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Live Weather Report Using IOT with Graphical Display

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Abstract
This paper presents the development of a cyber-physical system that monitors the environmental conditions or the ambient conditions in indoor spaces at remote locations. The communication between the system's components is per-formed using the existent wireless infrastructure based on the IEEE 802.11 b/g standards. The resulted solution provides the possibility of logging measurements from locations all over the world and of visualizing and analyzing the gathered data from any device connected to the Internet. This work encompasses the complete solution, a cyber-physical system, starting from the physical level, consisting of sensors and the communication protocol, and reaching data management and storage at the cyber level. The experimental results show that the proposed system represents a viable and straightforward solution for environmental and ambient monitoring applications.

Index Terms— Cyber-physical systems (CPSs), IEEE 802.11 standards, Internet of Things (IoT), wireless communication.

INTRODUCTION

THE IMPORTANCE of environmental monitoring is undoubted in our age. This is the field where wireless sensor networks (WSNs) have been first used, their primary purpose consisting in the observation of the physical world and the recording of physical quantities characterizing it. WSNs are large networks of resource-constrained sensors with processing and wireless communication capabilities, which implement different application objectives within a specific sensing field. They can also be used for ambient monitoring, a topic of great interest nowadays as well, indoor air quality representing an important factor affecting the comfort, health, and safety of building occupants. Finally, the use of wireless ambient sensors can lead to more energy-efficient buildings.

The constant attempts of social and economic bodies for the development of technologies for improving energy efficiency and reducing pollution and for the more efficient use of national infrastructure along with the needs of decreasing the cost of computation, networking, and sensing had lead to the emergence of a new generation of digital systems, called cyber-physical systems (CPSs), less than a decade ago. These include embedded systems, sensor networks, actuators, coordination and management processes, and services to capture physical data and to act on the physical environment, all integrated under an intelligent decision system.

In this context, wireless sensors can be used to collect physical information that is further exploited by CPSs. This will lead to CPSs composed of interconnected clusters of processing elements and large-scale wired and wireless networks of sensors and actuators gathering data about and acting upon the environment. These newly appeared

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systems have a lot of similarities with the Internet of Things (IoT), an enabler of ubiquitous sensing, that envisions a world in which many billions of Internet-connected objects or things, with sensing, communication, computing, and potentially actuating capabilities, will coexist, allowing an uninterrupted connection between people and things.

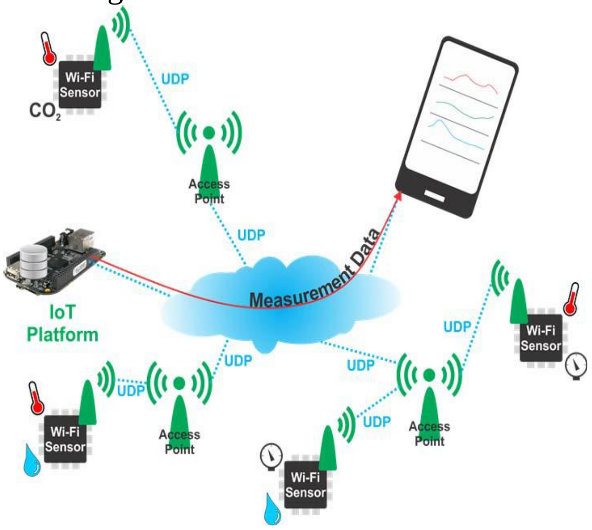

Fig. CPS for environmental monitoring.

This project presents a system for environmental and ambient parameter monitoring using low-power wireless sensors connected to the Internet, which send their measurements to a central server using the IEEE 802.11 b/g standards. Finally, data from all over the world, stored on the base station, can be remotely visualized from every device connected to the Internet. This overcomes the problem of system integration and interoperability, providing a well-defined architecture that simplifies the transmission of data from sensors with different measurement capabilities and increases supervisory efficiency. Until recently, Wi-Fi technology has not been considered for implementing wireless sensing solutions because of its inability to meet the challenges in these types of systems, with the major drawback consisting in the unsatisfactory energy consumption. However, this has changed, since new power-efficient Wi-Fi devices have been developed and new solutions can benefit from several advantages offered by this technology, namely, the reduction of infrastructure costs while improving total ownership costs, native IP-network compatibility, and the existence of familiar protocols and management tools. Furthermore, high transmission rates, which are required in industrial applications, are achievable and the access to the network in this case is easy and no special wireless adapters are required.

STATEMENT OF PROBLEM

Present innovations in technology mainly focus on controlling and monitoring of different activities. These are increasingly emerging to reach the human needs. Most of this technology is focused on efficient monitoring and controlling different activities. An efficient environmental monitoring system is required to monitor and assess the conditions in case of exceeding the prescribed level of parameters (e.g., noise, CO and radiation levels).

When the objects like environment equipped with sensor devices, microcontroller and various software applications becomes a self-protecting and self-monitoring environment and it is also called as smart environment. In such environment when some event occurs the alarm or LED alerts automatically. The effects due to the environmental changes on animals, plants and human beings can be monitored and controlled by smart environmental monitoring system. By using embedded intelligence into the environment makes the environment interactive with other objectives, this is one of the application that smart environment targets. Human needs demands different types of monitoring systems these are depends on the type of data gathered by the sensor devices. Event Detection based and Spatial

Process Estimation are the two categories to which applications are classified.

Initially the sensor devices are deployed in environment to detect the parameters (e.g., Temperature, Humidity, Pressure, LDR, noise, CO and radiation levels etc.) while the data acquisition, computation and controlling action (e.g., the variations in the noise and CO levels with respect to the specified levels). Sensor devices are placed at different locations to collect the data to predict the behavior of a particular area of interest. The main aim of the this project is to design and implement an efficient monitoring system through which the required parameters are monitored remotely using internet and the data gathered from the sensors are stored in the cloud and to project the estimated trend on the web browser.

PURPOSE OF PROJECT

There are a lot of high end systems available these days for round the clock weather monitoring. But these systems are implemented on a very large scale, for monitoring real time weather for a whole city or state. Implementing such system for a small area is not feasible, since they are not designed for it and the overhead for maintaining such systems for a small area is very high.

IOT BASED WEATHER MONITORING SYSTEM

It is the future technology of connecting the entire world at one place. All the objects, things and sensors can be connected to share the data obtained in various locations and process/analyses that data for coordinating the applications like traffic signalling, mobile health monitoring in medical applications and industrial safety ensuring methods, etc. As per the estimation of technological experts, 50 billion objects will be connected in IoT by 2020. IoT offers a wide range of connectivity of devices with various protocols and various properties of applications for obtaining the complete machine to machine interaction.

The traditional technologies like home automation, wireless sensor networks and control systems will become more efficient and smarter due to involvement of IoT. IoT is having a wide range of application areas. Such as Medical applications for monitoring the health of a patient and sends the information wireless. The present developing Wearable instrumentation is also based on IoT. The example wearable instrumentation is Smart wrist bands, navigation pills, etc. All this methods require an internet interface to update the health info or to control the device with a smart phone.

The IoT also plays a vital role in media applications for advertising and exchanging the information worldwide. The manufacturing processes also requires IoT for supply chain management, digital control systems for monitoring the manufacturing processes. The space requirements of IoT technology, the geographical specifications are always important in case of tracking applications. The geographical dimensions of objects is also important while obtaining the data from the objects. IoT in automobile applications and traffic maintenance became a most using area of automation. The automated devices in a vehicle should be connected to a cloud to update the car health within a period of time. By connecting the vehicles and traffic signalling systems to the internet, people can easily find the shortest path for their destination from the traffic monitoring systems and can navigate automatically by checking all other directions.

The Internet of Things is an rising topic of technical, social, and economic significance. consumer products, consumer durables, cars and trucks, industrial and utility elements, sensors, and other Daily used things are being combined with net connectivity and powerful information analytic capabilities that promise to transform the method we work, live, and play. Projections for the impact of IoT on the web and economy are spectacular, with some anticipating as several as a hundred billion connected IoT devices and a world economic impact of quite $11 trillion by 2025.

SUMMARY

This concludes that the present work was a success and it will provide a competent method for recording real time weather readings and help farmers whose livelihood depends on the weather in a country like India to produce better quality crops. It can be used to gather information about the requirements for each area over the years. The gathered information is used to determine the optimal conditions for plants to grow and the farmer can modify the environment suitable for the growth of the plant. This, in turn will have a huge impact on agriculture and also on farmers throughout the world.

LITERATURE REVIEW IMPORTANCE

Through weather monitoring system we can collect the information about humidity and temperature and according to current and previous data we can produce the results in graphical manner in the system. After reviewing many articles, there are presently no projects that mention monitoring the combination of temperature, lighting and humidity in one integrated system and have actuators to modify these settings. In addition to this, there is one research project that has discussed monitoring these three environmental conditions; however, there has been no mention about having actuators to modify. So our main idea was to coin a system that can sense the main components that formulates the weather and can be able to forecast the weather without human error.

COMPARISON OF DIFFERENT WEATHER MONITORING SYSTEMS

There's a comparison between differing kinds of weather monitering systems used currently and antecedently per their operating procedure, construction, economical aspects, time of installation, price and maintenance etc.

Ancient weather forecasting methods usually relied on observed patterns of events, also termed pattern recognition. For example, it might be observed that if the sunset was particularly red, the following day often brought fair weather. This experience accumulated over the generations to produce weather lore. However, not all of these predictions prove reliable, and many of them have since been found not to stand up to rigorous statistical testing. The simplest method of forecasting the weather, persistence, relies upon today's conditions to forecast the conditions tomorrow. This can be a valid way of forecasting the weather when it is in a steady state, such as during the summer season in the tropics. This method of forecasting strongly depends upon the presence of a stagnant weather pattern. It can be useful in both short range forecasts and long range forecasts. Measurements of barometric pressure and the pressure tendency (the change of pressure over time) have been used in forecasting since the late 19th century.

RELATED PROJECTS

a. Energy efficient wireless sensor network communications based on computational intelligent data fusion for environmental monitoring

The study presents a novel computational intelligence algorithm designed to optimise energy consumption in an environmental monitoring process: specifically, water level measurements in flooded areas. This algorithm aims to obtain a trade-off between accuracy and power consumption. The implementation constitutes a data aggregation and fusion in itself. A harsh environment can make the direct measurement of flood levels a difficult task. This study proposes a flood level estimation, inferred through the measurement of other common environmental variables. The benefit of this algorithm is tested both with simulations and real experiments conducted in Doñana, a national park in southern Spain where flood level measurements have traditionally been done manually.

b. ISSAQ: An integrated sensing systems for real-time indoor air quality monitoring

With growing transportation and population density, increasing global warming and sudden climate change, air quality is one of the critical measures that is needed to be monitored closely on a real-time basis in today's urban ecosystems. This project examines the issues, infrastructure, information processing, and challenges of designing and implementing an integrated sensing system for real-time indoor air quality monitoring. The system aims to detect the level of seven gases, ozone (O3), particulate matter, carbon monoxide (CO), nitrogen oxides (NO2), sulfur dioxide (SO2), volatile organic compound, and carbon dioxide (CO2), on a real-time basis and provides overall air quality alert timely. Experiments are conducted to validate and support the development of the system for real-time monitoring and alerting.

c. Performance study of multilayer perceptions in a low-cost electronic nose Nonselective gas sensor array has different sensitivities to different chemicals in which each gas sensor will also produce different voltage signals when exposed to an analyte with different concentrations. Therefore, the characteristics of cross sensitivities and broad spectrum of nonselective chemical sensors promote the fast development of portable and low-cost electronic nose (E-nose). Simultaneous concentration estimation of multiple kinds of chemicals is always a challengeable task in E-nose. Multilayer perceptron (MLP) neural network, as one of the most popular pattern recognition algorithms in E-nose, has been studied further in this project. Two structures of single multiple inputs multiple outputs (SMIMO) and multiple multiple inputs single output (MMISO)-based MLP with parameters optimization in neural network learning processing using eight computational intelligence optimization algorithms are presented in this project for detection of six kinds of indoor air contaminants. Experiments prove that the performance in accuracy and convergence of MMISO structure-based MLP are much better than SMIMO structure in concentration estimation for more general use of E-nose.

d. Quantification of individual gases/odors using dynamic responses of gas sensor array with ASM feature technique

This project is a continuation of our previous work in which a new feature technique called average slope multiplication (ASM) was proposed to classify the individual gases/odors using dynamic responses of sensor array. The ASM method is used to quantify the individual gases/odors in this project. Back propagation algorithm based two different neural network architectures (NNAs) called NNA1 and NNA2 are used to assess the ability of the ASM technique for quantification. The proposed method thus utilizes the newly developed feature method in the first stage and the specially designed neural quantifiers in the next subsequent stages. The ability of the proposed method has been insured by applying it on the published dynamic responses of the thick film gas sensor array. When the raw data were directly fed to the neural quantifiers, the results were 69% and 63% accurate for NNA1 and NNA2, respectively. The principal component analysis preprocessed version of raw data provided 74% and 67% quantification accuracy with the aforementioned architectures respectively. The performances of the ASM data were found to be 100% using both the network architecture without need of further preprocessing, with relatively less number of epochs and without any hidden layer. Thus, the proposed method can be utilized in electronic nose for classification/quantification purpose.

e. Low-Complex Synchronization Algorithms for Embedded Wireless Sensor Networks

In industrial applications of wireless sensor networks (WSNs), synchronized sampling of data on each sensor node is often required. Thus, the wireless communication protocol needs to support accurate timing synchronization. If due to a high sampling rate also high data throughput is required, WSNs based on the IEEE 802.15.4 physical layer often do not provide sufficient data rate. Wireless communications based on the well-established IEEE 802.11 wireless local area network (WLAN) standard provides high data throughput but not an accurate timing synchronization unless the protocol stack is severely changed. We propose two low-complexity consensus-based synchronization algorithms for the hybrid WSN introduced, which are executable at limited embedded computing capacity, e.g., on an 8 bit microcontroller. A time division multiple access-based synchronization packet broadcasting with three-step-controlled or proportional-integral (PI)-controlled clock adjustment enables 1 kHz sensor sampling rate with a sampling jitter <;15 µs for the three-step-controlled synchronization algorithm and <;1 µs for the PI-controlled algorithm.

f. Wireless Sensor Networks for Smart Grid Applications: A Case Study on Link Reliability and Node Lifetime Evaluations in Power Distribution Systems

Recent advances in embedded systems and wireless sensor networks (WSNs) made it possible to realize low-cost monitoring and automation systems for smart grids. This project presents opportunities and design challenges of WSNs for smart grid applications. WSN-based smart grid applications have been introduced, and some WSN standards and communication protocols have been discussed for smart grid applications. Importantly, node lifetime and link reliability in wireless sensor networking for smart grid applications have been evaluated through case studies based on field tests in electric power system environments.

SUMMARY

There are several technologies used for Weather monitoring system which include monitoring through GSM, monitoring through Rf communication etc. But in all that it's not possible for us to monitor the parameters like temperature and Soil moisture remotely. In some systems it's possible to monitor remotely using some wireless technologies but not for distance. Here we overcome that problem by using Raspberry pi and Thingspeak as web server. By using this we can monitor the parameters anywhere in the world.

EXISTING METHOD

In the present existing method we use to display the current tracking data on the display unit .If there is sudden change in the input data from nodes then previous data will be erased and present data will be displayed, we cannot analyze the tracking data for a particular interval of time. In the existing method we use to display the current data on the LCD. we cannot seen the output in tabular format and graphical because in LCD we can see the particular node values only it is not possible to see the previous values. In the existing method we use ARM7 it supports particular language. So in order to avoid this drawback we use graphical approach, tabular formate in proposed method.

PROPOSED METHOD

In the proposed method we use graphical approach in order to track the instantaneous data and analyze so that we can store the previous and current data without any loss.

We are designed a system by using ARM 32-bit Advanced processor which supports different features and algorithms for the development of industrial remote monitoring systems. Using ARM processor we can connect all types of sensors and we can connect wireless technology. In this we send data to the remote section. where we store the information in database and analyze the data for the future use.

The Internet of Things (IOT) describes the interconnection of devices and people through the traditional internet and social networks for various day-to-day applications like weather monitoring, healthcare systems, smart cities, irrigation field, and smart lifestyle.We are designed a system by using Raspberry pi microcontroller as central system and sensors like Temperature, Humidity, Gas and Sound were interfaced to microcontroller. Sensors collect the information from the environment and fed to microcontroller through ADC interface. Microcontrollers upload that information to web server using inbuilt Wi-Fi module. Then by using android app or web page we access this data from any ware in the globe.

OVERVIEW OF SYSTEM

The block representation of the proposed system is described below:

NODE DESCRIPTION AND WORKING

In the proposed system the sensor nodes are designed to collect the weather information from the different areas and send that to the cloud through wireless technology.

Here the Sensor Node consists of sensors like Temperature, Humidity and sound, smoke. This sensors convert the corresponding physical parameters into the electrical(voltage) and fed to the analog to digital converter(ADC). The ADC then convert the sensor signals into the digital and fed to the Raspberry pi microcontroller, which will process the sensor information according to the pre installed software and fed to the Cloud based Thingspeak open source web server.

BLOCK DAIGRAM

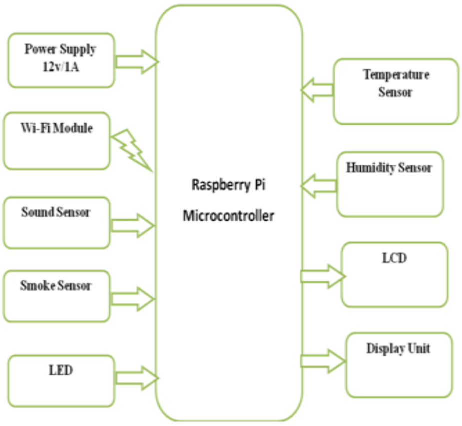

Figure 6.2: Block diagram of sensor node

HARDWARE SYSTEM DESIGN
RASPBERRY PI
INTRODUCTION

Raspberry Pi is a credit-card sized computer manufactured and designed in the United Kingdom by the Raspberry Pi foundation with the intention of teaching basic computer science to school students and every other person interested in computer hardware, programming and DIY-Do-it Yourself projects.

The Raspberry Pi is manufactured in three board configurations through licensed manufacturing deals with Newark element14 (Premier Farnell), RS Components and Egoman. These companies sell the Raspberry Pi online. Egoman produces a version for distribution solely in China and Taiwan, which can be distinguished from other Pis by their red coloring and lack of FCC/CE marks. The hardware is the same across all manufacturers.

The Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, VideoCore IV GPU and was originally shipped with 256 megabytes of RAM, later upgraded (Model B & Model B+) to 512 MB. It does not include a built-in hard disk or solid-state drive, but it uses an SD card for booting and persistent storage, with the Model B+ using a MicroSD.

The Foundation provides Debian and Arch Linux ARM distributions for download. Tools are available for Python as the main programming language, with support for BBC BASIC (via the RISC OS image or the Brandy Basic clone for Linux), C, Java and Perl.
As of February 2014, about 2.5 million boards had been sold.
The Idea to create the Raspberry Pi

The idea behind a tiny and affordable computer for kids came in 2006, when Eben Upton, Rob Mullins, Jack Lang and Alan Mycroft, based at the University of Cambridge's Computer Laboratory, became concerned about the year-on-year decline in the numbers and skills levels of the A Level students applying to read Computer Science. From a situation in the 1990s where most of the kids applying were coming to interview as experienced hobbyist programmers, the landscape in the 2000s was very different; a typical applicant might only have done a little web design. Something had changed the way kids were interacting with computers. A number of problems were identified: majority of curriculums with lessons on using Word and Excel, or writing webpages; the end of the dot-com boom; and the rise of the home PC and games console to replace the Amigas, BBC Micros, Spectrum ZX and Commodore 64 machines that people of an earlier generation learned to program on.

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Figure : A complete Commodore 64 System

There isn't much any small group of people can do to address problems like an inadequate school curriculum or the end of a financial bubble. But those students felt that they could try to do something about the situation where computers had become so expensive and arcane that programming experimentation on them had to be forbidden by parents; and to find a platform that, like those old home computers, could boot into a programming environment. Thus came the idea of creating the device which kids could buy and learn programming or hardware on – The Raspberry Pi.

INITIAL DESIGN CONSIDERATIONS

From 2006 to 2008 they created many designs and prototypes of what we now know as the Raspberry Pi. One of the earliest prototypes is shown below:

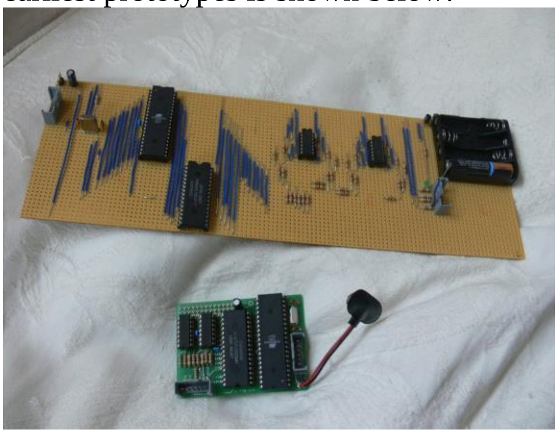


Figure 7.1.2.a: One of the earliest prototype of the Pi

These boards use an Atmel ATmega644 microcontroller clocked at 22.1MHz, and a 512K SRAM for data and frame buffer storage.

By 2008, processors designed for mobile devices were becoming more affordable, and powerful enough to provide excellent multimedia, a feature which would make the board desirable to kids who wouldn't initially be interested in a purely programming-oriented device. The project started to look very realisable and feasible. Eben (now a chip architect at Broadcom), Rob, Jack and Alan, teamed up with Pete Lomas, MD of hardware design and manufacture company Norcott Technologies, and David Braben, co-author of the BBC Micro game Elite, to form the Raspberry Pi Foundation to make it a reality. Three years later, the Raspberry Pi Model B entered mass production through licensed manufacture deals with Element 14/Premier Farnell and RS Electronics, and within two years it had sold over two million units!

EXPERIMENTAL RESULTS

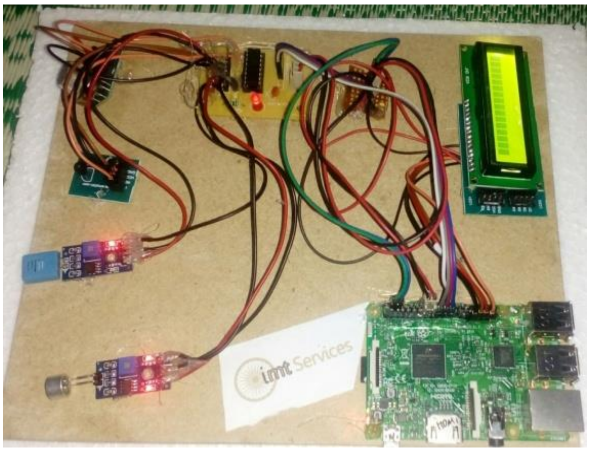
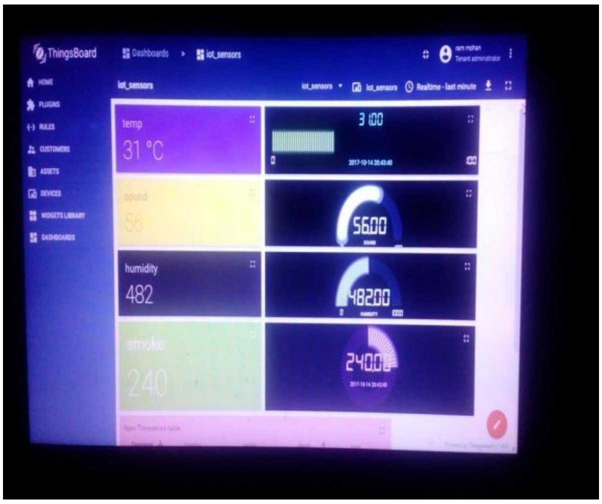
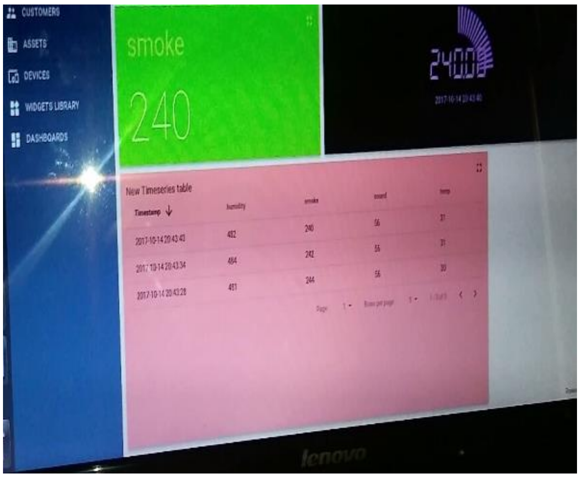


Fig: Experiment kit



a) Graphical output



b) Tableform output

Fig a and b Experimental Result

IOT sensor Monitoring:

- Raspberry pi board
- MCP3208
- LCD 16x1
- MQ-6 Smoke Sensor
- Sound Sensor
- Humidity sensor
- LM35 Temperature sensor

In this project we are using raspberry pi board as CPU for which all modules are connected. The project was meant to get sensor readings and report them to remote storages to view the reading in real time from any area. This can be acheived using iot platforms which we are going to discuss shortely.

Sensors we are using in this project are Temperature, Smoke, Humidity, Sound sensors. Every sensor has it own distinguishable way of getting the data and sampling it.

First of our class is temperatue sensor('C), it does show the very starting reading by getting initial room temperatue. For every incerease of 10mV voltage, it raises the value. Similarlly for smoke , humidity and sound sensor. Smoke Sensor(ppm) is different on its own as its takes minimum of 2-minutes for its full pledged functionality. This is because the coil inside need to be get heated enough to sensor the outside changes. Sound sensor report the data in dB, whose output is fed to lm393 comparator for better provision. Humidity sensor is a combination of smoke and temperature sensor, it responds for both scenorios. As it was meant for humidity, i reports any slight change in environment around , this can happens based on temperature or smoke around.

The main key concept of project is Internet Of Things(IOT), there were many open source platforms available providing free spaces for experimental purposes. In this project we are using THINGSBOARD iot plotform, which provides a way better widgets like analog guage,digital guage, cards and many more showing animated output based on java, ajax ,php and json scripts.

For publishing the data, we are using mosquitto iot(mqtt) platform which works on publish and subscribe basis.

We will be having three sections here, client ->gateway -> remote server. Client subscribe to "topics" called as services from remote server . Client uses "publish" and "subscribe" concepts to send and receive data from remote server. In between client and server we will be having a gateway, which enroutes the data packets and provides data integrity.

The lcd we are using in this project was 16x2 matrix lcd which can fit upto 32 words at a time. The lcd is used for message logging purpose. Here we used it for logging sensors data.

In this project, we are using Raspberry-pi powerd by jessie, and lcd for logging , l293d + motor for door management, pi-camera for live streaming and capturing images.

CONCLUSION

The development of a CPS, which monitors environmental parameters based on the existent IEEE 802.11 infrastructure, was presented. It employs sensors measuring the ambient or the environment, which send messages to an IoT platform using UDP. The communication protocol and the design of the nodes help in achieving low power consumption, offering battery lifetimes of several years. The system eliminates bulky solutions, provides the possibility of logging data where Wi-Fi network coverage exists, and can be used in a wide range of monitoring applications. Future work intends to enhance the reliability and security of the proposed system.

In the proposed architecture functions of different modules were discussed. The noise and air pollution monitoring system with Internet of Things (IoT) concept experimentally tested for monitoring two parameters. It also sent the sensor parameters to the cloud (Google Spread Sheets). This data will be helpful for future analysis and it can be easily shared to other end users.

FUTURE SCOPE

This model can be further expanded to monitor the developing cities and industrial zones for pollution monitoring. To protect the public health from pollution, this model provides an efficient and low cost solution for continuous monitoring of environment

REFERENCES:

[1] D. F. Larios, J. Barbancho, G. Rodríguez, J. L. Sevillano, F. J. Molina, and C. León, "Energy efficient wireless sensor network communications based on computational intelligent data fusion for environmental monitoring," IET Commun., vol. 6, no. 14, pp. 2189–2197, Sep. 2012.

[2] J.-Y. Kim, C.-H. Chu, and S.-M. Shin, "ISSAQ: An integrated sensing systems for real-time indoor air quality monitoring," IEEE Sensors J., vol. 14, no. 12, pp. 4230–4244, Dec. 2014.

[3] L. Zhang and F. Tian, "Performance study of multilayer perceptrons in a low-cost electronic nose," IEEE Trans. Instrum. Meas., vol. 63, no. 7, pp. 1670–1679, Jul. 2014.

[4] S. Sharma, V. N. Mishra, R. Dwivedi, and R. R. Das, "Quantification of individual gases/odors using dynamic responses of gas sensor array with ASM feature technique," IEEE Sensors J., vol. 14, no. 4, pp. 1006–1011, Apr. 2014.

[5] J. Wan, M. Chen, F. Xia, D. Li, and K. Zhou, "From machine-tomachine communications towards cyber-physical systems," Comput. Sci. Inf. Syst., vol. 10, no. 3, pp. 1105–1128, 2013.

[6] M. Broy, M. V. Cengarle, and E. Geisberger, "Cyber-physical systems: Imminent challenges," in Large-Scale Complex IT Systems. Development, Operation and Management (Lecture Notes in Computer Science), vol. 7539, R. Calinescu and D. Garlan, Eds. Heidelberg, Germany: Springer, 2012, pp. 1–28.

[7] F.-J. Wu, Y.-F. Kao, and Y.-C. Tseng, "From wireless sensor networks towards cyber physical systems," Pervasive

Mobile Comput., vol. 7, no. 4, pp. 397–413, 2011.
[8] S. Gao et al., "A cross-domain recommendation model for cyberphysical systems," IEEE Trans. Emerg. Topics Comput., vol. 1, no. 2, pp. 384–393, Dec. 2013.
[9] A. Zaslavsky. (Sep. 2013). Internet of Things and Ubiquitous Sensing. [Online]. Available: http://www.computer.org/portal/web/computingnow/archive/september2013, accessed Sep. 2014.