Environmental Monitoring

Ideation Phase Problem Statement

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Project Name	Environmental Monitoring: Advance Environmental Monitoring

Student’s details

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Project Definition:

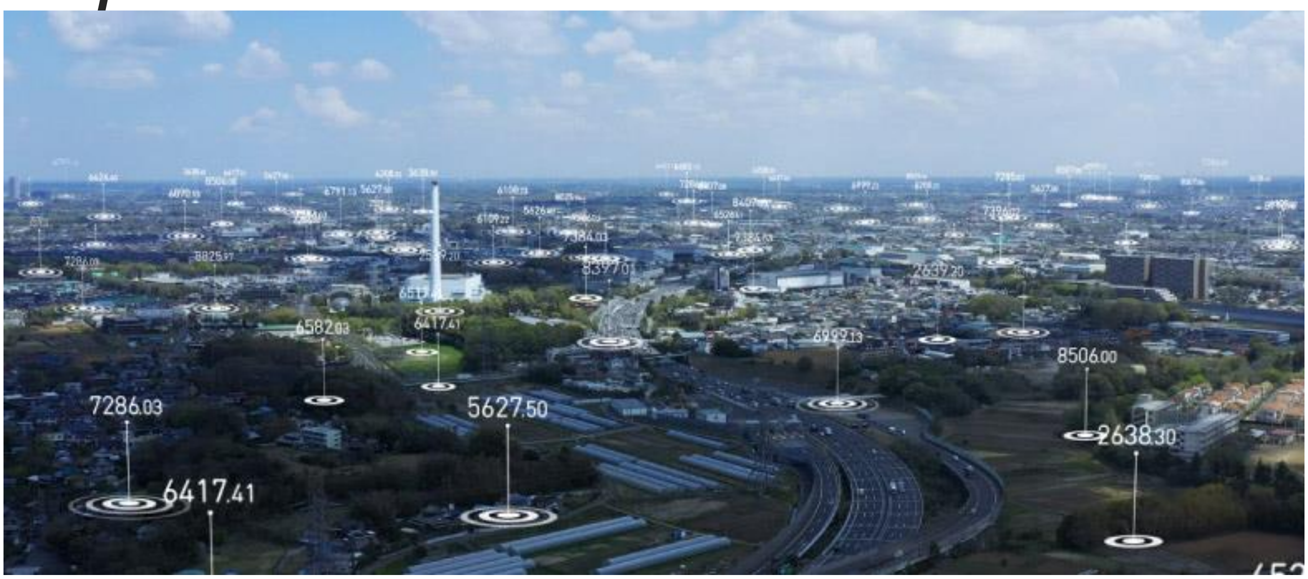
Information on visitors is essential for managing outdoor recreation to ensure • quality recreation experiences • sustainable use of the area (e.g. knowing and managing impacts on terrain, wildlife, etc.) • promotion of public health and well-being • tourism planning • efficient protection of nature and cultural heritage • sufficient financing. Visitor information is important at different levels. It is essential for local land managers and for local tourism development, as well as for regional, national and international policy, planning, reporting, research and comparisons. Moreover, visitors themselves are often interested in such information and as citizens they have a right to know about visitationton the areas. Harmonised visitor information should be gathered because there is a need to obtain comparable and reliable visitor information across different areas and across time. Ad hoc information gathering can lead to inaccurate and non-comparable results.The choice of methods in any particular case depends on the aim of visitor monitoring, the questions to be asked, the type of area, the extent of various activities, the number and types of visitors, and so on. This manual focuses on onsite visitor monitoring methods, which yield information about the actual users of the area. With the methodology presented in this manual, one does not obtain information on non-visitors, e.g.potential visitors.

Desing Thinking:

- Project Objectives: Define objectives such as real-time environmental monitoring, aiding park visitors in activity planning, promoting outdoor experiences, and enhancing visitor satisfaction.
- IoT Devices Designs: Plan the deployment of IoT sensors (e.g., temperature and humidity sensors) in public parks
- Environmental Monitoring Platform: Design a web-based platform to display real time environmental data to the public.
- Integration Approach: Determine how IoT devices will send data to the environmental monitoring platform.

Project Objectives:

Real-time environmental monitoring and assessment technologies are more sophisticated than ever



The technologies used in real-time environmental monitoring systems include a wide variety of hardware, software, and methodologies. Some of the most common technologies include:

Real-Time Sensor Networks

A dispersed group of environmental sensors monitor and record the conditions of an environment, and stream data in real-time over the Internet via their own API or bespoke connection. Once data is transmitted to a data center, it is subject to anomaly detection, which identifies potentially inaccurate data produced from compromised monitoring devices. Typically a stream-based importer is used to ingest data into a database.

Analytics Platforms

Provides a centralized location where massive GIS datasets can be ingested, queried, visualized on a granular level, and analyzed at scale in real-time. An accelerated analytics platform features interactive data visualizations , and allows analysts to cross-filter billions of geospatial data records and polygons alongside other features in milliseconds.

Sensor Observation Service

A web service to query real-time sensor network data and sensor data time series, and applicable to use cases in which real-time sensor data streams need to be managed in an interoperable way. SOS allows querying observations, real-time sensor metadata, as well as representations of observed features. Standards are defined by the Open Geospatial Consortium.

Geographic Information Systems

GIS are computer and software tools for gathering and analyzing data connected to geographic locations and their relation to human or natural activity on Earth. GIS mapping software uses spatial data to create maps and 3D models out of layers of visual information, revealing patterns and relationships in the GIS data. remote sensing data is pulled from sources like USGS Earth Explorer and the Socioeconomic Data and Applications Center.

Telemetry Systems

Telemetry is the automatic in situ recording of measurements or other data at remote points and their transmission to receiving IT equipment at a different location. Common options include cellular, radio, or satellite. Telemetry platforms are appropriate for a variety of remote, real-time monitoring applications.

The Internet of Things

IoT based environmental monitoring enable us to visualize, monitor, and control crucial phenomena in the environment with the use of devices that can sense, process, and wirelessly transmit data to remote storage such as the cloud, where data can be stored, analyzed, and presented in a valuable way.

Machine Learning

Data history is recorded with data science tools like Pandas inside a Notebook environment. Machine Learning models can then be implemented as a way of infilling or back painting missing data. Deep learning algorithms have revolutionized the ability to detect complex objects in imagery, such as wisps of clouds. A human element is still necessary, a role filled by an environmental monitoring technician.

The benefits and advantages of environmental monitoring in real-time are enormous

The objectives of environmental monitoring are simple: minimize the impact an our activities have on environment . Real-time environmental monitoring systems are helping humans develop a proactive relationship with the Earth, and   advancing earth analytics can even help mitigate catastropic events. Continuous environmental monitoring with real-time technologies helps provide data that is used to identify trends, make predictions, and establish parameters and trigger levels, which is essential for early warning strategies.

A major benefit of the proliferation of real-time environmental monitoring is accountability. Our ability to conduct environmental monitoring and impact assessments in some of the most remote corners of the world ensures corporate compliance and adherence to government regulations. Real-time monitoring helps agencies and enterprises set environmental performance goals and emission reduction targets , and create environmental monitoring reports to track their progress.

Another major benefit is the improvement of disaster response and preparedness. Disaster management data collection an emergency management software facilitate innovative emergency management endeavors such as crisis mapping, social media mining, and event simulations, which use enormous volumes of real-time and historical data to assist emergency management directors and their teams in developing proactive, protective strategies, such as flood warning systems.

Real-time environmental monitoring applications are all around us every day

The practical applications of real-time environmental monitoring are vast and varied. Wildfires, landslides, flooding, biodiversity, and waste and pollution are all issues of increasing concern as the climate crisis is predicted to worsen in coming years. Wildfire monitoring systems have been particularly useful in 2020, which saw a record-setting number of wildfires ravage California.

Air Monitoring

Wireless sensor networks for real time air pollution monitoring is performed with the use of specialized observation tools, such as sensor networks and Geographic Information System (GIS) models, from multiple different environmental networks and institutes is integrated into air dispersion models, which combine emissions, meteorological, and topographic data to detect and predict concentration of air pollutants and measure temperature humidity.

Soil Contamination Monitoring

Grab sampling (individual samples) and composite sampling (multiple samples) are used to monitor soil, set baselines, and detect threats such as acidification, biodiversity loss, compaction, contamination, erosion, organic material loss, salinization, water leak detection, and slope instability. Salinity monitoring, contamination monitoring, and erosion monitoring help identify imbalances, toxins, and behavior that can impact everything from crop yield to diseases.

Water Quality Monitoring

Water quality monitoring and sampling equipment and techniques include judgmental, simple random, stratified, systematic and grid, adaptive cluster, grab, and passive; semi-continuous and continuous environmental condition monitoring; remote sensing, and biosensors for water quality monitoring, are used to measure and monitor ranges for biological, chemical, radiological, microbiological, and population parameters.

Environmental monitoring solutions feature tools and capabilities that are tremendously useful to data analysts

Whether you're measuring air quality or analyzing soil samples, most real-time environmental monitoring solutions tend to feature the same general capabilities and features:

- Automated data collection tools for quantitative and qualitative data
- Built-in notifications for tracking environmental samples
- Validation and auditing tools
- Regulatory exports and reports
- Multi-tiered security
- Local Language Support
- Built-in GIS mapping
- Mobile integrations
- Advanced query tools
- Pre-built calculations for analytical data

Data science is quickly becoming one of the most valuable tools for protecting the environment

Data science and Artificial Intelligence are helping drive technological innovations for some major environmental initiatives and projects. Some compelling examples include:

Simulation Modeling of the Earth

Scientists are creating a digital twin of our planet that will capture continuous, real-time environmental data to help improve climate forecasts. Scientists and policymakers will be able to evaluate different scenarios that would support sustainable development and influence environmental policies.

Accelerating Research at NASA

is combining AI and machine learning with high-performance computing to manage and gain insight from its increasingly massive data stores. Projects include landslide detection, surface water monitoring, and habitat suitability prediction.

Environmental Protection Using AI

Microsoft's "AI for Earth" initiative provides scientists and researchers access to AI and machine learning technology, awarding grants to support projects related to agriculture, biodiversity, climate and water. One such project is Ocean Cleanup, which uses machine learning to identify plastic pollution in rivers and simulate how it moves in the ocean.

There are still major challenges in implementing real-time environmental monitoring systems

As is the case with many advanced technologies, the greatest barrier of entry for real-time environmental monitoring systems is upfront cost. While real-time monitoring systems are not cheap, billions of dollars are spent every year on asset management, and a significant percentage of those funds are wasted on inefficiencies. Real-time monitoring systems combine preventive risk analysis and logistics to help teams make smarter, data-driven decisions.

Managing the sheer volume of existing environmental assets is growing impractical without advanced environmental monitoring tools, so while the upfront cost may cause sticker shock, the long-term benefits and savings from real-time monitoring outweighs the initial cost.

The HEAVY.AI Difference

As the pioneer in accelerated analytics, the HEAVY.AI data science platform is used to find real-time data insights beyond the limits of mainstream analytics tools. While the enormous volumes of data collected by modern environmental monitoring sensors and IoT devices easily overwhelm legacy GIS tools, HEAVY.AI's accelerated analytics platform allows analysts to cross-filter billions of location data records and polygons alongside other features in milliseconds. Learn more about how HEAVY.AI supports government data analytics for the public sector as well as across a wide variety of use cases.

2.**IoT Devices Designs:**

Plan the deployment of IoT sensors (e.g., temperature and humidity sensors) in public parks.

HUB / Gateway

A device that provides a usable output in response to a specified measurement. The sensor attains a physical parameter and converts it into a signal suitable for processing
eg :
electrical, mechanical, optical) the characteristics of any device or material to detect the presence of a particular physical quantity.\

IOT HARDWARE

IOT HARDWARE

Transducer :

- A transducer converts a signal from one physical structure to another.
- It converts one type of energy into another type.
- It might be used as an actuator in various systems.

Sensor's characteristics :

1. Static
2. Dynamic

1. Static characteristics :
It is about how the output of a sensor changes in response to an input change after steady state condition.

- **Accuracy:** Accuracy is the capability of measuring instruments to give a result close to the true value of the measured quantity. It measures errors. It is measured by absolute and relative errors. Express the correctness of the output compared to a higher prior system. Absolute error = Measured value – True value
  Relative error = Measured value/True value

- **Range:** Gives the highest and the lowest value of the physical quantity within which the sensor can actually sense. Beyond these values, there is no sense or no kind of response.
  e.g. RTD for measurement of temperature has a range of -200`c to 800`c.
- **Resolution:** Resolution is an important specification for selection of sensors. The higher the resolution, the better the precision. When the accretion is zero too, it is called the threshold.
  Provide the smallest changes in the input that a sensor is able to sense.
- **Precision:** It is the capacity of a measuring instrument to give the same reading when repetitively measuring the same quantity under the same prescribed conditions.
  It implies agreement between successive readings, NOT closeness to the true value.
  It is related to the variance of a set of measurements.
  It is a necessary but not sufficient condition for accuracy.
- **Sensitivity:** Sensitivity indicates the ratio of incremental change in the response of the system with respect to incremental change in input parameters. It can be found from the slope of the output characteristics curve of a sensor. It is the smallest amount of difference in quantity that will change the instrument's reading.
- **Linearity:** The deviation of the sensor value curve from a particularly straight line. Linearity is determined by the calibration curve. The static calibration curve plots the output amplitude versus the input amplitude under static conditions.
  A curve's slope resemblance to a straight line describes linearity.
- **Drift:** The difference in the measurement of the sensor from a specific reading when kept at that value for a long period of time.
- **Repeatability:** The deviation between measurements in a sequence under the same conditions. The measurements have to be made under a short enough time duration so as not to allow significant long-term drift.

Dynamic Characteristics :
Properties of the systems

- **Zero-order system:** The output shows a response to the input signal with no delay. It does not include energy-storing elements.
  Ex. potentiometer measure, linear and rotary displacements.
- **First-order system:** When the output approaches its final value gradually. Consists of an energy storage and dissipation element.
- **Second-order system:** Complex output response. The output response of the sensor oscillates before steady state.

Sensor Classification:

- Passive & Active
- Analog & digital
- Scalar & vector

3. **Passive Sensor** –
   Can not independently sense the input. Ex- Accelerometer, soil moisture, water level and temperature sensors.
4. **Active Sensor** –
   Independently sense the input. Example- Radar, sounder and laser altimeter sensors.
5. **Analog Sensor** –
   The response or output of the sensor is some continuous function of its input parameter. Ex- Temperature sensor, LDR, analog pressure sensor and analog hall effect.
6. **Digital sensor** –
   Response in binary nature. Design to overcome the disadvantages of analog sensors. Along with the analog sensor, it also comprises extra electronics for bit conversion. Example – Passive infrared (PIR) sensor and digital temperature sensor (DS1620).
7. **Scalar sensor** –
   Detects the input parameter only based on its magnitude. The answer for the sensor is a function of magnitude of some input parameter. Not affected by the direction of input parameters.
   Example – temperature, gas, strain, color and smoke sensor.
8. **Vector sensor** –
   The response of the sensor depends on the magnitude of the direction

and orientation of input parameter. Example – Accelerometer, gyroscope, magnetic field and motion detector sensors.

Types of sensors –

- **Electrical sensor:**

Electrical proximity sensors may be contact or non-contact.

Simple contact sensors operate by making the sensor and the component complete an electrical circuit.

Non- contact electrical proximity sensors rely on the electrical principles of either induction for detecting metals or capacitance for detecting nonmetals as well.

- **Light sensor:**

Light sensors are also known as photo sensors and one of the important sensors.

Light dependent resistor or LDR is a simple light sensor available today.

The property of LDR is that its resistance is inversely proportional to the intensity of the ambient light i.e when the intensity of light increases, its resistance decreases and vice versa.

- **Touch sensor:**

Detection of something like a touch of finger or a stylus is known as touch sensor.

It's name suggests that detection of something.

They are classified into two types:

9. Resistive type
10. Capacitive type

Today almost all modern touch sensors are of capacitive types.

Because they are more accurate and have better signal to noise ratio.

- **Range sensing:**

Range sensing concerns detecting how near or far a component is from the sensing position, although they can also be used as proximity sensors.

Distance or range sensors use non-contact analog techniques. Short range sensing, between a few millimetres and a few hundred millimetres is carried out using electrical capacitance, inductance and magnetic technique.

Longer range sensing is carried out using transmitted energy waves of various types eg radio waves, sound waves and lasers.

- **Mechanical sensor:**

Any suitable mechanical / electrical switch may be adopted but because a certain amount of force is required to operate a mechanical switch it is common to use micro-switches.

- **Pneumatic sensor:**

These proximity sensors operate by breaking or disturbing an air flow.

The pneumatic proximity sensor is an example of a contact type sensor. These cannot be used where light components may be blown away.

- **Optical sensor:**

In there simplest form, optical proximity sensors operate by breaking a light beam which falls onto a light sensitive device such as a photocell. These are examples of non contact sensors. Care must be exercised with the lighting environment of these sensors for example optical sensors can be blinded by flashes from arc welding processes, airborne dust and smoke clouds may impede light transmission etc.

- **Speed Sensor:**

Sensor used for detecting the speed of any object or vehicle which is in motion is known as speed sensor .For example – Wind Speed Sensors, Speedometer ,UDAR ,Ground Speed Radar .

- **Temperature Sensor:**

Devices which monitors and tracks the temperature and gives temperature's measurement as an electrical signal are termed as temperature sensors .These electrical signals will be in the form of voltage and is directly proportional to the temperature measurement .

- **PIR Sensor:**

PIR stands for passive infrared sensor and it is an electronic sensor that is used for the tracking and measurement of infrared (IR) light radiating from objects in its field of view and is also known as Pyroelectric sensor .It is mainly used for detecting human motion and movement detection .

- **Ultrasonic Sensor:**

The principle of ultrasonic sensor is similar to the working principle of SONAR or RADAR in which the interpretation of echoes from radio or sound waves to evaluate the attributes of a target by generating the high frequency sound waves .


Retail and Logistics

IoT sensors are pieces of hardware that detect changes in an environment and collect data. They're the pieces of an IoT ecosystem that bridge the digital world to the physical world. IoT sensors may detect things like temperature, pressure, and motion, and if they are connected to a network, they share data with the network

IoT Based Temperature and Humidity Monitoring over ThingSpeak using Arduino UNO and ESP8266

In this project, we are using the **DHT11 sensor for sending Temperature and Humidity data to Thingspeak using Arduino and ESP8266**. By this method, we can monitor our DHT11 sensor's temperature and humidity data over the internet using the ThingSpeak IoT server. And we can view the logged data and graph overtime on the Thingspeak website.

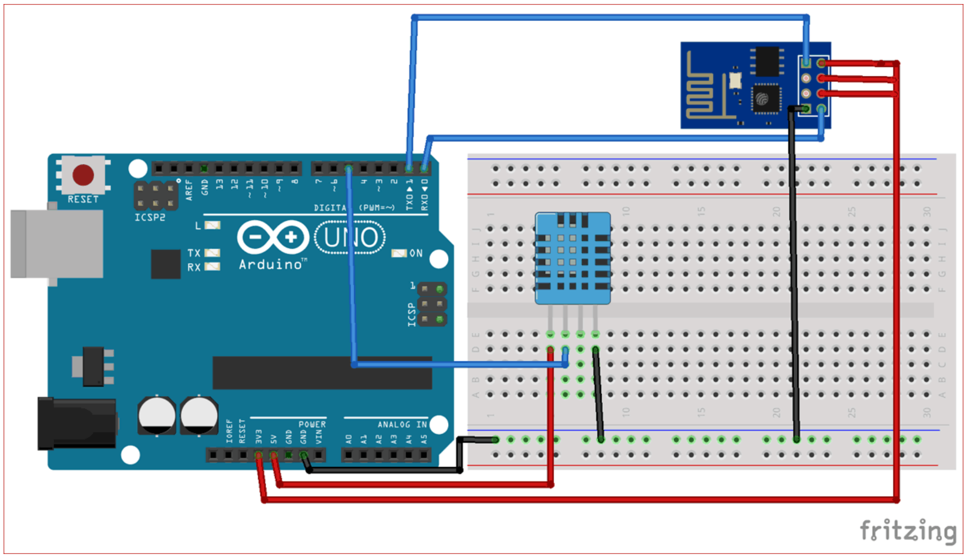
Here Arduino Uno reads the current temperature and humidity data from DHT11 and sends it to the ThingSpeak server for live monitoring from anywhere in the world. We previously used and to upload the data on the cloud. **ThingSpeak** is an open data platform for monitoring your data online where you can set the data as private or public according to your choice. ThingSpeak takes a minimum of 15 seconds to update your readings. It's a great and very easy-to-use platform for building IoT projects.

Components Required

- Arduino Uno
- ESP8266 WiFi Module
- DHT11 Sensor
- Breadboard

- Jumper Wires

Temperature and Humidity Monitoring System Circuit Diagram



Connections are given in below table:

S.NO.	Pin Name	Arduino Pin
1	ESP8266 VCC	3.3V
2	ESP8266 RST	3.3V
3	ESP8266 CH-PD	3.3V
4	ESP8266 RX	TX
5	ESP8266 TX	RX

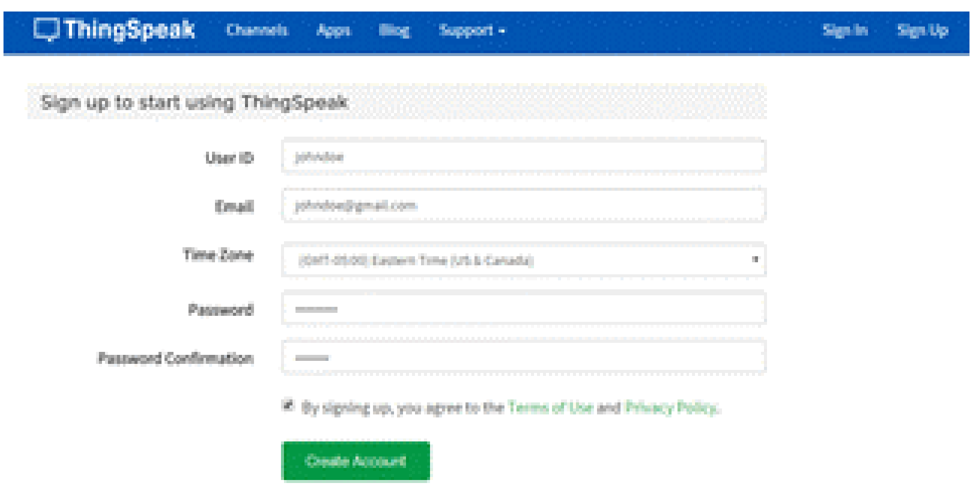
6	ESP8266 GND	GND
7	DHT-11 VCC	5V
8	DHT-11 Data	5
9	DHT-11 GND	GND

Step 1: ThingSpeak Setup for Temperature and Humidity Monitoring

For creating your channel on Thingspeak, you first need to Sign up on Thingspeak. In case if you already have an account on Thingspeak, just sign in using your id and password.

Click on Sing up if you don’t have account and if you already have an account, then click on sign in.

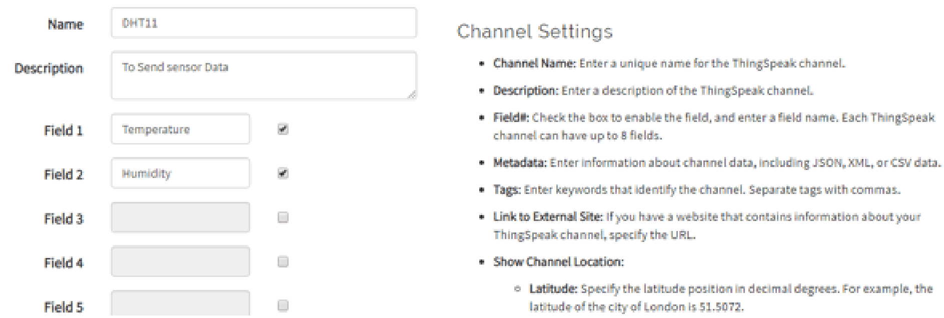
After clicking on signup, fill in your details.



After this, verify your E-mail id and click on continue.

Step 2: Create a Channel for Your Data

Once you Sign in after your account verification, Create a new channel by clicking “New Channel” button.



After clicking on “New Channel”, enter the Name and Description of the data you want to upload on this channel. For example, I am sending my DHT11 sensor data, so I named it DHT11 data.

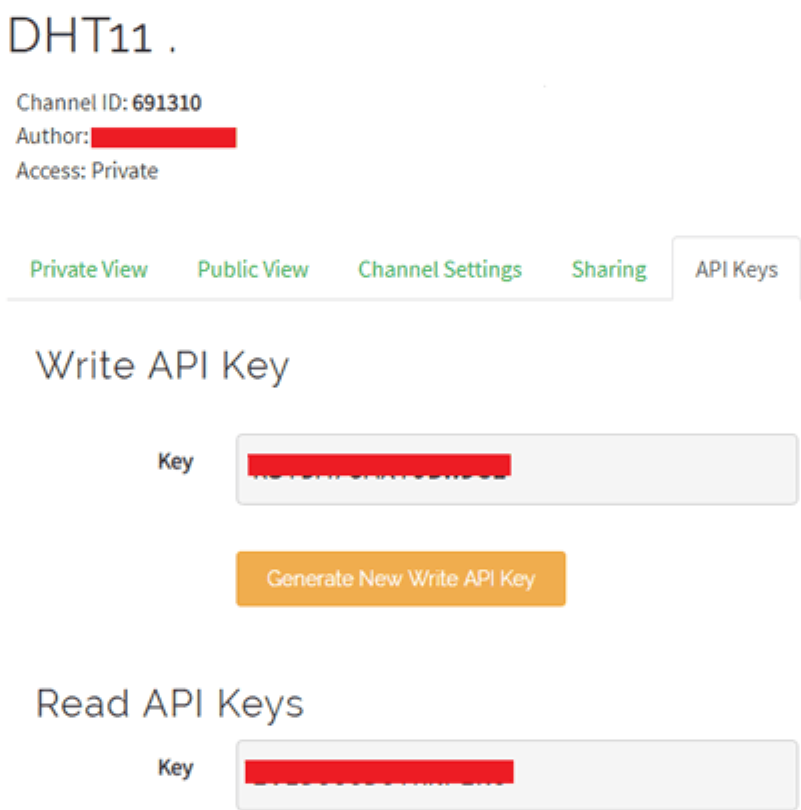
Enter the name of your data ‘Temperature’ in Field1 and ‘Humidity’ in Field2. If you want to use more Fields, you can check the box next to Field option and enter the name and description of your data.

After this, click on the save channel button to save your details.

Step 3: API Key

To send data to Thingspeak, we need a unique API key, which we will use later in our code to upload our sensor data to Thingspeak Website.

Click on “API Keys” button to get your unique API key for uploading your sensor data.



Now copy your “Write API Key”. We will use this API key in our code.

Programming Arduino for Sending data to ThingSpeak

To program Arduino, open Arduino IDE and choose the correct board and port from the *‘tool’* menu.

Complete code is given at the end of this tutorial. Upload it in Arduino UNO. If you successfully upload your program, Serial monitor will look like this:

```
AT
AT+CWMODE=1
AT+CWJAP="CircuitLoop","circuitdigest101"
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=56
AT+CIPCLOSE
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=56
GET /update?key=9B6ILVOYMUSVOADA&field1=19.7&field2=50
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=56
GET /update?key=9B6ILVOYMUSVOADA&field1=19.7&field2=50
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=56
GET /update?key=9B6ILVOYMUSVOADA&field1=19.7&field2=50
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=56
GET /update?key=9B6ILVOYMUSVOADA&field1=19.7&field2=50
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=56
GET /update?key=9B6ILVOYMUSVOADA&field1=19.8&field2=50
AT+CIPSTART="TCP","184.106.153.149",80
AT+CIPSEND=56
```

After this navigate to your Thingspeak page and open your channel at Thingspeak and output will be shown as below:

Hence, we have successfully monitored Temperature and Humidity data over ThingSpeak using Arudino and ESP32.

Code

```
#include <stdlib.h>

#include <DHT.h>

#define DHTPIN 5        // DHT data pin connected to Arduino pin 5

#define DHTTYPE DHT11     // DHT11 (DHT Sensor Type )

DHT dht(DHTPIN, DHTTYPE); // Initialize the DHT sensor

#define SSID "WiFi Name"     // "WiFi Name"

#define PASS "WiFi Password"       // "Password"

#define IP "184.106.153.149"// thingspeak.com ip
```

```
String msg = "GET /update?key=Your API Key"; //change it with your key...
float temp;
int hum;
String tempC;
int error;
void setup()
{
  Serial.begin(115200); // use default 115200.
  Serial.println("AT");
  delay(5000);
  if(Serial.find("OK")){
    connectWiFi();
  }
}
void loop(){
   start:
  error=0;
  temp = dht.readTemperature();
  hum = dht.readHumidity();
  char buffer[10];
  tempC = dtostrf(temp, 4, 1, buffer);
  updateTemp();
  if (error==1){
    goto start;
  }


  delay(5000);
}
void updateTemp(){
```

```
  String cmd = "AT+CIPSTART=\"TCP\",\"";
  cmd += IP;
  cmd += "\",80";
  Serial.println(cmd);
  delay(2000);
  if(Serial.find("Error")){
    return;
  }
  cmd = msg ;
  cmd += "&field1=";
  cmd += tempC;
  cmd += "&field2=";
  cmd += String(hum);
  cmd += "\r\n";
  Serial.print("AT+CIPSEND=");
  Serial.println(cmd.length());
  if(Serial.find(">")){
    Serial.print(cmd);
  }
  else{
    Serial.println("AT+CIPCLOSE");
    //Resend...
    error=1;
  }
}
  boolean connectWiFi(){
  Serial.println("AT+CWMODE=1");
  delay(2000);
  String cmd="AT+CWJAP=\"";
```

```
  cmd+=SSID;
  cmd+="\",\"";
  cmd+=PASS;
  cmd+="\"";
  Serial.println(cmd);
  delay(5000);
  if(Serial.find("OK")){
    return true;
  }else{
    return false;
  }
}
```

3.Environmental Monitoring Platform: *Design a web-based platform to display real time environmental data to the public.*

Abstract

Smart and sustainable communities seek to ensure comfortable and sustainable quality of life for community residents, the environment and the landscape. Pollution is a key factor affecting quality of life within a community. This research provides a detailed insight into a successfully developed and deployed framework for an environmental monitoring platform for an urban study to monitor, in real time, the air quality and noise level of two cities of the Dominican Republic—Santo Domingo and Santiago de Los Caballeros. This urban platform is based on a technology range, allowing for the integration of multiple environmental variables related to landscape and providing open data access to urban study and the community. Two case studies are presented: The first highlights how the platform can be used to understand the impact a natural event, for example, how dust landscapes (such as the Sahara) impact a community and the actions that can be taken for wellness and preventive care. The second case focuses on understanding how policies taken to prevent the spread of COVID-19 affect the air quality and noise level of the landscape and community. In the second

case, the platform can be used to expand the view of decision makers in the urban landscape and communities that are affected.

1. Introduction

Smart and sustainable cities are an expression of the multiple domains of urban life in which technology and policies can be applied to a community within their landscape [1]. The vision has progressed to focus on the alignment between policies related to human capital, education, economic development, territorial and governance, and how these could be improved with the use of ICT [2]. To become a smart and sustainable community, its development must combine ICT with territorial, human and social capital, along with broad economic policies [3]. Currently, the development of smart cities seeks to ensure a comfortable and sustainable quality of life for the residents of the community, the environment and their landscape [4]. This creates a bigger emphasis on the sustainability of the community and the surrounding territories .

2. An Environmental Monitoring Platform for Urban Studies in a Smart and Sustainable City

The link between health complications and poor air quality or prolonged exposure to noise level has been extensively established [8,18,19,20,21]. Citizens' awareness of pollution levels and how to adapt their behavior as a response has become a new focus. In Oslo, Norway, a group of sensors were deployed in kindergartens to plan children's outdoor activities depending on the pollution levels [22]. Kumar et al. [23] measured the impact individual vehicles had during drop-off and pick-up time at a school compared to other times of the day by measuring the air quality at different points in the school with the purpose of promoting commuting in their student population. This shows the importance of environmental pollution awareness among citizens of a smart and sustainable community.

Internet of Things (IoT) in Environmental Monitoring for Urban Studies

To obtain the environmental data needed to observe changes in the contaminants, multiple monitoring stations are needed. Through IoT, these environmental sensors generate massive amounts of data that, if used properly, can enhance objective decision making. However, detailed observations of air quality on an urban scale are rare given the high cost of traditional monitoring stations [22], especially in developing countries.

Advances in sensor technology have allowed for the development of low-cost measurement equipment for the observation of small-scale spatial variability of pollutants [27]. These sensors, being smaller and cheaper, allow for the deployment of a higher-density network in urban spaces through

IoT [28]. This advancement has allowed for the expansion of existing platforms for permanent [24] or transitory purposes on time-specific needs [29]. Besides the cost, these internet-enabled sensors allow for fast deployment and a customizable array of environmental variables depending on the requirements of each territory [30].

Engaging with Environmental Data

Through an environmental monitoring platform, researchers have looked for the opportunity to establish a link between the landscape and the community so that they could monitor the contaminants that have a direct impact on their daily lives. This implies that engaging with different actors of society is important to obtain a holistic view and to better understand what problems are affecting the community and their surrounding territories. In turn, this will allow interventions to be established that have positive behavioral changes [36]. With this focus, different perspectives have been proposed and a citizens science approach has been widely accepted.

Open Data

Open Data is defined as data that are available, accessible, and can be re-used and redistributed by anyone. This type of data must be available on a commonly used and machine-readable format. The license of the data must be allowed for re-use and redistribution so that the data can be repurposed for other services. Finally, there should be no restriction on who can use the data [44].

Design and Implementation Framework

For an environmental monitoring platform for urban studies to successfully engage with the community, a holistic approach must be followed. Guided by the presented literature, this study proposes a framework with four dimensions: First, an internet-enabled network of sensors is needed. These sensors must be customizable so they can adapt to the requirements of the place where they are deployed and the capacity to measure the variables of interest [17,22,36]. The data collected must be placed in a reliable and secure infrastructure that is easily accessible by the community. Therefore, open data are considered as another dimension [50,51]. For the general public to make sense of the data, creating interactive, easy-to-understand visualizations of the territories impacted is important and used as a third dimension [52]. Finally, for citizens to go beyond the provided solutions, they need to develop the capacity to use the data and create innovative solutions for their own needs. Based on this perspective, the last dimension focuses on capacity building [3,16,43,53], as shown in Figure 1.

3. Methodology

The platform was designed for the Dominican Republic, a country located in the Caribbean, forming part of the Greater Antilles. The country occupies the eastern part of the island of Hispaniola. The Dominican territory is divided into 32 provinces, of which the city of Santo Domingo is its capital and biggest city, and the city of Santiago de los Caballeros is the second largest in terms of population and economic contribution. The city of Santo Domingo has a population of more than 2 million inhabitants. The second largest is Santiago, a city in the center of the country, with great industrial and agricultural development and a population of approximately 1.5 million [54]. The platform was designed following the architecture described in this section.

4.Integration Approach:

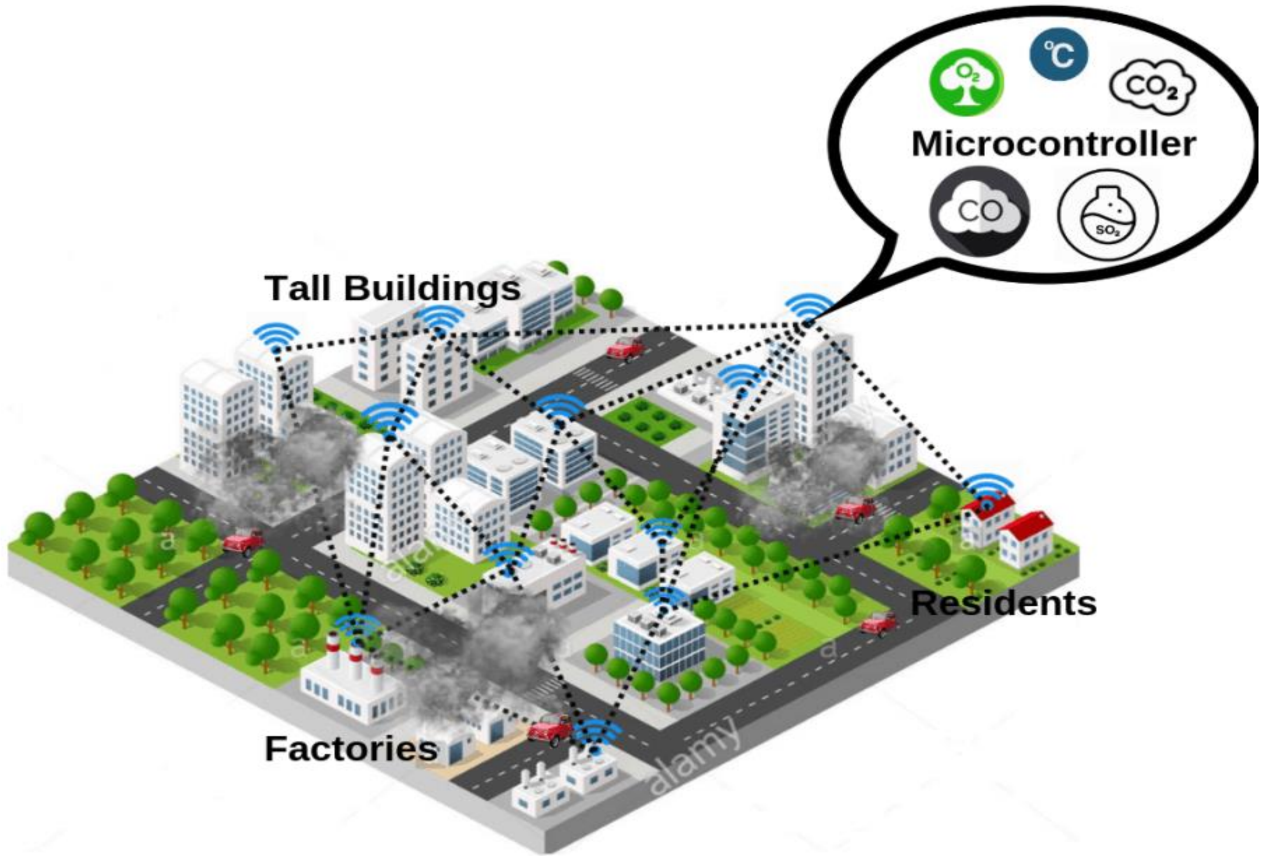
Determine how IoT devices will send data to the environmental monitoring platform.

Industrial IoT gateway manufacturers CMSGP is the best **industrial IoT gateway manufacturers in India**. Our products offer customized hardware and software for specific applications. IoT gateway collects data from pre-existing devices, saves and sends to the cloud and helps in reducing response time and network transmission costs. These devices have wide applications in retail automation, logistics automation, factory automation, building automation and security, oil, gas, power, energy sectors, etc.

Industrial IoT applications are widely used in smart product design principles, data-driven automation practices, fleet management, etc. It also helps in enhancing different types of equipment with remote monitoring and maintenance capabilities, along with which, it improves performance and cost efficiency of their operations. We have designed in compliance with industry standards that are also easily programmable.

industrial IoT gateway manufacturers and suppliers in India

We are a leading company in the field of industrial IoT gateway. We have been in this business for over a decade and have been manufacturing quality products consistently. We offer their customers a wide range of products, including IoT gateways, industrial sensors and industrial control systems. All these products are designed to work together to provide accurate data capture and analysis in real time. We have earned a reputation for making reliable products at an affordable price. Our strong focus on customer service has made them one of the most trusted companies in the industry. We also offers a full suite of customization options so that you can get exactly what you need for your specific needs.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