product...Internet of things is a global infrastructure for our information society which enables us to overcome all the flaws or errors persisting in our old systems. The main approaches of these system is to provide an error free system with low cost and also to provide an accurate result.

This paper provides an complete view of requires needs of pollution, already prevailing existing systems and their errors, limitations, restrictions.... present challenges being faced. We deeply evaluate many factors like designing, architecture and sensing nodal mechanism of the monitoring system.

II. RELATED WORKS

As there is a huge development in the industrial sector and urbanisation, the environment is highly contaminated, which disturbs the life of people. Air pollution is one of the major problems in today's environment. To minimize the effect of air contamination, the global environment took major efforts on air monitoring. [7] explains about the Internet of Things (IoT) system which detects the air contamination. Here we use many gas sensors, but do not have any measurement procedure, and they did not follow any proper architecture for system.

[8] explains about the monitoring system on IOT concept where low price transducers are used from MQ series, where data is not collected properly or the transducer calibration, which is mandatory in less price transducers. [9] explains with an fixed Wi-Fi network w.r.t MQTT protocol. The aim is to screen the air pollution level, and only one pollutant is recognised.

[10] means to recognize particular matter only and tells the client through electronic mail utilizing a low-price dust

sensor and different software's for information transmission. [11] utilizes network communication and IOT in air pollution monitoring system. In this system they used low-cost sensors, which has many limitations in providing results. [12] introduced a mobile air quality monitoring system to achieve a low-price solution. This experiment utilizes a public transport roof as a sensor transporter.

The majority of the current experiments discussed now, spot the attention on one or two pollutants; if the system measures more pollutants, then the system`s capability was not clear. Where they utilized less price sensors, they do not have an alignment system and don't manage with sensor drift compensation. In addition, power management techniques is not designed properly for the above projects

TABLE I
SUMMARY OF THE RELATED WORKS

System	Carrier	Sensing Node	Communication protocol	Cost estimation
[12]	Not Mentioned	AVR ATmega128	MQTT	700
[14]	Quad Copter	Not Mentioned	Not Mentioned	1500
[15]	Not Applicable	STC12C5A60 S2	2.4 GHz ISM Band	1500
[16]	Public	ARM Mbed	WIFI	1000
[17]	Mobile Sensors	Arduino, Raspberry PI	Zigbee Module	1400
[18]	Not Applicable	Arduino	WIFI	1200
[19]	Not Applicable	TIMSP430	WIFI, Bluetooth	1200

III. PROPOSED WORK

In accordance to the edge-computing working system the total work has been classified into three layers

A. Sensing Layer

This layer is the premise for the air pollution monitoring system. Detection of Air quality is one of the major objectives of this system. Sensors play the major role in this layer over a large area to detect air quality

B. Edge Computing Layer

This zone is made out with edge-computing devices. The main duty is to speak with Sensing layer and Application layer. ECD accumulates the information from the first layer and after, sends the data to the next layer.

C. Application Layer

This application layer should provide collaborative assistance to customers. This process is divided into 2 types: The IoT cloud and user applications. When it gets detailed information from devices, it saves the information in cloud and presents the data in many ways like graphs, tabular columns etc

IV. BLOCK DIAGRAMS

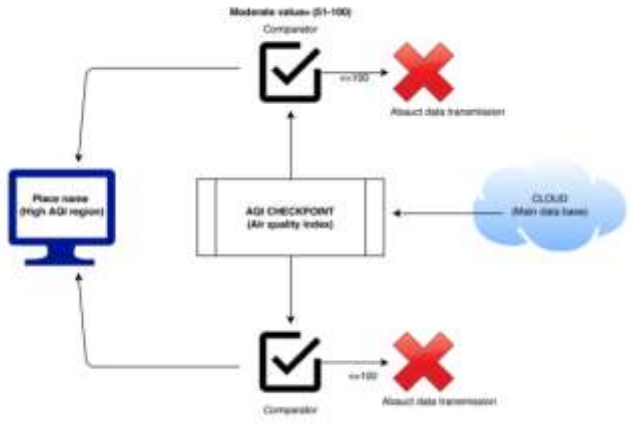


Figure 1: Detailed explanation about the Application layer.

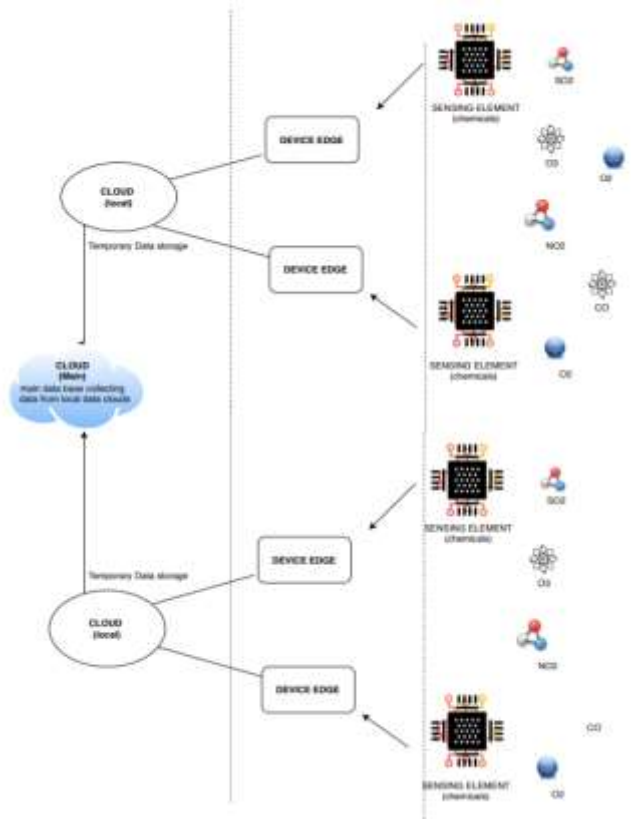


Figure 2: System architecture of the Air Pollution Monitoring System

V. METHODOLOGY

(1) Place the sensing elements i.e., Device with sensors, in the atmosphere where pollution rate must be estimated.

(2) The system is initiated by sensing the presence of the chemicals and transmission of the real time data to the next layer. (chemicals like SO2, NO2, CO, CO2...).

(3) Then, in the Application layer / edge computing layer, the real time data sent is transmitted to AQI checkpoint where the data is estimated in terms of AQI (Air Quality Index).

(4) The AQI value thus estimated is compared with the moderate AQI value 100 and then, further transmission takes place accordingly.

(5) case(i): If the AQI value <= 100 then transmission of signal will get abducted. case(ii): If the AQI value >100 then, The data is further transmitted to the next stage says local cloud.

(6) Similarly, each local cloud gathers information from the places (selected for monitoring purpose).

(7) Finally, All the local clouds transmit the data to the Big cloud i.e., main data base, and then the data in the local clouds will gets vanished as they are used as temporary storage.

(8) The final analysis of all the results will be displayed on the monitor and further steps can be taken to prevent the pollution rate.

Thus, monitoring is done and precautions can be taken.

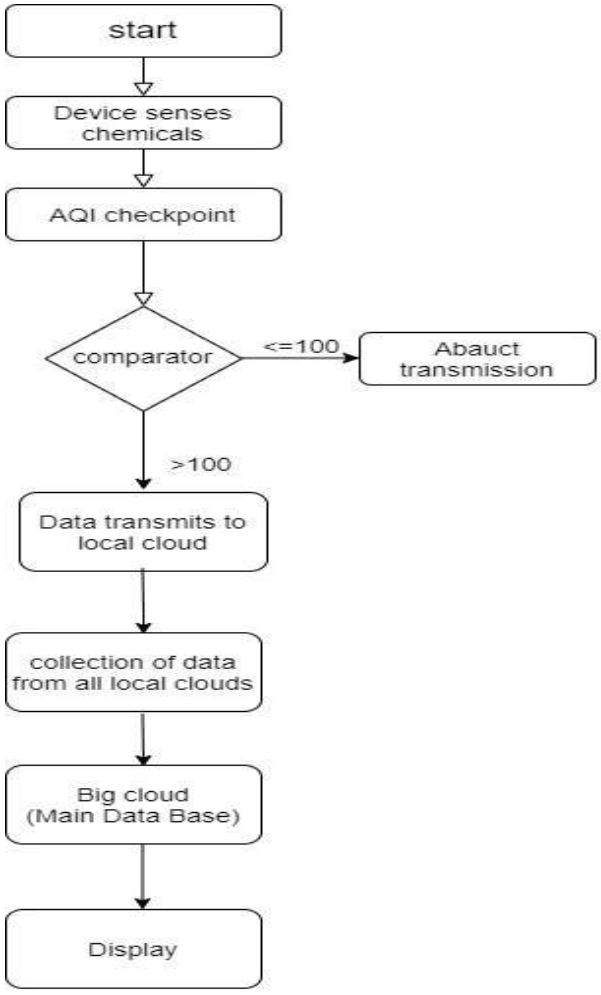


Figure 3. Flow chart of project methodology

VI. RESULT

The sensing layer passes the information to the edge-computing layer. This layer transmits data into AQI check point, where the data is analysed according to the table1. Hence the information collected by all the clouds is sent to

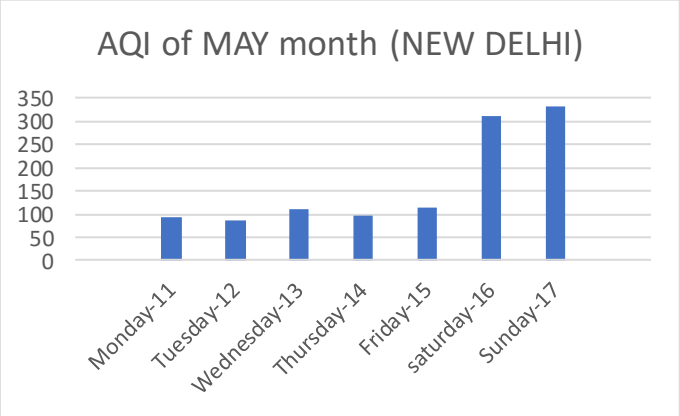
the main cloud. Here the final analysis of all the results will be displayed on the monitor. and the measures were taken in the targeted areas i.e., areas with high AQI value. This Air Pollution Monitoring System maintain the day wise AQI value record as shown in the Graph1. Graph 2 compares the average AQI value of the different cities. The metropolitan cities as more AQI value then the towns, villages etc.,.

Here the result is displayed in three types of data visualisations. Graph 1 explains the day to day AQI report. Graph 2 shows the comparison of AQI values of different cities. Graph 3 explains about the temperature of the city.

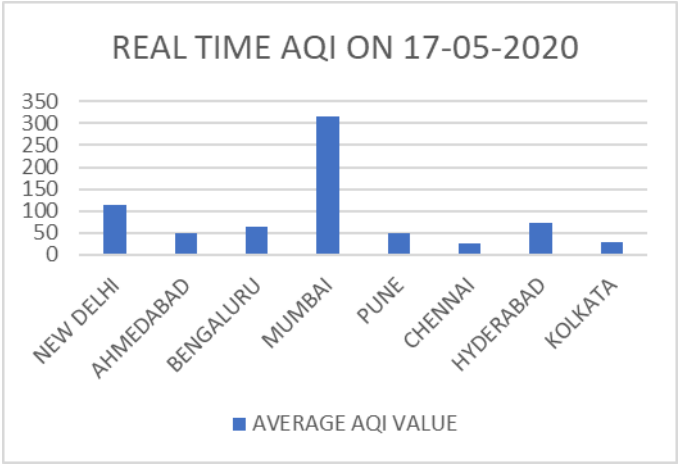
By this Edge Computing Based Air Pollution Monitoring System we can know pollution levels (air pollution) of the cities and measures are taken to minimize the effect of air pollution on peoples

TABLE 2
AQI LEVELS ACCORDING TO ENVIRONMENT PROTECTION AGENCY

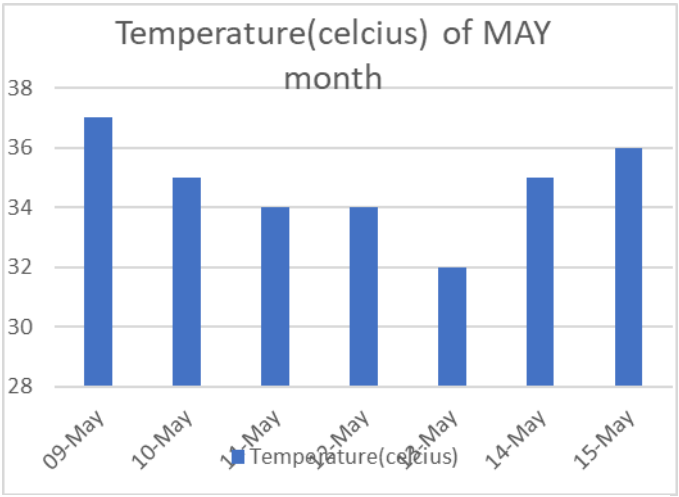
AQI VALUE	HEALTH APPREHENSION
0-50	GOOD
51-100	MODERATE
101-150	UNHEALTHY FOR SENSITIVE GROUP
151-200	UNHEALTHY
201-300	EXTREMELY UNHEALTHY
301-500	HAZARDOUS



Graph1: AQI measurement day-wise record of New Delhi from 11 May to 17 May 2020



Graph 2: Average AQI value of the cities is compared on 17 May 2020



Graph 3: Temperature of this MAY month from 09 May to 15 May 2020

VII. CONCLUSION

In this paper, we developed an edge-computing based IoT architecture for the air pollution monitoring system. This experiment mainly focuses on merging of open access and cheap/less price technologies. This working model was manufactured with a mini model, and with a deployed Arduino platform. This working model is able to recognize numerous pollutants present in air and PM along with Temperature. Algorithms are engaged in avoiding short-term sensor flaws and managing the cross-sensitivity difficulties/issues. This project is accounted with automatic calculation so that the result provided i.e. reports provided by sensors were accurate and efficient. Data visualizations were used to present the data.

From the huge amount of data, required amount of data was provided, and issued to people at the local areas to create realization among end users. This experiment is marvellous idea for various applications like industries monitoring, household etc.,

REFERENCES

[1] Zeba Idrees, Zhuo Zou, Lirong Zheng, "Edge Computing Based IoT Architecture for Low Cost Air Pollution Monitoring Systems: A Comprehensive System Analysis, Design Considerations & Development", MDPI, Basel, Switzerland 2018

[2] Raghavendra Khot,Vidya Chitre,"Survey on air pollution monitoring systems",2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS),IEEE

[3] Ahmed M.M., Banu S., Paul B. Real-time air quality monitoring system for Bangladesh's perspective based on Internet of Things; Proceedings of the 2017 3rd International Conference on Electrical Information and Communication Technology (EICT); Khulna, Bangladesh. 7–9 December 2017; Piscataway, NJ, USA: IEEE;

[4] Devahema P.V., Garg A., Anand A., Gupta D.R. IoT Based Air Pollution Monitoring System. J. Netw. Commun. Emerg. Technol. 2018;3:100–103

[5] Alshamsi A., Anwar Y., Almulla M., Aldohoori M., Hamad N., Awad M. Monitoring pollution: Applying IoT to create a smart environment; Proceedings of the 2017 International Conference on Electrical and Computing Technologies and Applications (ICECTA); Ras Al Khaimah, UAE. 21–23 November 2017; Piscataway, NJ, USA: IEEE

[6] Lee S., Jo J., Kim Y., Stephen H. A framework for environmental monitoring with Arduino-based sensors using Restful web service; Proceedings of the 2014 IEEE International Conference on Services, 2014

[7] Caya M.V.C., Babila A.P., Bais A.M.M., Im S.J.V., Maramba R. Air pollution and particulate matter detector using raspberry Pi with IoT based notification; Proceedings of the 2017 IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM); Manila, Philippines. 1–3 December 2017; Piscataway, NJ, USA: IEEE; 2017.

[8] Min K.T., Forys A., Schmid T. Demonstration abstract: Airfeed: Indoor real time interactive air quality monitoring system; Proceedings of the 13th International Symposium on Information Processing in Sensor Networks; Berlin, Germany. 15–17 April 2014; Piscataway, NJ, USA: IEEE

[9] Li Y., He J. Design of an intelligent indoor air quality monitoring and purification device; Proceedings of the 2017 IEEE 3rd Information Technology and Mechatronics Engineering Conference (ITOEC); Chongqing, China. 3–5 October 2017; Piscataway, NJ, USA: IEEE

[10] Fioccola G.B., Sommese R., Tufano I., Canonico R., Ventre G. Polluino: An efficient cloud-based management of IoT devices for air quality monitoring; Proceedings of the 2016 IEEE 2nd International Forum on Research and Technologies for Society and Industry Leveraging a better tomorrow (RTSI); Bologna, Italy. 7–9 September 2016.