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Indoor Air Quality: IoT Solution

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Abstract— this paper gives a proposal for addressing the issue of indoor air quality using the internet of things communication model. The description of the effects of lowmoderate levels of carbon dioxide on the occupants on the indoor space is presented. A system, containing sensor networks and being internet of things enabled, is proposed, to facilitate in achieving efficient indoor air quality system. The system is designed to contain three major areas of functionality: first, the wireless sensor network that will provide the system with the part per million reading of the room's carbon dioxide. Second, this information is passed through a wireless access point and gets dumped on a server machine. Third, the server side stores and processes this data. The server side contains user interface and notification system functionalities.

Keywords— Internet of things (IoT), wireless sensor networks, indoor air quality (IAQ).

I.INTRODUCTION

The Internet of Things (IoT) is a recent communication paradigm that envisions a near future, in which the objects of everyday life will be equipped with microcontrollers, transceivers for digital communication, and suitable protocol stacks that will make them able to communicate with one another and with users, becoming an integral part of the internet [1]. The Internet of things is, hence, concept which allows mundane "things" or objects to communicate with each other to facilitate activities requiring high co-ordination with ease. This is done by connecting these things over the internet infrastructure with each other. This paper discusses about using this concept of IoT to enable efficient air quality systems indoors in either public places like office buildings, schools or private places like homes.

The main pollutant of indoor air is the carbon dioxide gas and ironically the major source of it is humans itself. A study at the Department of Energy's Lawrence Berkeley National Laboratory (Berkley Lab) shows that even a moderate amount of carbon dioxide indoors impairs cognition. In enclosed spaces such as schools and conference rooms where cognition and learning is of utmost value, such a factor for deteriorating of performance must not be accepted. The 2012 LBNL-SUNY article states that, "In surveys of elementary school classrooms in California and Texas, average carbon dioxide concentrations were above 1,000 ppm, a substantial proportion exceeded 2,000 ppm, and in 21% of Texas classrooms peak carbon dioxide concentration exceeded 3,000 ppm".

Below are some of the graphs of this survey shown to explain the relation of carbon dioxide levels with cognition explicitly.

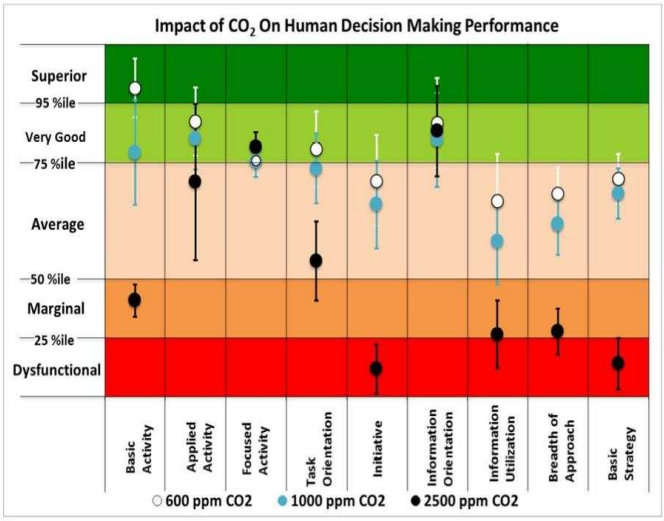

Fig.1. Graph indicating the extent of impaired cognition over three levels of co2, 600ppm, 1,000ppm and 2,500 ppm

The above graph shows on nine scales of decision-making performance, test subjects showed significant reductions on seven of the scales at carbon dioxide levels of 1,000 parts per million and large reductions on seven of the scales at 2,500 ppm. The most significant decline in performance that is, rated as "dysfunctional", were for taking initiatives and thinking strategically.

This paper addresses this problem by proposing a system that will alert the occupants of the room of the rising level of carbon dioxide inside to take further action.

II.SYSTEM DESCRIPTION

The air quality measurement of an indoor space can be done using a network of wireless sensors and having them dump their data onto a remote server which will process it further.

The carbon dioxide sensors can be integrated with a wireless local area network access point which collects and dumps data onto to the server periodically using internet protocols such as UDP.

The system when deployed will monitor the carbon dioxide levels in the room in real time and continue collecting data periodically in programmed intervals. The current system only monitors activity of carbon dioxide gas, it can be extended to monitor activities of other gases for different analysis.

A. Sensor Nodes

The system uses one type of sensor which monitors the parts per million reading of the carbon dioxide gas and many such sensing units are placed all around the room to be monitored. The sensing units are wireless and hence connected in a wireless sensor network and communicate with the remote server over a wireless access point.

B. Wireless access point

For the current system, as it is on experimental basis, each of the sensing units comprises of a raspberry pi acting as a wireless access point for the system. As Figure.2 shows, the access point collects the co2 concentration data from the sensors and dumps it onto the server using internet protocols like UDP.

There can be many such access points located all around the area to be checked and the server will consolidate all these inputs in its database and run the threshold program over the consolidated data.

C. Remote Server

The remote server encompasses a simple web server like Tomcat web server. All of the user interface and result display responsibilities are taken by the server.
The server gets input from the access point as groups of sensor data at regular time intervals. A local database is maintained on the server machine which maintains a database for each access point's entries. In each database it maintains a table for every sensor corresponding to that access point. Timestamps, sensor ID, access point ID etc. also constitute the entries of the database.

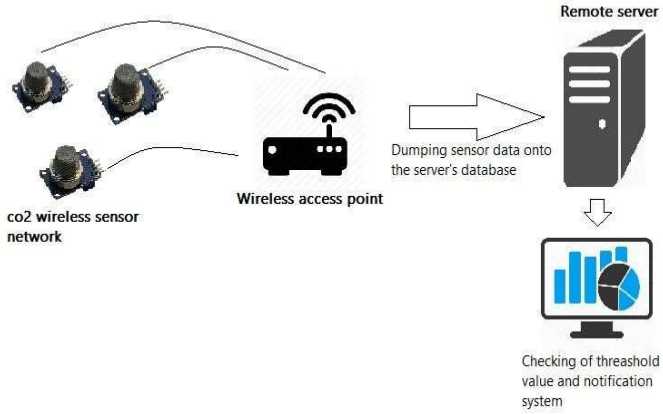

Fig. 2 Schematic diagram of the system as a whole

On the server an application program will be running that uses, analyses, and draws out conclusions on the data dumped by the sensors in the database.

On the server side a program cumulates all the readings obtained by the range of sensors and calculates an average reading per unit time. This average is compared with a stored threshold value set according to environment conditions. The threshold value is set as the maximum allowed value of carbon dioxide (in ppm) in the room. When the average crosses the threshold value then the notification alert system will be activated.

On activation, the notification system will pop up and/or ring a sound alarm showing that the air quality in the room has dropped and action needs to be taken.

Apart from the notification system, the server side program also tabulates graphs and analysis reports of timeline and records of the frequency of alert system being activated.

In further version of development the server side functionality can be extended to a mobile application (android or ios) for the notification mechanism to be more agile, instant and faster. For example, in a school, the notification system mobile application can be installed in the class teacher's mobile device. This way the application contains only the notification part of the system making it a light application.

III.CONCLUSIONS

By using this indoor air quality system the first step of addressing a problem is being done, that is, notification. As the sensor network is wireless and also the entire communication is wireless, the only infrastructure required is the internet itself.

When used efficiently, this system can visibly reduce impaired cognition among employees of an office building or increase the learning capacity of students in a school classroom. Thus when productivity of people is increased naturally the organization benefits.

Also as this is a system based on the internet of things, it has a huge scope for improvement, advancement and being widely deployed. It has an extended future scope and hence can change with the ever evolving technology.

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V.FUTURE SCOPE

This system has vast scope for future improvements. The current system provides a notification on the server machine, this can be extended to provide such a notification on a mobile application to whosoever's mobile device concerned with the issue.

With the advancement of the internet of the things technology, a future of this project could be that the current system communicates with the IoT enabled ventilation system of the indoor space. As the threshold value of the sensor data collected is crossed, the ventilation system is directed to pull in fresh air from outside or make any other change subjective to the implementation of the system.

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