IoT based air pollution monitoring and predictor system on Beagle Bone Black

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***Abstract*— Urban air pollution rate has grown to alarming state across the India. Most of the cities are facing issue of poor air quality which fails to meet standards of air for good health. It is indeed necessary to develop an air pollution measurement and prediction system for a smart city. This proposed work acquires carbon dioxide and carbon monoxide level in the air along with Global Positioning System (GPS) location by using pollution detection sensor and uploads into Azure cloud services. Low cost embedded Beagle bone board along with gas sensors are used for data acquisition. Microsoft's Azure Machine learning service is used to predict the pollution metrics with the help of previous data. Processed data is fetched and represented by Power BI tool. Calibrated gas sensor data is fetched from sensors and successfully uploaded into cloud. Data stored in cloud is utilized by different cloud services to make the data meaningful. Proposed system is implemented and useful to monitor and reduce the pollution in a smart city by avoiding the pollution causes**

***Keywords*— Beagle Bone, Data Acquisition, Android Application, Power BI tool, Gas Sensor, Smart city.**

I. INTRODUCTION

As per World Health Organization [WHO] air pollution is infectivity of the indoor or outdoor environment by any chemical and biological agent which changes characteristics of the environment. Household combustion devices, vehicles and forest fires are common origin of air pollution and noise pollution. Pollutants which are responsible for health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulphur dioxide. Air pollution cause respiratory and other diseases, which can be deadly [1] . WHO has measured quality of air in approximately 1500 cities and Indian capital city was the one of the most polluted cities around the world. Delhi is having highest concentration of particulate matter which is smaller than 2.5 micrometer [2].

Air pollution and lack of air quality monitoring points represent environmental and technological challenges for cities and environments around the world [3, 4]. To face this issue, industry has focused its efforts in finding a versatile technological alternative that allows the improvement of the air quality measuring process and provides reference values in network sites where conventional monitoring fails to cover appropriately. Unfortunately, existing products and the generated results do not represent low-cost solutions.

The IoT based work for measuring the power consumed in the home appliances has already implemented on Xively IoT platform and Beagle bone black5. Similarly gas sensor data acquisition and monitoring is also implemented on Beagle Bone Black6. The literature shows that an Internet of Things application, of which a physical object is embedded with electronics, software, sensors and wireless connectivity to allow monitoring air pollution on real-time[5, 6].

II. SYSTEM SETUP

A. Hardware Setup

Beagle Bone Black is a low-cost, community-supported development platform for developers and hobbyists as shown in figure 1. Boot Linux in under 10 seconds and get started on development in less than 5 minutes with just a single USB cable.It also has-

1. 512MB DDR3 RAM
2. 4GB 8-bit eMMC on-board flash storage
3. 3D graphics accelerator
4. NEON floating-point accelerator

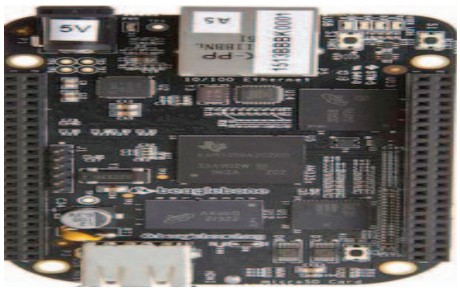

Figure 1: Beagle Bone Black

B. Software Setup

Python programming is used to configure GPIO pins of beagle bone and for enabling the inbuilt ADC. This script is used to fetch data from ADC and perform decision making processing on fetched data. Sensor data is stored in the cloud with the help python SQL and Event hub API. Generally socket is used for connection between two platform such as cloud and python. Machine learning service is also deployed and fetched by python script. Power BI service is used for data representation on desktop and mobile also.

III. METHODOLOGY

A. Block Diagram:

This proposed system consist of Beagle bone Interfaced with air pollution measure sensors such as carbon dioxide [CO2], carbon monoxide [CO] and noise sensor. MQ-7 sensor is used for measuring CO and MQ-11 sensor for measuring H2. GPS module is used for taking the current location which is used to represent pollution concentration at different locations as shown in figure 2.

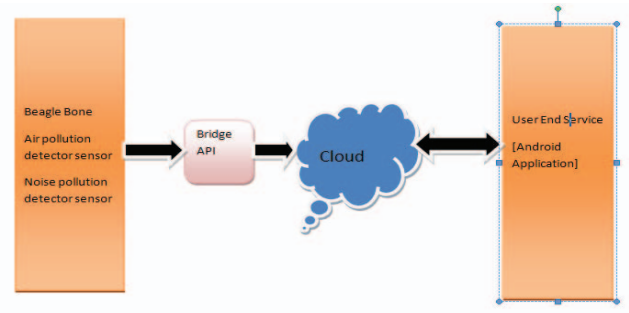

Figure 2: Block Diagram

CO2 Concentration and it's side effects		CO concentration and it's side effects		Noise in DB it's side effects	
350-1000 PPM	Indoor space with good air flow	35 PPM	CO Max exposure for 8 hours work day	Less than 115 DB	Acceptable
950-2000 PPM	Complaint of tiredness and poor air	800 PPM	CO Death within 2 to 3	Greater than 115	Affect human health
2000-5000 PPM	Headaches ,sleepiness and stagnant etc				

Figure 3: Concentration of pollutant and its effect

The chart in Figure 3 explains different concentration and its effect on human health for CO2, CO and noise

B. Calibration of Sensor

Analog output from sensor is read from Analog pin of Beagle bone black. Analog pin read the input signal in the range 0 v to 1.8 v. Hence we need to multiply by 1800 to input value from Analog pin to get equivalent sensor output value.

C. Data Processing in Beagle Bone Black:

Data from sensor is uploaded on Azure Cloud with the help of python SQL.

D. Creation of reserved data base:

Reserved data base is created in the beagle bone itself in the form of .CSV file. It is saved for only one day. At the end of each day, same data present in the .CSV file is uploaded in the cloud data base. Data which was missed to upload in the cloud is updated in the cloud. It helps to provide more reliability to "Pollution Monitoring System". Old data in the beagle bone is deleted with the help of automated shell script.

E. Cloud Data Analytics:

Data from different sensor is stored in the Azure data base. This data from database is fetched as a input for machine learning service. Machine learning service is used to train the module with the help of previous data.

Such trained module is used to predict the observations related to pollution metrics in future.

This machine learning service is deployed as a web service and can be used for any user to get prediction as shown Figure 5.

F. Data Representation:

Power BI is used to represent sensor data fetched by beagle bone black. Observe the real time data from sensor on power BI and mobile also.

Different report are generated as per audience and published as a web service. So that anyone who having credential can observe the reports and real time modifications in the report data.

The above mentioned block diagram shows interconnection between beagle bone ,cloud and end user application as shown Figure 2.

IV. IMPLEMENTATION AND RESULTS

Below diagram is the complete system to acquire the data from gas sensor and as well as to upload the data in the Azure cloud as shown Figure 4.

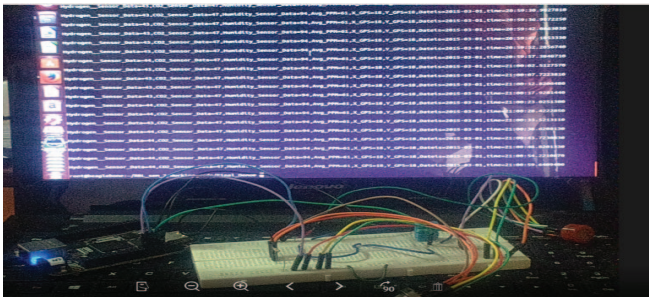

Figure 4: Complete system with hardware

Data from gas sensors is sensed with the help of inbuilt ADC in the beagle bone black as shown in Figure 4. This data is uploaded in Microsoft's Azure Cloud with the help of "EVENT HUB" cloud service and data is stored in the SQL data base present in cloud itself

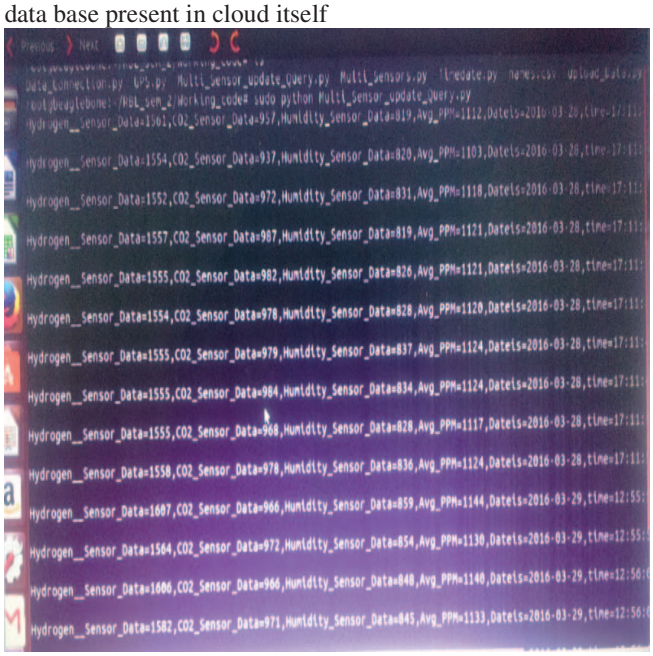

Figure 5: Concentration of pollutant and its effect

Thus cloud platform is used as software as a service and database as a service shown in Figure 2. This shows that data is sensed from sensor and uploaded in the cloud.

However it is always not possible to upload the sensor data to cloud due to interrupted internet connection. So, separate local data base is created in beagle bone black and whenever system is started or after every 12 hours, local database is synchronized and recreated again in the local system. The below diagram shows local database in the form of CSV [Coma Separated Value] as shown Figure 6.

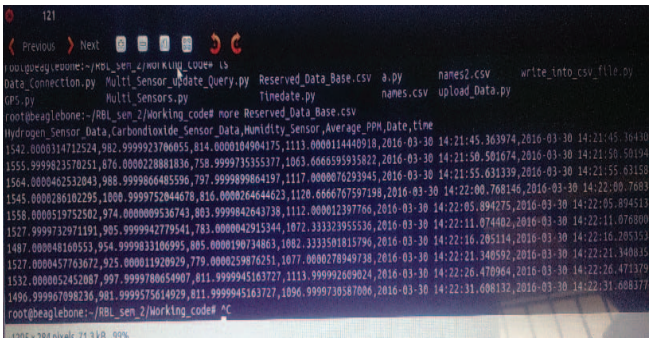

Figure 6: Local Data Base Creation

Machine learning service is implemented in machine learning studio which takes data stored in the cloud and perform analysis to predict future pollution related result. This service is deployed as web service as shown Figure 7.

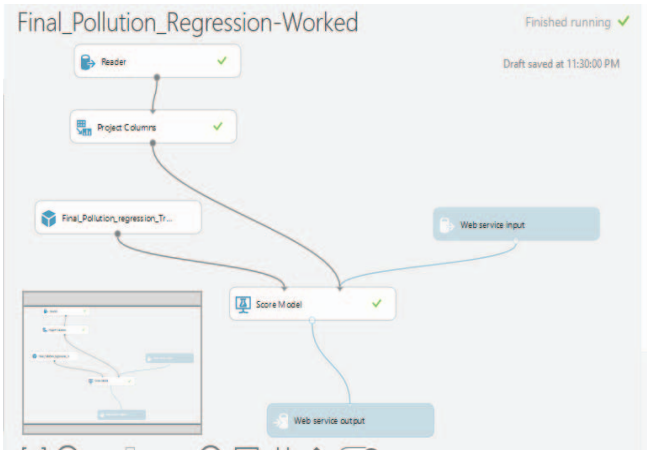

Figure 7: Machine learning service

Deployed web service is fetched with the help of python script for any user as shown Figure 8.

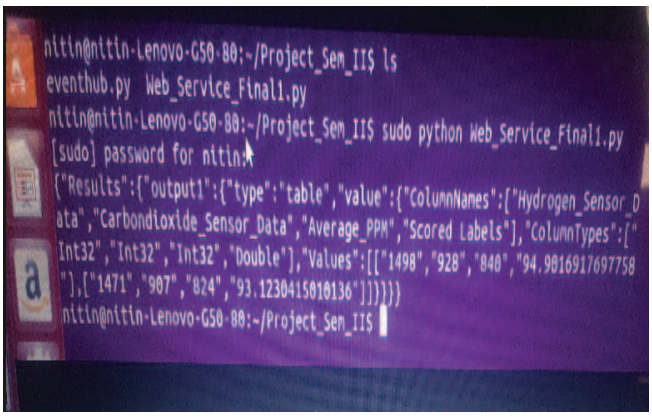

Figure 8: Machine learning service is deployed as web service

Cloud data is represented in Power BI tool as shown in below figure. This is the graphical representation of cloud data and can be used for monitoring purpose by publishing the Power BI service and data can be fetched on Android mobile application to monitor real time data as shown Figure 9.

Figure 9: Power BI representation of Data

Data from sensor is stored in cloud SQL data base as shown below Figure 10.

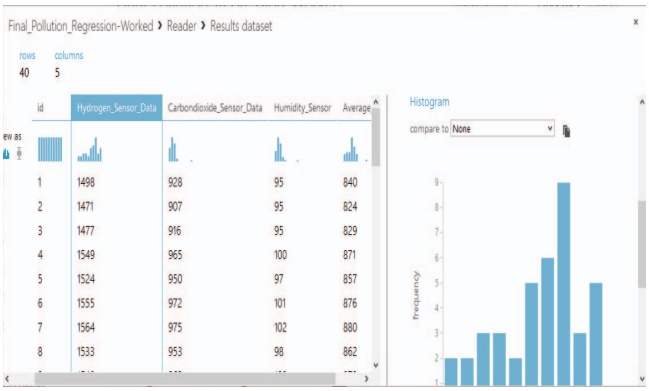

Figure 10: Sensor data in Cloud

V .CONCLUSION

Objective of this work is to develop an air pollution measurement and prediction system for a smart city which stores the data in the cloud. Cloud data is used for data analytics which can be used for taking the decision to minimize pollution and reduce the effect of pollution on environment.

Since smart phones and mobile applications have revolutionized the human life, same work can be integrated to mobile apps. In future, other gas sensors for nitrogen dioxide and sulphur dioxide and noise level monitoring also could be included.

REFERENCES

[1] Air pollution, http://www.who.int/topics/air_pollution/en/. Date Accessed : 1/2/2016

[2] Delhi air pollution is worst in world. http://money.cnn.com/2015/04/14/news/economy/india-delhi-air-pollution/. Date accessed: 12/02/2016

[3] Huang, Le Hui, and Bin Gui. Discussion on Air Pollution and Its Control Measures. Advanced Materials Research. 2014, 1010-1012, pp. 839

[4] S. Kumar and D. Katoria. Air Pollution and its Control Measures. International Journal of Environmental Engineering and Management. ISSN 2231-1319. 2013, 4(5), pp. 445-450.

[5] Nitin Sinha and John Sahaya Rani Alex. IoT Based iPower Saver Meter. Indian Journal of Science and Technology. 2015, 8(19).

[6] Nitin Sinha, Korrapati Eswari Pujitha, John Sahaya Rani Alex. Xively Based Sensing and Monitoring System for IoT. 2015 International Conference on Computer Communication and Informatics (ICCCI -2015). 2015, pp. 1-6.