**A Novel Mechanism for Collaborative Internet of Things Architecture for Smart Cities and Environmental Monitoring Scheme**

**Abstract**

Once it comes to daily life, the Internet of Things (IoT) would have a significant impact. It is a development of the concept of smart cities and the IoT, which is individuals enhance their quality of life. People's dependence on technology is increasing at a faster rate than ever before. It is a low-cost technique to utilize the cloud computing service to increase the advantages and scope of smart cities given that actuators and sensors are frequently implemented in smart cities with limited resources nowadays. Since a smart city supplements reliable communication between apps and devices, new architectures and procedures are needed to guarantee this connectivity. The decision tree is used to generate chains like what happened and what would happen next for the prediction process. Community-Based Monitoring (CBM) is a topic that this research touches on as a crucial component of the upcoming IoT. Since customers should be able to develop their facilities by comprehending the many data flows that are available. A cloud service must be used to handle all the data. Geographical Information System (GIS) is being used for the temporal analysis of the datasets, and the e-Science platforms that consist of Data as a Service (DaaS), Infrastructure as a Service (IaaS), Software as a Service (SaaS), and Platform as a Service (PaaS) which are used for analysis and computing of a system. All data should be stored and retrieved from the cloud.

**Keywords:** IoT, Cloud Computing, Decision Tree, Community-Based Monitoring, Geographical Information System.

1. **Introduction**

The IoT would have an immense effect on human lives [1]. This is primarily aimed at reducing prices for equipment, which makes it more accessible to everyone, and making communal circumstances for users [2][3]. IoT organizations continually expand their specific cloud services. As a result, the end operator is forced to use specific tools solely in the manufacturer's predictions without the option of taking new services which come from using the data provided by heterogeneous devices [4]. Conquering restrictions is difficult to work, and almost impossible for individuals without networking or computer programming expertise [5]. However, this is an essential aspect of the forthcoming IoT because consumers should be capable to build their facilities by understanding the various data flow accessible, and instead of sticking to what the producer has designed [6]. A critical topic of concern was the sensing of the environment and the detection of possible dangers to people and wildlife. This study coincides with the area of Community-Based Monitoring (CBM) [7][8]. This concept is described as a method for monitoring, tracking, and responding to the problems of joint environmental concern to people, government agencies, industry, academics, community organizations, and local institutions [9]. CBM has been implemented in many projects and it is classified in addition to participant skills and awareness [10]. This advancement along with the rapidly expanding environmental monitoring IoT technology gave rise to the Collaborative IoT (C-IoT) concept.

Surveys provide an application-based discussion of special systems created for different components of smart cities, followed by case studies of towns with ongoing smart city initiatives [11][12]. This paper describes the collaborative mechanisms which are used to make the smart environment monitoring scheme with the help of IoT architecture [13]. This application of these technologies is mentioned in all areas such as management, transportation, etc. Ideally, the perception of a smart city goes beyond the usually fixed limits of the administrative and social structure of conventional cities by allowing them to connect in a more unified and committed way [14][15].

* 1. **Internet of Things for Smart Cities**

IoT is an internet-based connected device system. It comprises a desktop, a mobile device, a laptop, machinery, sensors, domestic appliances, and cars. These gadgets aim to share data with other devices across the internet [16].

The IoT is the capable technology that has allowed for making digital, providing birth to the idea of intelligent cities, which is at the center of Smart City projects [17]. The Internet indicates the omnipresent connectivity of gadgets to the “Internet”, which enables them to transmit cloud data and lead them to action. To assist decisions and policy-making, IoT includes data gathering and data analysis activities for information extraction. More than 75 billion devices are expected to be connected to the internet by the year 2025 [18][19], which would significantly extend the applications that are performed by these devices.

* 1. **IoT Designs for Smart Cities**

By the use of cloud computing services, the IoT brings together data sensing, transmission/reception, processing, and spatial activities. As can be seen in Figure 1, [18] a standard architecture for the Internet of Things is made up of five distinct layers, each of which is responsible for processing information from the layer below it. Additionally, it presents the three distinct IoT design alternatives.

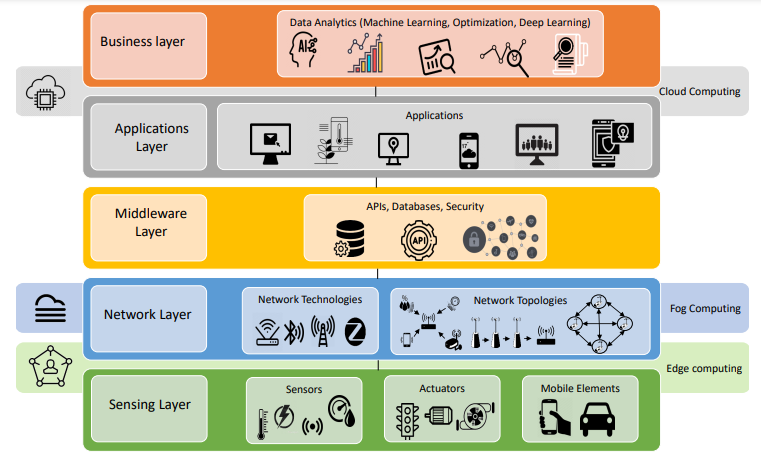


Figure 1. IoT Architecture of the System

The physical measures of attention and actuators that can activate on physical substances are all part of the Sensing layer, which is also known as the perception layer and includes devices like the Radio Frequency Identification (RFID) approach to learning for reading RFID identifiers and other comparable devices [20][21]. The Middleware layer receives the statistics generated by the Sensing layer using wireless communication systems such as Wi-Fi, cellular broadband, Zigbee, and Bluetooth, amongst others [22]. The Middleware layer functions as a generic port between the hardware of the detection layer and the Application layer. The Application layer is responsible for making use of data to provide services to users and relational database features [23][24]. The Business layer is linked to the Application layer, which is responsible for the development of strategies and protocols that contribute to the overall system's management [25].

1. **Review of Literature**

This section discusses and studies the relevant work done by various authors about collaborative IoT architecture for smart cities and environmental monitoring schemes.

Syed et al. [26] stated that the IoT is a system that eliminates the need for human interaction by combining a variety of different devices and technologies. This opens the door to the prospect of having smart cities all over the world. By introducing several different technologies and enabling exchanges between them, the IoT has helped to accelerate the development of smart city systems that provide residents with improved opportunities for environmentally responsible living, increased opportunities for relaxation, and increased productivity. The IoT for Smart Cities initiative is active in some places and is dependent on a wide range of underlying technologies for its operation. An in-depth analysis relates to smart cities. Technologies that enable these regions to occur in conditions of designs used, networking technologies utilized, and Artificial Algorithms used in IoT-based Smart City systems are noted as the fundamental aspects that comprise the IoT-based Smart City design.

Hamdan et al. [27] stated that the fast development of IoT applications as well as their intrusion into everyday lives, has resulted in a massive quantity of IoT gadgets and massive amounts of IoT-generated data. Because the supplies of IoT gadgets are restricted, managing, and accumulating IoT data in these devices is wasteful. Conventional cloud-computing sources are utilized to address several IoT source-restriction problems; however, utilizing cloud sources causes additional challenges, such as inactivity in time-critical IoT applications. As a result, edge-cloud computing technology has just developed. This technology enables data handling and storing at the network's edge. This investigates Edge-Computing Architectures for IoT (ECAs-IoT) in categorization based on several aspects such as data location, instrumentation services, protection, and large information.

Sanchez-Corcuera et al. [28] stated that during the last decades, the advent of Information and Communication Technology (ICT) generated a tendency to provide everyday items with smartness, aiming at a more pleasant human existence. The Smart Cities paradigm emerges as a reaction to the aim of establishing a city where its inhabitant's well-being and rights are protected, and industry, and urban planning is evaluated from a conservation and viable point of view. However, more research projects are financed and delivered for Smart Cities, while still confronting difficulties in implementation. In addition, cities across the world adopt Smart City elements to enhance their people's facilities or value of life.

Ray [29] stated that the IoT is a platform that makes better gadgets every day, smarter every day, and more information every day. The study of architecture always paves the path for the sector. The author examines the internet of object-oriented architectures that increase the knowledge of tools and techniques linked to enable the development needs. The intended designs directly or indirectly aim to address issues with the actual world via the creation and use of a strong IoT. To encourage the academics and industry to look for potential ways to adjust the exact capacity of IoT, research problems have also been explored to integrate the gap within the current trends of architecture.

Ahmed and Rani [30] stated that the Internet of Things (IoT) has accelerated worldwide expansion by offering digital services to consumers, resulting in the creation of smart projects by linking heterogeneous equipment. The Smart City Project is an incredibly convoluted concept that faces a great deal of opposition. Urban IoT is intended to promote the coming visualization of smart cities by using emerging hybrid technologies to offer value-added services to residents. The initial layer in Urban IoT architecture is the Data Layer. The sensor platform employs the improved Ad-hoc On-Demand Distance Vector (AoDV-SPEED) protocol described in the data layer. The hybrid method performs the conventional SPEED protocol in terms of latency, power, miss ratio of pack communication, and pack distribution rate. The structure, problems, and inclinations of Smart city IoT, as well as a usage for the smart street, emphasize the significance of the suggested system. Smart City initiatives are also addressed to understand the significance of IoT in smart cities and its forthcoming.

1. **Background study**

An Integrated Information System (IIS) that combines e-Science, cloud computing, IoT, and Geoinformatics for environmental management and monitoring, considering the case of the changes in the regional climate and its ecological effects. In the perception layer, web services and multi-sensors are used to collect data; in the network layer, private and public networks are used to access and move large data. The main tools and technologies that were used by the author are online analytical processing, extraction-transformation-loading, application gateway, real-time operational database, IoT-application infrastructure, application software for different tasks and platforms, etc. The middleware layer of IIS was used to implement Application Program Interfaces (APIs). The application layer is responsible for organizing, storing, processing, and distributing data and other relevant information, as well as environmental monitoring and management applications. According to the findings of the case study, there has been a discernible increase in air temperature in Xinjiang during the past 50 years i.e., between 1962–2011, as well as an apparent increase in precipitation since the initial 1980s. The research reveals that such an IIS benefits research activity not just in data gathering enabled by an IoT, but also in applications and web services based on e-Science platforms and cloud computing and that the effectiveness of decision-making and monitoring processes is significantly improved. The author presents the prototype of IIS for environmental monitoring, as well as a new approach for the future and application, particularly in the age of IoT and big data [31].

1. **Problem formulation**

The concept of smart cities and the IoT has made it possible for residents of modern cities to enjoy a higher standard of living. Technology is such a vital part of lives that the reliance on its benefits is rising quicker than ever. Given that the actuators and sensors deployed in smart cities usually have limited resources in today’s time, it is a lowdown practice to use the service of cloud computing to extend the benefits and scope of smart cities. Given that communication between applications and devices is critical for a smart city’s services to work well, new architectures and mechanisms to ensure communication reliability must be designed. In the current work, the major focus is concentrated on the modes of data collection like with installed sensors. The individual mobile devices somehow can fetch some data required for monitoring things. After processing the data from various sources, different patterns have been drawn in a way that the input from one type can be used for monitoring the second section. For example, using the weather data for rains can predict the route diversions where there is a chance for water lodging. Cloud services here have been used for data management and also for storage and retrieval of data, also the cloud services for linking individual IoT devices. For the prediction process, the decision tree is being covered which helps in generating chains like what happened and what would be the next.

1. **Research Gap**

Following are the different research gaps in the research work:

* The previous approaches do not work on the multi-monitoring system to make the smart environment monitoring paradigm.
* There is a lack of issues seen in the previous models like management of the multisource data from the multi-sensors, standardized processing, and complexity.
* There is a significant issue with the management of data since the methods for collecting the data are both expensive and difficult to duplicate.

1. **Research Objective**

Following are the different research objectives of the research work:

* Making a prediction model promotes the entire process of the environment monitoring system.
* To make an integrative system that is valuable for transformation, processing, perception, management, and sharing the information of multisource data.
* To introduce an environment monitoring system that is used to aware the public with the help of an IoT paradigm.

1. **Methodology**

A revolutionary method of environmental monitoring has been established based on an IoT structure made possible by the proliferation of new technologies over the last decade, which set the foundation for an integrated architecture for an effective environmental monitoring system [32].

* 1. **Decision Tree**

For each internal node to represent a feature tree, a leaf node to represent a class label, and branches to indicate conjunctions of features that lead to those class label labels, the Decision Tree is used. The categorization criteria are represented by the routes that lead from the root to the leaf [33][34]. Machine learning, data mining, and statistics all make use of the decision tree as a predictive modeling tool. There are several methods to segment data collection, and this method is used to generate decision trees. Sustained learning algorithms like this one are among the most extensively used and effective in the world today [35]. In a non-parametric supervised learning approach, Decision Trees are used in both regression and classification. Calculation of the decision tree is done using information gain and entropy. The formula for calculating the entropy is shown in equation 1:

(1)

Where, is the probability of an element/class ‘i’ of the data.

The formula for calculating the information gain is shown in equation 2:

(2)

Where T is the target value and X is the actual variable of the dataset.

* 1. **Proposed methodology**

The framework of a proposed methodology is depicted in Figure 2.

Diagram

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Figure 2. The framework of the proposed methodology

Following is the stepwise explanation of the proposed methodology:

**Step 1: Transport management based on environmental monitoring**

For environmental monitoring, the smart transportation phase is primarily used to collect information and other relevant information about specific physical aspects, including knowledge, methods and techniques, real-time datasets, and so on. Transport management is an important part of environmental monitoring. There are a variety of sensors that are used to capture real-time data, such as in situ instruments, remote sensing platforms, and other sensors that can be used in conjunction with the IoT. The transport management phase connects many devices and sensors; the base and core layer are where sensor technologies are rapidly grown and widely used in IoT.

**Step 2: Data Collection and Preprocessing**

All the data is collected from the first for further preprocessing. After collecting all the data, the next step is to preprocess the data. Various types of feature engineering approaches are applied to shape the data in a form that is required to train the model.

**Step 3: Draw patterns**

The crucial step after pre-processing is to create a pattern using various devices to collect data from IoT devices and sensors. The environment monitoring system and transport management work together to control the flow of polluting motors vehicle. A real-time operational database is transformed, loaded, and extracted using the extraction-transformation-loading method. Once significant data has been obtained and transformed utilising relational analytical processing into the required format, operations such as drill-down, data cutting, data rolling up, and turning can be performed. In an IoT sensory environment, the name addressing configuration server is utilized to connect numerous systems.

**Step 4: Data management**

All the data should be managed and stored using a cloud service. For the system's analysis and computation, e-science platforms such as Data as a Service (DaaS), Infrastructure as a Service (IaaS), Software as a Service (SaaS), and Platform as a Service (PaaS) are all used, with GIS acting as the main tool.

**Step 5: Prediction/learning process**

After the data management phase in above step, the use of machine learning algorithms comes. The model is trained using machine learning techniques so that it can make accurate predictions in the future. For this problem, a Decision tree is used in the learning process. The drawn pattern is used as an input to the Decision tree. The decision tree is a better fit algorithm for this problem. The decision tree is easily handled different interlinked patterns that’s why the decision tree is used as a machine learning algorithm in the learning phase.

**Step 5: Provide monitoring**

Based on the learning process the model is now ready to predict to provide the monitoring for the transport, and video surveillance for weather forecasting. With the help of this paradigm a good environment monitoring scheme is provided which is very important for making smart cities.

**Step 6: Flow the same to the public**

Now, in the end, all these predictions are made available to the public with a cloud computing-based IoT paradigm. All this information is made available to the public to make people aware.

1. **Results**

**Result 1.** Figure 3 shows the climatic change and its ecological consequences in the study region, datasets from several sources decision tree classifier using with R-square error is -1.025566486253986 and the confusion matrix of the test dataset shows the mean absolute error is 45.345, mean squared error is 3239.895, root mean squared error is 56.920075544573905.

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Figure 3. Error rate

**Result 2.** Figure 4 shows the dataset collaborative mechanisms which are used to process their data research area's ecological reactions to the climate change, multisource datasets, stationid, station Name, city, state, vehicles, mean temp, humidity, wind speed, mean pressure, precipitation.

Table

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Figure 4. Dataset

**Result 3.** The relationship between the mean temperature and the month is shown graphically in Figure 5 a month on the x-axis and the mean temperature on the y-axis. The average temperature increases from January to April by an increment of 30°C., and then it steadily falls until April, which reaches 21°C. Once again, the increase from May to June is 22°C and the decrease from June to December is constant.

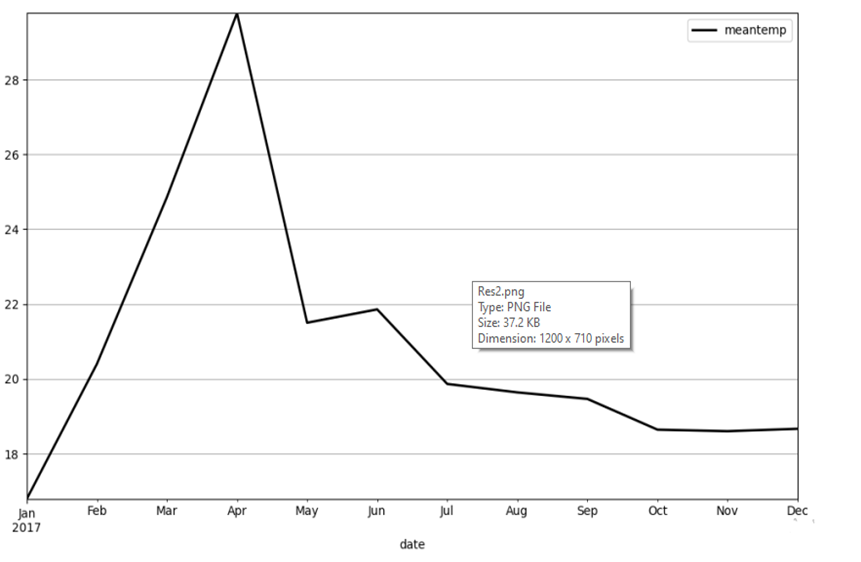
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Figure 5.Mean temperature

**Result 4.** Figure 6 illustrates visually the Humidity between the average temperature and the month on the x-axis and the humidity on the y-axis. The average temperature drops by 0 degrees Celsius from January to April before rising until April and May, it reaches 60°C.  Again, the difference between May to June is 54 ℃, and the difference between June and September is always higher. Similarly, the temperature decreased from September to November to 54 ° C before rising to 57 ° C in December.

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Figure 6. Humidity

**Result 5.** Figure 7 illustrates visually the wind speed between the average temperature and the month on the x-axis and the wind speed on the y-axis. The rising temperature drops by 9 from January to march and then falls until it reaches 7.2°C.  Again, the difference between April to June is a rise of 54℃, and the difference between June to august is always lower. Similarly, the temperature rising from August to October is 12.5°C and then decreased to 1°C in December.

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Figure 7. Wind Speed

**Result 6.** The relationship between the mean pressure and the month is shown graphically in Figure 8 shows the month on the x-axis and the mean pressure on the y-axis. The average temperature increases from January to February at an increment of 1015°C, and then it steadily falls until April, when reaches 1005°C. Once again, the increase from May to June is 1011°C and the increase from June to December is constant.

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Figure 8. Mean Pressure

**Result 7.** The various monthly mean temperature ranges are broken down into their respective ranges Figure 9 shows the month on the x-axis and the mean temperature on the y-axis which can be seen here. The red line illustrates several dates that represent different mean temperatures. The application layer is in charge of storing, organizing, analyzing, and distributing the data that pertains to the environment to be increased concerning mean temperature. The blue line represents the mean average temperature from January through April, with each month represented by an increment.

Chart, line chart, histogram

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Figure 9. Mean temperature Month-wise

**Result 8.** Figure 10 shows a year on the x-axis and the mean temperature on the y-axis data that relates to the environment is going to be stored, organized, analyzed, and distributed by the application layer, which oversees those tasks. The blue line illustrates the mean temperature through by year, with an increment being used to depict each year or month.

Chart

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Figure 10. Mean temperature year wise

**Result 9:** The various monthly humidity ranges are broken down into their respective ranges Figure 11 shows the month on the x-axis and the humidity on the y-axis, which can be seen here. The red line illustrates several dates that represent different mean temperatures. The application layer is in charge of storing, organizing, analyzing, and distributing the data that pertains to the environment is to be decreased concerning humidity changes. The blue line represents the humidity temperature from January through April, with each month represented by a decrement.

Chart, line chart, histogram

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Figure 11. Humidity Month wise

**Result 10:** Figure 12 shows the year on the x-axis and the humidity on the y-axis data that relates to the environment is going to be stored, organized, analyzed, and distributed by the application layer, which oversees those tasks. The blue line illustrates the mean humidity through by year, with a decrement being used to depict each year or month.

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Figure 12. Humidity year wise

**Result 11:** The various month of wind speed ranges are broken variation into their respective ranges in Figure 13, which shows the month on the x-axis and the wind speed on the y-axis which can be seen here. The red line illustrates several dates that represent different mean temperatures. The application layer is in charge of storing, organizing, analyzing, and distributing the data that pertains to the environment is to be randomly changed through oscillation concerning wind speed changes. The blue line represents the wind speed from January through April, with each month represented by random changes through their output outcomes.

Chart, line chart

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Figure 13. Wind Speed Month-wise

**Result 12:** Figure 14 shows the year on the x-axis and the wind speed on the y-axis data that relates to the environment is going to be stored, organized, analyzed, and distributed by the application layer, which oversees those tasks. The blue line illustrates the wind speed through by year, with a random chance by their oscillatory output being shown to them depict each year or month.

Chart

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Figure 14. Wind Speed year wise

**Result 13.** The various monthly mean pressure ranges are broken down into their respective ranges in Figure 15, which shows the month on the x-axis and the mean pressure on the y-axis can be seen here. The red line illustrates several dates that represent different mean temperatures. The application layer is in charge of storing, organizing, analyzing, and distributing the data that pertains to the environment is to be first increased and then constant pressure concerning humidity changes. The blue line represents the mean pressure from January through April, with each month represented by the first increment and then constant pressure speed.

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Figure 15. Mean pressure month-wise

**Result 14.** Figure 16 shows the year on the x-axis and the mean pressure on the y-axis the data that relates to the environment is going to be stored, organized, analyzed, and distributed by the application layer, which oversees those tasks. The blue line illustrates the mean pressure through by year, with the first increment and then constant pressure speed being used to depict each year or month.

Chart

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Figure 16. Mean pressure year wise

1. **Comparative Results**

This section contains the comparative analysis between the techniques that were suggested earlier and the proposed one. Comparative analyses of studies are performed to identify the performance and assemble their error comparison among techniques. Figure 17 depicts the comparative analysis of the error rate**.** Table 3 shows the Comparison of techniques between error rates as given below:

Table 3. Comparison of techniques in between error rate

|  |  |  |
| --- | --- | --- |
| **Author Name** | **Techniques** | **Error rate** |
| Proposed | Decision Tree | 56.93% |
| Montori et al. [3] | Machine Learning | 88.83% |
| Capponi et al. [5] | Collaborative approach | 89.53% |

Figure 17. Comparison Graph.

1. **Conclusion**

In combination with sensors and actuators that can activate on physical substances, the sensing layer also includes devices that can capture data on physical measurements of attention in a slight manner, as well as actuators that can be used to interpret RFID, IDs, and another similar device. Sensor data is sent to the Middleware layer through a variety of wireless network protocols, including Wi-Fi, cellular internet, Zigbee, and Bluetooth. The middleware acts as a link between the detecting layer and the application layer, bridging the gap between the software and the hardware worlds. Organization and implementation of actions that aid in system management is handled by this layer, which is connected to an application-layer component. Using the charge of storing, organizing, analyzing, and distributing data to determine emission and transition probability helps to enhance the several dates, years, and months. Based on these probability results are then analyzed to determine the most accurate humidity. The experimental results show that the intended methodology performs excellent with a humidity of 52%. In the future, researchers want to use a new method and a larger training set. The accuracy of analyzing, and distributing data should be enhanced.

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