

# IOT Digital Twin Based Air Quality Monitoring System

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**Abstract-** In recent times IoT (Internet of Thing) plays a major role in the daily routine of human life. Majorly this technology is showing its impact in medical applications. In contrast, micro stations as a kind of low-cost air monitoring equipment can be distributed densely though their accuracy is relatively low. This paper proposes a deep calibration method for low-cost air monitoring sensors equipped in the micro stations, which consists of two sensors for CO<sub>2</sub> and PM<sub>2.5</sub> that are important for air quality monitoring with compensated weather monitoring capabilities were deployed in the villages. The end users can query the system and access the data together with the analytic information via the developed Web-based user interface dashboard. Baseline algorithms called predictive method that facilitate setting of triggers for each sensing node and pushing of notifications for when a measured parameter exceeds a certain threshold value are proposed and implemented. Later, an IoT based monitoring system has been developed to measure the air quality but monitoring and gathering the data from multiple nodes.

**Keywords:** IoT, Data Acquisition, Toxic gases, Sensors, Microcontroller

## I. INTRODUCTION

The Internet of things (IoT) has become one of the major communication paradigms that is spreading over a different range of applications and provides the possibility of centralized data accessibility and fusion. The users and authorized personnel (e.g. medics and physicians in healthcare) might be able to access data depending on the task's definition for each individual.

This restricted accessibility is important in healthcare due to privacy and confidential data protection. IoT can connect numbers of sensors, vehicles, houses, and appliances, together to the Internet which allows users to share data, information, and resources. This leads to data fusion that can highly contribute to data analysis, accessibility and ease of use in applications. IoT flexibility has caused the development of many new trends for improving data accessibility, higher efficiency of resources usage and data communication

between different sources to improve the overall performance of data integrity. This has become possible due to advancing technologies in protocol communication technologies, heavy concentration on the Internet and wide infrastructure usability by users. As a consequence, individuals are more interested in centralized data acquisition and observation to save time and effort. Smart city, smart home, healthcare, and environmental monitoring are important topics that have been adopted within IoT. In particular with rapid urbanization, industrialization and an increasing rate of elderly in European countries, healthcare has become one of the major concerns that have gained much attention in recent years.

## INTERNET OF THINGS (IoT)

Today, Internet application development demand is very high. So IoT is a major technology by which we can produce various useful internet applications. Basically, IoT is a network in which all physical objects are connected to the internet through network devices or routers and exchange data. IoT allows objects to be controlled remotely across existing network infrastructure. IoT is a very good and intelligent technique which reduces human effort as well as easy access to physical devices. This technique also has autonomous control feature by which any device can control without any human interaction.

The above figure shows the connectivity of various devices of different fields with Internet and exchange data between them. So above figure represents the connectivity of world through various existing technologies.



**Reduced Waste** – Our current insights are superficial, but IoT provides real-time information leading to effective decision making & management of resources. For example, if a manufacturer finds fault in multiple engines, he can track the manufacturing plant of those engines and can rectify the issue with manufacturing belt.

Nowadays, we are surrounded by lots of IoT enabled devices which are continuously emitting data and communicating through multiple devices. Moving ahead, let's discuss the required hardware for building an IoT application. We will also look at the IoT devices which we are using in our day-to-day life.

## IOT HARDWARE

Now you would be wondering what the required hardware for preparing an IoT solution is. The answer to this question is, you'll first require sensors that will sense the environment, then you require a remote dashboard to monitor your output and display it in a clearer & conceivable form. At last, you will require a device with the capability of serving & routing. The key task of the system would be detecting specific conditions and taking actions accordingly. One thing to keep in mind is securing the communication between the devices and the dashboard.

Some of the common sensors that you are surrounded by are accelerometers, temperature sensors, magnetometers, proximity sensors, gyroscopes, image sensors, acoustic sensors, light sensors, pressure sensors, gas RFID sensors, humidity sensors & micro flow sensors.

Nowadays we also have many wearable devices like smart watches, shoes & 3D glasses. This is the best example of a smart solution. 3D glasses adjust television's brightness and contrast according to your eye and your smart watches keep track of your daily activities and fitness.

But I feel the most important device which has tremendously contributed to IoT are the cell phones. Mobile apps have immensely contributed to revolutionizing the technology world. Cell phones are already encased with applications and sensors that reveals lots of information about its user. It has Geo-location information, it can sense and trace light condition, the orientation of your device and a lot more information. It also comes with multiple connectivity options like Wi-Fi, Bluetooth and cellular that helps them to communicate with other devices. Thus, due to these default qualities of cell phones, it is the core of the IoT ecosystem. Today, Smartphone can interact with smart watch and fitness band to further ease and enhance the user experience.

IoT uses multiple technologies and protocols to communicate with devices based on the requirements. The major technologies & protocols are Bluetooth, wireless, NFC, RFID, radio protocols and Wi-Fi-Direct.

IoT applications are flourishing across all industries & market. The IoT has a multitude of expansion over various industries. It spans over all groups of users, from those who are trying to reduce & conserve energy in their home to large organizations who want to improve their business operations. IoT has not only proved itself useful in optimizing critical applications in many organizations, but also have boosted the concept of advanced automation which we have imagined a decade before. Let's understand the capabilities of IoT across different industries and look how they are revolutionizing them.

## IOT ACROSS VARIOUS DOMAINS

**Energy Applications:** The energy rates have raised to a great instinct. Individuals and organizations, both are searching ways to reduce and control the consumption. IoT provides a way to not only monitor the energy usage at the appliance-level but also at the house-level, grid level or could be at the distribution level. Smart Meters & Smart Grid are used to monitor energy consumption. It also detects threats to the system performance and stability, which protect appliances from downtime and damages.

**Healthcare Application:** Smart watches and fitness devices have changed the frequency of health monitoring. People can monitor their own health at regular intervals. Not only this, now if a patient is coming to the hospital by ambulance, by the time he or she reaches the hospital his health report is diagnosed by doctors and the hospital quickly starts the treatment. The data gathered from multiple healthcare applications are now collected and used to analyze different disease and find its cure.

**Education:** IoT provides education aids which helps in fulfilling the gaps in the education industry. It not only improves the quality of education but also optimizes the cost and improves the management by taking into consideration students response and performance.

**Government:** Governments are trying to build smart cities using IoT solutions. IoT enhances armed force systems and services. It provides better security across the borders through inexpensive & high-performance devices. IoT helps government agencies to monitor data in real-time and improve their services like healthcare, transportation, education etc.

**Air and Water Pollution:** Through various sensors, we can detect the pollution in the air and water by frequent sampling. This helps in preventing substantial contamination and related disasters. IoT allows operations to minimize the human intervention in farming analysis and monitoring. Systems automatically detect changes in crops, soil, environment, and more.

**Transportation:** IoT has changed the transportation sector. Now, we have self-driving cars with sensors, traffic lights that can sense the traffic and switch automatically, parking assistance, giving us the location of free parking space etc. Also, various sensors in your vehicle indicate you about the current status of your vehicle, so that you don't face any issues while travelling.

**Marketing your product:** Using IoT, organizations can better analyze & respond to customer preferences by delivering relevant content and solutions. It helps in improving business strategies in the real-time.

Now that we are aware of the powerful IoT solutions that have been astoundingly impacting various domains, let's take a deep dive and understand Arduino and Raspberry Pi, which is commonly used to prepare IoT solutions.

## IOT APPLICATION – SENSING THE ENVIRONMENT & NOTIFYING

IoT solutions are widely used in numerous companies across industries. Some most common IoT applications are given below:

**Smart Thermostats:** Helps you to save resource on heating bills by knowing your usage patterns.

**Connected Cars:**IoT helps automobile companies handle billing, parking, insurance, and other related stuff automatically.

**Activity Trackers:** Helps you to capture heart rate pattern, calorie expenditure, activity levels, and skin temperature on your wrist.



Fig: IoT Applications

**Smart Outlets:** Remotely turn any device on or off. It also allows you to track a device's energy level and get custom notifications directly into your smartphone.

**Parking Sensors:** IOT technology helps users to identify the real-time availability of parking spaces on their phone.

**Connect Health:** The concept of a connected health care system facilitates real-time health monitoring and patient care. It helps in improved medical decision-making based on patient data.

**Smart City:** Smart city offers all types of use cases which include traffic management to water distribution, waste management, etc.

**Smart Home:** Smart home encapsulates the connectivity inside your homes. It includes smoke detectors, home appliances, light bulbs, windows, door locks, etc.

**Smart Supply Chain:** Helps you in real time tracking of goods while they are on the road, or getting suppliers to exchange inventory information.

## EXISTING SYSTEM

Health issues are getting rectified with the introduction of IoT devices. IoT is not limited to home appliances this can be extended to health issues also. [4] IoT works for smart cities. Most of the patients are readmitted to the hospital after their discharge from the hospitals. The reason for their readmission is due to the missing schedule of taking the right medicine at right time. The introduction of IoT in health systems can do the wonders. Authors in [5] proposed that there are different kinds of devices available for different purposes. [6] Proposed that most of the patient's life can be saved if they reach the hospitals in time. That means timely treatment is very important.

## DISADVANTAGES

- Less accuracy to detect the location
- Low efficient
- Environmental accidents
- High Maintenance
- Unpredictable Incidents
- Safety issues

## PROPOSED SYSTEM

Real-time monitoring systems may assist in monitoring and control over the mining environment. LoRa technology offers its most of the advantages ideal for the real-time monitoring system. Thus, the primary objective of this project is decided to design an efficient real-time monitoring system so that various leaked mine gases could be identified at times and preventive measures could be devised accordingly. The research investigations to be carried out with the following objectives:

- Detection of different toxic gases within mining environment
- Communication establishment between sensors and LoRa
- Establishment of Wireless Sensor Network
- Design of a real-time monitoring system

In this project, a wearable system for vital signs and environmental variables monitoring is presented. The system allows monitoring the physiological condition of people working at high altitude. The variables directly measured by the proposed device are: the ambient temperature (AT) and relative humidity (RH), air quality (AQ). In terms of safety, it is advisable to measure both rates constantly and objectively, in order to assess the risk factors and act accordingly. This work presents the implementation of a healthcare monitoring system (hardware and software) and the experimental results. The goal of the proposed monitoring system is to evaluate the worker’s health condition during the time spent working at high altitude.


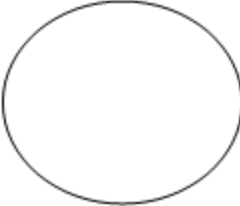

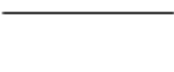
**ADVANTAGES**

This project riding two and four-wheeler becomes more safe able and value thing to detect the location. Such that the rider can get a safe journey along with their vehicle. It helps the driver to control vehicle easily. And it is most economical and easy to use.

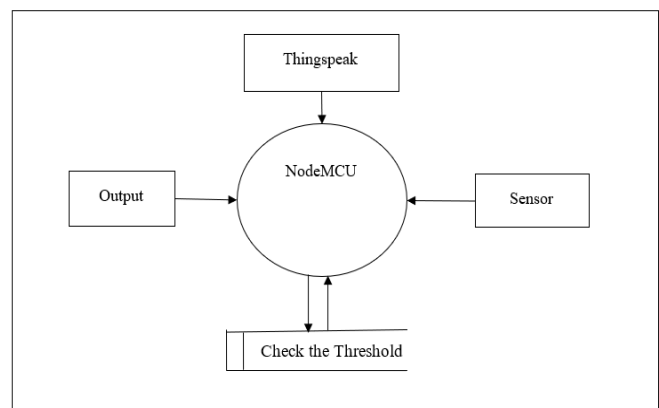
**LOGICAL DEVELOPMENT**

**DFD**

A Data Flow Diagram (DFD) is a graphical representation of the “flow” of data through an information system. DFD’s can be used for visualization of data processing. Using a DFD, users can visualize how the system will operate, what the system will accomplish, and how the system will be implemented.

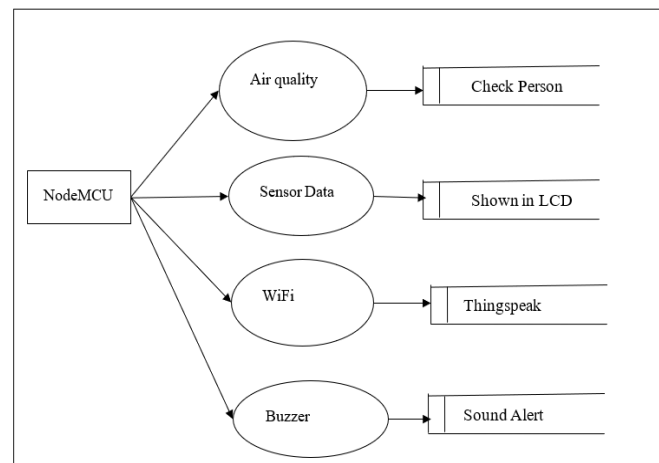
Symbols	Description
	A rectangle defines an entity
	A circle shows process within the system
	An arrow shows the flow of information
	A data store shows the holding place of the information

**Level 0**



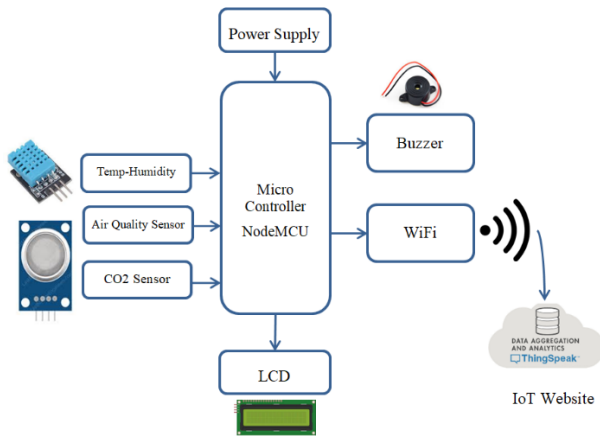
**Fig: Flow Chart-Level 0**

**Level 1**



**Fig: Flow Chart-Level 1**

**ARCHITECTURE DESIGN**



**Temperature Sensing:**

Internal Body Heat Level (BH): The BH is an estimation that demonstrates the limit of the body to direct the inward temperature inside the typical qualities. At high or low elevation and furthermore different areas because of the outrageous wavering of the surrounding temperature, this guideline is progressively exceptional.

Surrounding Heat Level (SH) and Relative Humidity (RH): Environmental conditions essentially influence the body capacities. For instance, high SH and low RH could cause vasodilation and drying out which may rapidly cause decompensation.

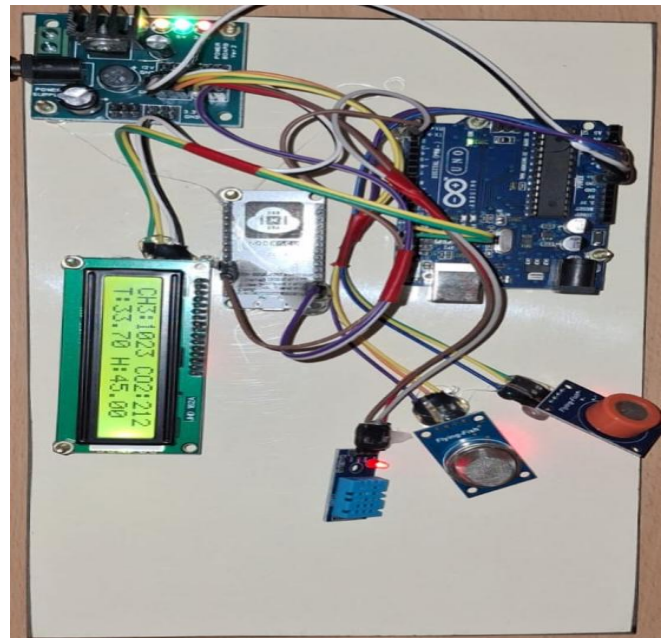
**Heart Beat Sensing:**

Heart Pulse Rate (HPR): The HPR is one of the peak significant signals to assess the cardiovascular capacity. By classification HPR is the quantity of withdrawals of the heart every moment (beats/min). Also, the pulse changeability is investigated to decide pressure and weakness levels. As indicated by the National Health Service, coming up next are the best standard typical heartbeat rates very still, very still in bpm (beats/min): Just born baby and matured from 0-1 year - 80 to 140, matured from 1 - 2 years old - 80 to 120, small kid matured 2 - 6 years old 75 to 120, Child matured 7 - 12 years old 75 to 110. Adult matured individual 18+ years old - 60 to 100.

**Data Acquisition and MCU Processing**

The MCU Microcontroller Unit was applied using a modest Arduino NANO based ATmega328P IC. It’s a higher-end Pico Power 8-bit RISC based controller. This controller associations 32 KB In-System Programming flash memory with read-write aptitudes, 1KB EEPROM, 2KB SRAM, 23

all-purpose I/O lines of 6 analog input, soft serial ports, multiple digital I/O, flexible timers/counters, internal and external interrupts, energy saving methods that stability energy consumption and handling speed, among other features that beats state observing scheme supplies. The maneuver accomplishes approaching of 1 MIPS per MHz. The info from the controller is also transmitted to the low power BLE.



**Fig: Hardware Output**



**Fig: Simulation Output**

**CONCLUSION**

This system represent a low-cost real-time air quality monitoring system. The air quality measurement device is built on ESP32 NodeMCU board connects to 4 sensors:

DHT22, MQ-7, MQ-131 and PPD42NJ to detect the temperature, humidity, carbon monoxide (CO) concentration, and. The air quality monitoring dashboard is implemented on Node-RED to receive and display air quality data.

In this work, a power-efficient, long-range communication enabled, automated, and decentralized IoT - based quality monitoring system is introduced which on the one hand, leverages the unique nature of proposed system by providing tamper resistant decentralized and trustable distributed systems, and on the other hand, employs WiFi communication protocol to provide long range and low power enabled communication. This helps in communicating with IoT sensors in environment far from gateways.

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