A STUDY ON AN IOT BASED POLLUTION AWARENESS MODEL THROUGH CARBON LEVEL MONITORING AND PREDICTION IN URBAN AREAS

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ABSTRACT

People's lives have improved as a result of IoT. It has demonstrated how influential it is on both humans and industries. IoT tools are employed not just in industrial applications but also in the monitoring of climatic health. It may be used to measure the air's carbon content with extreme precision. We have designed a low-cost wireless monitoring system based on IoT that will assist in measuring air quality because IoT has extensive uses. The gadget has three sensors since we wanted to be able to use a C-written API to measure the relative humidity, temperature, dust level, and carbon dioxide concentration. For additional processing and analysis, the results are shown on a webpage and can also be seen on a smartphone. There are also some natural sources of air pollution, such as ash released by volcanic eruptions or smoke and gases from unattended wildfires. Even though these occurrences are not often, they nevertheless contribute significantly to environmental degradation whenever they arise. The WHO's statement is utterly unexpected. According to a WHO report, major cities in developing and underdeveloped countries pollute the air more than cities in wealthy countries. Nonetheless, many developed countries also struggle with environmental degradation. Human health consequences of air pollution are divided into short-term and long-term effects.

KEY WORDS: Internet of Thing, wireless, monitoring system, webpage, smartphone.

INTRODUCTION

The development of numerous high-rise buildings is required by the growth in metropolitan regions' population, automobile use, and industrialisation. Due to a lack of adequate infrastructure, as more people move to urban areas, the quality of life suffers. The term "air pollution" refers to the presence of any undesirable or unwanted elements in the atmosphere that may be harmful to human health or the health of any other living thing or have any other detrimental effect on the environment, including the climate or the materials.

Ammonia, carbon monoxide, carbon dioxide, sulphur dioxide, nitrous oxide, methane, and chlorofluorocarbons are only a few examples of the many different types of gaseous pollutants. Not only is air pollution a leading cause of all illnesses and allergies, but it also has the potential to be fatal. It can destroy our environment as well as hurt other living things including food crops. Air pollution can be brought on by both human activities and natural phenomena.

There are numerous wireless sensor-based air monitoring devices on the market that gather data from a target area and send it to the sink using the proper routing protocols. Pollution can reach the atmosphere of the planet in a variety of ways. The main causes of air pollution are primarily people or their high-achievement activities. Continuous smoke emissions from manufacturing plants, automobiles, aircraft, and aerosol-holding containers are the end result of high-intensity activities. Second, smoking cigarettes has a small but significant contribution to air pollution. These types of contamination have been dubbed "anthropogenic sources" since they are unquestionably man-made.

Generally speaking, short-term effects are transient. One or more of the outcomes is pneumonia or bronchitis. In addition, they might result in irritation of the skin, eyes, nose, or throat. Headaches, nausea, and vertigo can also be brought on by airborne pollutants. Air pollution is also considered to include offensive odours coming from sewer lines, garbage disposals, and factory exhaust. Although not particularly harmful, these odours are still quite unpleasant. The dangerous long-term effects of pollution can linger for many years or even until a person passes away. Even death may result from this. Some of the long-term health implications of air pollution include heart disease, lung cancer, and abnormalities in the respiratory system. These three body parts are not the only ones on the list of negative impacts. Long-term harm to the neurological system, brain, kidneys, liver, and other organs are also damaged. The World Health Organization estimates that 2.5 million individuals worldwide pass away each year as a result of air pollution. We only talk about outdoor pollution when considering pollution remedies, but indoor air quality is just as crucial.

Rise in pollution of air day by day due to increase in Industrialization and modernization in lack of effective air quality monitoring methods is providing a moral problem in front of each individual as well as societal obligation to researchers and scientists. Many sectors have therefore concentrated their efforts on creating alternative techniques that will aid in measuring and bettering air quality. Wireless monitoring systems are being used to measure the concentration of air contaminants. For example, oxygen, nitrogen dioxide, carbon dioxide, and other sensors have been combined in a Wasp-mote card. The concept is also expanded to include the attachment of suitable sensors to a mobile device that can instantly gauge the concentration of CO in the air. Today, air pollution is closely monitored in order to regulate industrial activity. Real-time measurements of $CO2$, $NO2$, CO, and $O2$ gas concentrations are taken using calibration technology. A web based mobile real time air quality monitoring system has been successfully created and installed. A comprehensive remedy has not yet been found, though. The main goal of this suggested approach is to provide a cost-effective system that can forecast the concentration levels of many greenhouse gases that contribute to global warming and climate change.

In the event that environmental quality criteria such as noise, CO, and radiation levels exceed the permitted threshold, we need a monitoring system that is effective and can assess and monitor environmental conditions. A smart environment is one that may be utilised for self-protection and self-monitoring when it is furnished with items like sensors, microcontrollers, and various other softwares. This sophisticated system for environmental monitoring tracks and manages the impact that environmental changes have on people, plants, and animals. We must first gather data in order to forecast the behaviour of a certain region of interest, therefore sensors are placed in strategic spots. The primary goal is to communicate the sensor data to the cloud in order to estimate the future trend as well as to effectively monitor the necessary parameters remotely. Internet of Things (IoT) can therefore save us at this point.

The Internet of Things (IoT) paradigm can be thought of as a self-configuring, networked collection of intelligent, smart objects with little processing power but with sensing and actuation capabilities. According to numerous recent studies, cloud computing has proven to be a more effective alternative method to address the majority of the problems caused by IoT. In circumstances where a single provider is unable to meet customer demands, service composition is essential. A multi-cloud IoT environment results from this. The primary environmental worry is the quick increase in energy demand and carbon emissions brought on by cloud computing. Network traffic has significantly increased as a result of the dramatically growing density of IoT application users, providers, and data centres.

SYSTEM MODELING AND APPROACH

Five separate layers that comprise the communication system of the model are supported by the architecture of our prototype model. Data collection layer, data forwarding and formatting layer, network layer, data storage layer, and application layer are the names of the layers.

• DATA GATHERING LAYER:

This layer is used to collect various environmental data types needed to display the state of the air quality. This layer connects a restricted number of battery-powered sensors to an embedded system in order to accomplish this goal. These sensors gather information from the environment about varied CO2 concentrations at various times and transmit it to the following layer.

• LAYER FOR DATA FORWARDING AND FORMATTING:

For data collection and preprocessing, various embedded systems (ES) or microcontrollers are employed, as necessary. These devices have a processing unit, a memory that is programmable, and a limited amount of storage, which allows them to collect data from sensors and conduct specified actions on that data. For the aforementioned purposes, many boards including Arduino, Raspberry Pi, Adafruit Flora, Particle Photon, and others are employed. These devices have the duty to accept the gathered data and transmit it to the destination locally or worldwide for further processing.

• THE NETWORK LAYER

The data perceived by the sensors and gathered by ES must be transferred across various wired or wireless networks to the storage layer or, if necessary, directly to the application layer. If necessary, collected data can potentially be sent to the cloud via a completely separate network technology known as ubiquitous sensor networks. Bluetooth, ZigBee, or Infrared devices are used for communication over short distances, and internet-enabled Wi-Fi, LAN, or WAN can be utilised if data storage on servers is required. One WIFI module is employed in the network layer to establish the connection between the suggested model and server.

LAYER FOR DATA STORAGE:

Sometimes it is absolutely required to preserve the information gathered in order to monitor the air quality or to statistically evaluate the data. The Cloud storage is one of the most popular storage options for IoT applications. Depending on the need, the data might also be kept on regional or international database servers. The suggested paradigm makes use of several types of storage to enable data flow between sensors and servers.

IN THE APPLICATION LAYER

The suggested approach uses various display devices and web browsers to present a view of the gathered data.

INFRASTRUCTURE FOR SENSORS

• DHT22

DHT22 sensor is used to measure environmental characteristics for better result analysis. With a +-0.5 degree precision, the temperature measurement spans the range from -40 to +125 degrees Celsius. The DHT22 has a greater capacity for monitoring humidity, with a range of 0 to 100% and an accuracy of 2-5%. A NTC sensor and an additional IC, which once again includes two electrodes for moisture retaining, are attached to the sensor's back side to measure the humidity parameter. The conductivity or relative resistance of the electrodes that are attached changes as the humidity changes. This change in resistance is measured, processed, and ready for the microcontroller to read and process by the IC. This sensor contains four pins, three of which—VCC, GND, and data pin—are used during operation while the fourth is left unutilized.

• MQ-135

NH3, alcohol, smoke, and CO2 levels are detected or measured using this to regulate air quality. Since it has a digital pin, the sensor may function without a microprocessor. This sensor's use of SnO2 strengthens its durability and improves its ability to detect gases in the air. With an increase in pollution level of gases, the resistance reduces for the gas sensor.

• DUST OPTICAL SENSOR

An optical dust sensor called the GP2Y1010AU0F is used to gauge dust particle concentration. To enable the detection of dust in the air, an infrared emitting diode and a phototransistor are linked diagonally into the apparatus. Since this sensor is good at detecting extremely small particles, such as cigarette smoke, it is frequently employed in air purifier systems. It operates on relatively little current, between 4.5 and 5.5 volts.

RESEARCH METHODOLOGY

SYSTEM ARCHITECTURE AND FUNCTIONS

The Internet of Things revolution allows us to track and monitor everything at any time, from any location, without physically being there. Hence, neither the event's location nor the controller's location pose a challenge to one another. The model's sole function is to support real-time CO_2 level detection for online, offline, or hybrid modes of air quality monitoring.

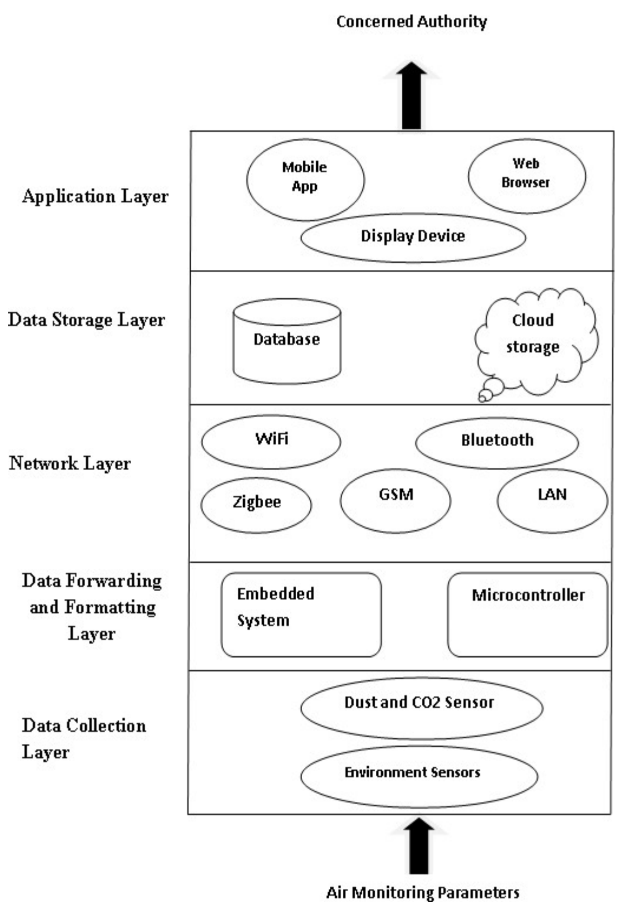


FIG. 1: LAYERING OF MODEL FOR THE PROPOSED NETWORK

The key feature of our communication model is data delivery from beginning to end. As a result, we have used a variety of layers in our network communication, which calls for a layering design. Since data extraction, collection, and transmission from the environment to various users make up the complete communication process, layers must be connected to one another. Data packets will be transmitted from source to destination using several levels and undergoing various processes. The model for Carbon Level Monitoring using IoT-based Framework (CIF) has been proposed using the techniques below.

PACKET CREATION PROCESS

At each monitoring board, data packet creation and processing are done. The rate at which sensors may transmit data is the same as the rate at which packets are generated. Four separate fields are used by the data packet to communicate.

NAME OF THE SENSOR

Every sensor in the network has an ID assigned to it in order to uniquely identify it. The id is utilised throughout the entire network for packet communication between the sender and receiver. To create the path, the sensors' positions and related IDs will be saved. If the sensor moves to a new place, its ID can be used to properly update its location.

TIMING MARK

The radio module's time stamp is applied to each packet as it is formed during communication. This time stamp determines the order in which each data packet is processed. Time is regarded as being of major relevance in any real-time scenario when an application has been created to monitor CO2 levels since it captures variation in CO2 levels over a given period of time.

DATA GATHERING

A sensor transmits information to a radio module. Data fields keep track of all pertinent CO2 and environmental data using various measures.

DATA RETENTION

The sensor modules' data is kept in a local database. The database includes many attributes that record information like the amount of battery life left and the typical Received Signal Strength Indicator (RSSI), which is used to store location data.

PACKET COMMUNICATION PROCESS

Any data that is gathered from various sensors connected to the environment at the data collection layer is sent as a data packet. Each packet contains data, a sensor ID, a timestamp, and the relevant data value.

Every data packet will be gathered and sent through the data forwarding and formatting layer, which is controlled by the Node MCU microcontroller. It supports Wi-Fi transmission and sends data to the target server through the network layer.

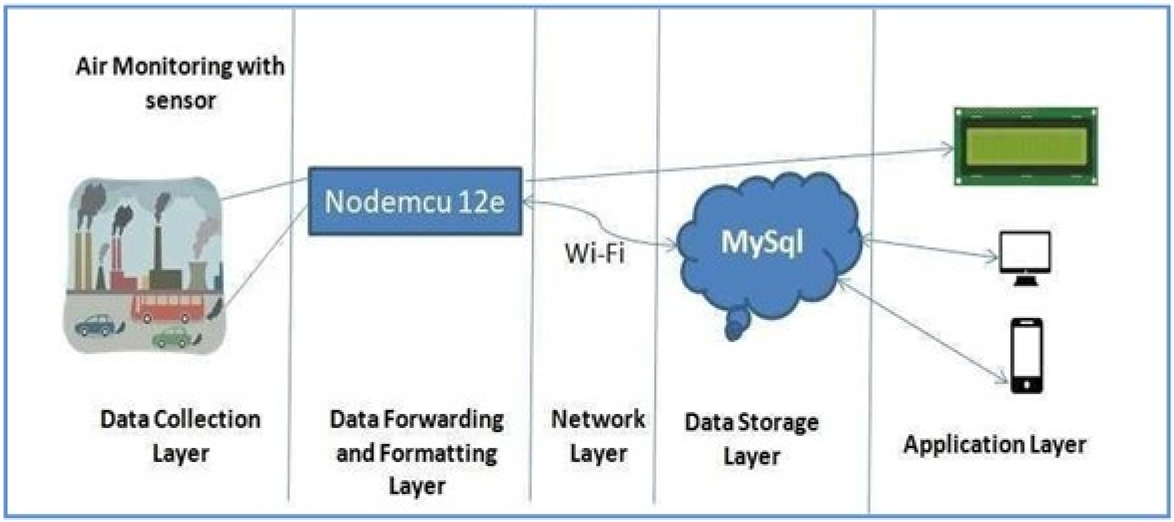


FIG. 2: WORKING MODEL OF CIF

For additional processing and analysis in the data storage layer, the data will be saved on local as well as worldwide servers. As seen in figure, the expected CO2 level can be predicted and depicted as a graph in the application layer at various time intervals in real-time.

EXPERIMENTAL SETUP

The DHT22, dust sensor, and MQ-135 are attached with the microcontroller as indicated to collect and propagate data to the necessary server for analysis and to accomplish the goal of air quality monitoring. According to its capabilities, NodeMCU will use a CD4051 multiplexer to gather the output analogue signals from all of the sensors. The D6, D7, and D8 pins of the CD4051B are used to link its three select lines to NodeMCU. The instructions for NodeMCU state that it should first send all LOW signals to the CD4051B's I0 channel, through which it reads data from the MQ-135, and then send LOW signals through D6 and D7 and HIGH signals through D8 to the channel's I1, which is where the dust sensor will send data to NodeMCU.

These analogue impulses are converted to digital signals as and when necessary by the microcontroller, which is programmed using the Arduino IDE. DHT22 keeps track of environmental temperature and humidity readings to represent the state of the environment. Our model also records the current date and time so that we may perform real-time monitoring.

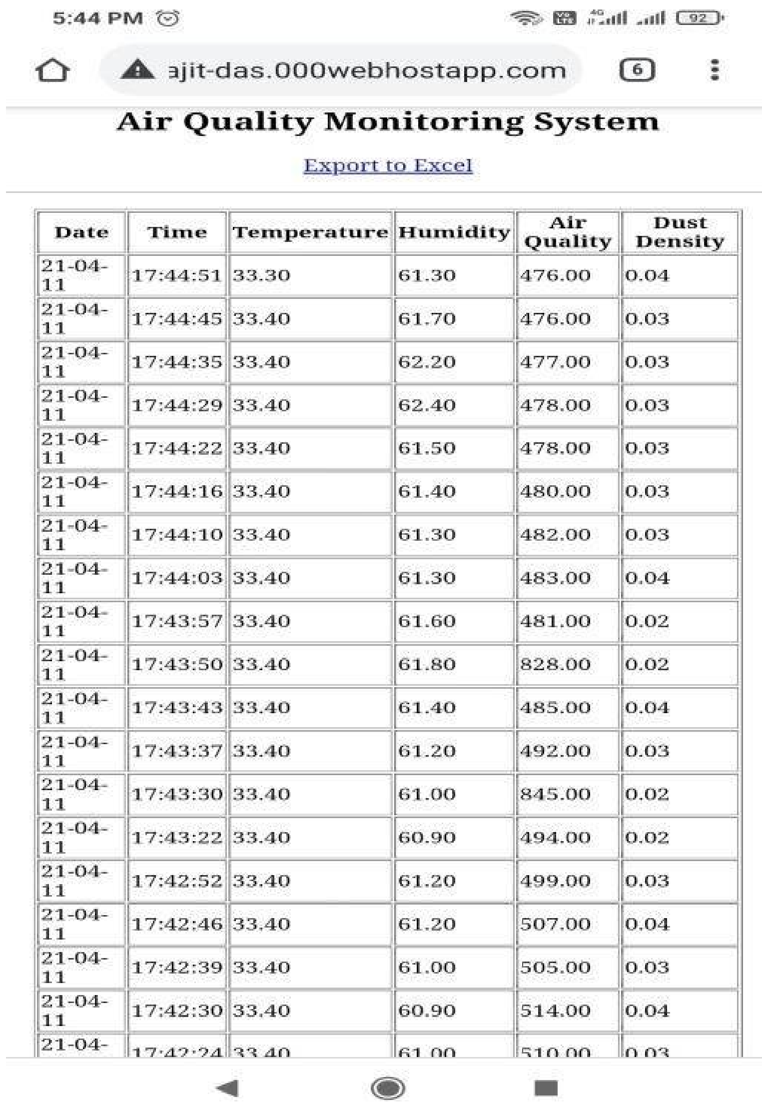
The digital data delivered from the NodeMCU to the database server is depicted. The model to connect to the local Wi-Fi has been developed using the stationary mode of NodeMCU, which has two modes: access point mode and stationary mode.

Using Apache as the web server, we may build a local server utilising MySQL as the database. PhPMyAdmin, a MySQL database tool, is popular due to its streamlined user interface. On the server side, PHP script is kept and called by the server. The GET method is used by NodeMCU to transport data from the device to the server via the script.

A smartphone application allows users worldwide to observe the experimental outcomes in real-time. The actual demonstration of the parameters obtained from the CIF model is shown. Blynk, an open source IoT platform that allows for remote management of IoT hardware as well as the storage and presentation of data sent by the model, has been used to provide instant view on mobile devices. The database server and the Blynk server get the data from the CIF model in parallel.

RESULTS AND DISCUSSION

It is possible to extract any data gathered from sensors and kept in databases for examination. The state of the carbon level has been revealed through analysis of the air quality and other environmental indicators. The model has been put to the test for a case study three times and in three separate locations. At various dates, the environment's vital signs are noted in the morning, evening, and night. By analysing the ideal environmental state, it is clear that a number of factors will cause the temperature to steadily rise over time. By taking into account 100 distinct parameter values, the CIF model in figure 4.8 illustrates the similar problem. The model's DHT22 sensor produces real-time temperature data to inform logged-in users of the state of the environment. Other parameter values, such as ambient humidity, air quality, and percentage of dust density, are represented in Figures. Values for the parameters have been gathered at various instants of time to examine the state of the carbon level.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Air Quality Monitoring System

Export to Excel

Date	Time	Temperature	Humidity	Air Quality	Dust Density
21-04-11	17:44:51	33.30	61.30	476.00	0.04
21-04-11	17:44:45	33.40	61.70	476.00	0.03
21-04-11	17:44:35	33.40	62.20	477.00	0.03
21-04-11	17:44:29	33.40	62.40	478.00	0.03
21-04-11	17:44:22	33.40	61.50	478.00	0.03
21-04-11	17:44:16	33.40	61.40	480.00	0.03
21-04-11	17:44:10	33.40	61.30	482.00	0.03
21-04-11	17:44:03	33.40	61.30	483.00	0.04
21-04-11	17:43:57	33.40	61.60	481.00	0.02
21-04-11	17:43:50	33.40	61.80	828.00	0.02
21-04-11	17:43:43	33.40	61.40	485.00	0.04
21-04-11	17:43:37	33.40	61.20	492.00	0.03
21-04-11	17:43:30	33.40	61.00	845.00	0.02
21-04-11	17:43:22	33.40	60.90	494.00	0.02
21-04-11	17:42:52	33.40	61.20	499.00	0.03
21-04-11	17:42:46	33.40	61.20	507.00	0.04
21-04-11	17:42:39	33.40	61.00	505.00	0.03
21-04-11	17:42:30	33.40	60.90	514.00	0.04
21-04-	17:42:24	33.40	61.00	510.00	0.03

FIG. 3: LIVE DEMONSTRATION OF CIF MODEL THROUGH MOBILE VIEW

When the model is performed, it is discovered that the morning humidity % is increasing in contrast to the other two times. Shows data on air quality, which makes it evident that due to heavy vehicle and industrial use, the parameter delivers the worst values for evening hours, while being better in the morning and then at night. The full comparison demonstrates the truth regarding the state of the air quality by taking into account 100 readings taken at various periods. Data is collected separately at three different time periods, namely in the morning, the evening, and the night, for remote validation regarding the accurate response from sensors. Makes it clear that our model is operating effectively and delivering data regularly to faraway places to monitor the carbon level. Dust density sensor values are highest in the evening, lowest in the morning, and intermediate results are seen at night, as shown in figure.

FIG. 4: LIVE DEMONSTRATION OF CIF MODEL THROUGH BLYNK APP INTERFACE

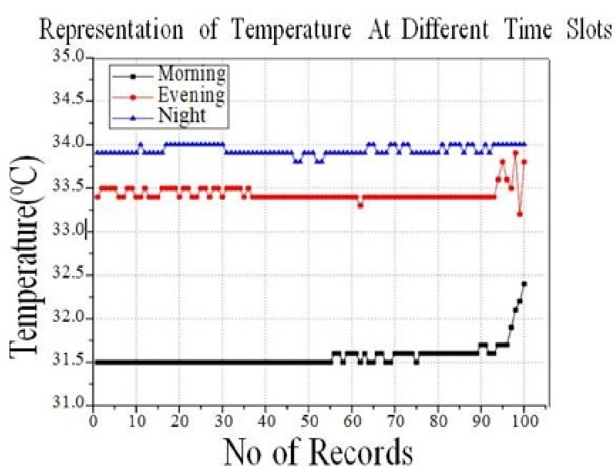

FIG. 5: TEMPERATURE AT DIFFERENT TIMES USING CIF MODEL

AIR QUALITY PREDICTION

The AQI will become more adaptive and better for people's health when a system is built to measure CO2 levels and anticipate hourly air quality. As a result, systems that will issue alerts based on air quality are vital and important for individuals. This section's goal is to forecast air quality based on past CO2 levels using the Auto-Regressive Integrated Moving Average (ARIMA) model.

Time series analysis can now be applied to the acquired data to forecast the carbon level. To fit the model to the series, some preprocessing is applied to the gathered data. Generally speaking, "morning," "evening," and "night" were when data was collected. Table-1 displays a sample of the morning data that was obtained. The statistical properties of the data are described in Table. The value of the air quality is found to be between 525 and 914.

TABLE-1: A DATA SAMPLE CAPTURED IN THE MORNING

Index	Temperature	Humidity	Air Quality	Dust Density
1	31.5	70.1	545	0.04
2	31.5	70.1	544	0.03
3	31.5	70.1	548	0.04
4	31.5	70.2	866	0.01
5	31.5	70.2	556	0.04

TABLE -2: STATISTICAL PARAMETERS OF THE DATA

	Temperature	Humidity	Air Quality	Dust Density
count	157.000000	157.000000	157.000000	157.000000
mean	31.714013	69.740764	727.968153	0.034904
std	0.235736	0.544901	132.022940	0.014260
min	31.500000	68.600000	525.000000	0.010000
25%	31.500000	69.300000	616.000000	0.030000
50%	31.600000	70.000000	679.000000	0.040000
75%	32.000000	70.200000	890.000000	0.040000
max	32.100000	70.700000	914.000000	0.170000

The first 160 readings from the CO2 sensor in the morning are displayed. The data does not follow a normal distribution, as illustrated by the QQ plot, and the greatest values are not as huge as would be expected.

INTERNET OF THINGS

IoT is a networked object that is roughly related with networks. According to the RFID tag within the box, everything is related to a smart city and is represented numerically by larger objects. The IoT offers the most robust standards for communication in the twenty-first century. The capabilities of communication and computing, which include the digital process of transceivers communication and microcontrollers, lead the daily process of objects to become a network part in this environment. It includes a high-persistence network model and allows for unified collaborations between diverse device kinds, including monitoring cameras, environmental sensors, and applications in the medical and other industries. This system's main goal is to construct a low-cost Internet of Things for tracking various water contaminants, including Temperature, Conductivity, pH, and Turbidity using integrated sensors.

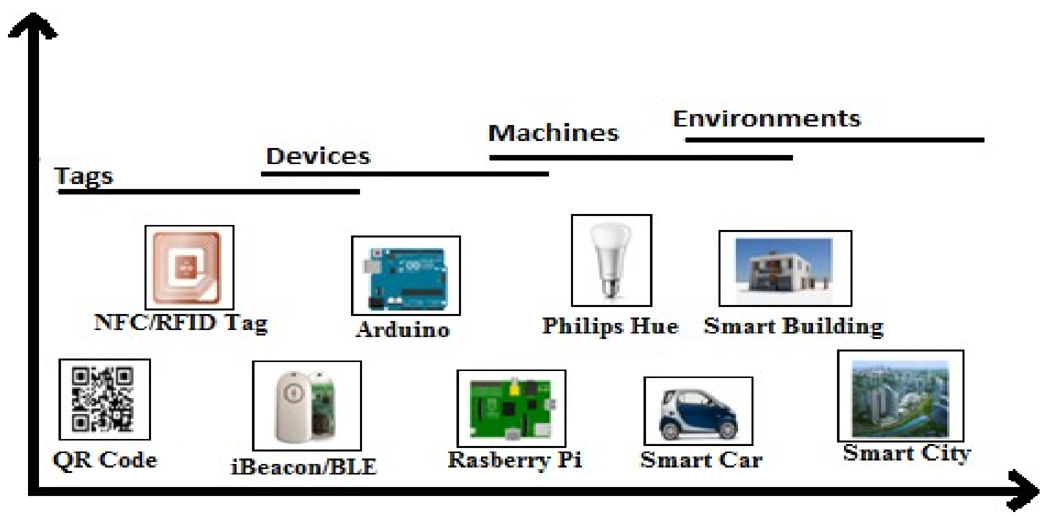

FIGURE-6: LANDSCAPE OF INTERNET OF THINGS

CONCLUSION

Pollution of the environment is one of the main issues. Pollution happens when contaminants interact with air, water, and soil. To secure ourselves and our family, we have to be alert and need to keep an eye on the level of pollution. When pollution levels exceed acceptable thresholds, they need to be purified. For the purpose of reducing air pollution, it is necessary to measure the air's pressure, temperature, radiation (perhaps UV radiation), smoke, nitrogen dioxide, and carbon monoxide content. In order to quantify the level of air pollution, we also need to determine the sensors that can detect pressure, temperature, the amount of UV radiation, general air quality, NO2 and CO concentrations, and the amount of CO.

Modernization brought about by urbanisation is always accompanied by complex problems relating to the urban environment. Population expansion, increased economic activity, industrialization, and a shift in lifestyle are the main effects of urbanisation. This introduces an entirely new set of management-related issues for e-waste. Severe environmental pollution might result from unmanaged trash.

Urbanization causes pollution, which not only harms people and animals but also has a terrible impact on food productivity. The necessity of monitoring water contamination is equal. Without involving humans, amphibious vehicles have been created to check water quality. Most nations in the world lack access to clean water. s and the difference between a regular. The proportion of its parameters determines the quality of the air. CO2 has a big impact on the crucial factor of air quality.

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