Smart Garbage Monitoring System And Protection Of Collected Data Using Blockchain

J COMPONENT FINAL REPORT

Submitted in the fulfilment for the J Component of Privacy and Security in IoT (BCT3004)

CAL COURSE

in

B.Tech. Computer Science and Engineering

by

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Abstract:

A lot of waste is accumulated in major metropolitan cities and developed areas due to urbanisation and solid waste management is a major concern faced by my municipality where the accumulated dust must be properly disposed of as early as possible to keep the surroundings clean. When this work is done manually it requires a lot of manpower. So in order to solve this problem we use an IoT technology based project where the system detects the amount of waste accumulated in the bins and when the bin is full it gives an indication to concerned authorities to clean the bins and keep the surroundings clean. This project presents the development of a smart garbage monitoring system in order to measure waste level in the garbage bin in real-time and to alert the municipality, in particular cases, via SMS. This project contains an Ultrasonic sensor which is used to measure the level of bin, GPS module to fetch the location information of bin, GSM module to send the message to concerned authorities with a Node mcu to control the entire process. It is supposed to generate and send the warning messages to the municipality via SMS when the waste bin is full or almost full, so the garbage can be collected immediately. This can be helpful to the concerned authorities to clean the surroundings and keep it clean and tidy. And for improved privacy and security of IOT data, we use blockchain technology where the data collected from the sensor gets stored in the blocks which is tamperproof. Using blockchain technology for privacy and security helps in building decentralised structure, reduced costs, visibility and traceability.

Keywords:

Smart Garbage Monitoring, Blockchain Technology, UV Sensor, IFTTT, Thinkspeak Server, ganache, truffle, metamask

Introduction:

Nowadays due to urbanisation, a lot of areas in major cities and towns are highly populated and in order to accommodate those people many apartments and flats have been built. This is due to high housing demands which have drastically risen as a result of migration from villages to cities to find work. Inorder to accommodate the growing population in the urban area, the government has built flats, apartments or condominiums, to provide shelter for them. Due to this drastic rise of population in major cities, it leads to many problems in the community. One such major problem is improper disposal of waste at highly populated areas. This problem arises due to accumulation of a high amount of wastes due to high population and improper disposal of those wastes accumulated leads to pollution and even it affects human relations.

The waste disposal can be managed more properly and efficiently by constantly monitoring the bin status and the garbage level. In addition, the municipality can be alerted when the bin is full or almost full, thus promoting dynamic scheduling and routing of the garbage collection. By comparing to the conventional static scheduling and routing, this dynamic scheduling and routing are said to allow operational cost reduction, by reducing the number of trucks, the manual labour cost and the transport mileage savings.

This methodology can be implemented using IOT, where ultrasonic sensor can sense the garbage bin capacity and send the data to thingspeak server, from where using API settings, IFTTT can be linked to thingspeak and sends alerts to the authorities when the garbage bin is reached upto a certain limit. For providing the security and privacy collected from sensor, blockchain technology can be used.

Related work:

A. IOT:smart garbage monitoring using android and real time database

• This paper mainly studies implementation of IoT-based smart garbage systems using the ultrasonic sensor on internet networks.

• The sensory device integrated to the monitoring system was able to monitor the height level of garbage volume, and display it on the location map. When the garbage can is already full, automatically there will be an alarm notification for the waste transport officer

. • From the test results, it has been figured out that the notification could appear on the application when the garbage can has accommodated the garbage by 50% and 70% of the garbage can height.

• The application could take and display the data of the garbage can that has been sent and stored on the firebase database.

• Waste management is more efficient and optimally in terms of time management.

• The imperfection that is discovered after using this system, all officers will receive the same notification, it confuses who must collect the garbage from several irregular locations.

B. Smart Garbage Monitoring System using Internet of Things

• In this paper an ultrasonic sensor is used to monitor the level of garbage. IR sensor is used to monitor the nearby persons and automatically drives the DC motor to open the lid of the dustbin.

• The dustbin data is uploaded to the cloud using IOT which helps for clearing the wastage from the dustbin.

• Once the user opens the application, it gets registered using his name and password. In the page, if entered information matches the data in the database then login is successful.

• Users would be able to access the information like status and location of the bin. When the bin is filled, then the red LED is lit up and the green LED is empty. This information is also represented on the web server and is stored in the database.

• This paper concludes that the arduino with IOT technique overcomes all those disadvantages which are use of minimum route, and clean environment. Time consuming, high costs, greater traffic and congestion, unnecessary fuel consumption, increased noise and air pollution as a result of more trunks on the road.

C. Smart Real Time Garbage Management System [3] :

• In this journal, Garbage monitoring system is implemented with sensors, NodeMCU and GPS modules, sensed data of dustbins are continuously monitored by the municipal authorities through ThingSpeak web page.

• When the bins are maximally filled, municipal authorities notify the nearest truck driver by updating the ThingSpeak channel with the location of the bin.

• The authors proposed contact less distance measurement using ultrasonic sensors (HC-SR04) and arduino module.

• This monitoring system is equipped with an ultrasonic sensor, GSM and Liquid crystal display are interfaced with arduino.

• Here garbage levels are detected and updating the status of the bin to the user by sending messages through GSM.

• The authors have proposed that how thingspeak establishes Sensing and Monitoring functions in IoT accompanied by Matlab analysis.

• This system helps in reducing fuel, workers and overall expenditure. It eventually helps to keep the cleanliness of the city and also avoids the spread of harmful diseases.

D. Real Time Smart City Garbage Collection and Monitoring System Using GSM and GPS [4] :

• The sensors would be placed in the common garbage bins sited on the public places.

When the garbage reaches the level of the sensor, then that signal will be given to the

AT89S52 Controller.

• The controller will give a signal to the driver of the garbage collection truck as to

which garbage bin is completely filled and desires urgent attention.

• AT89S52 will give indications by sending SMS using GSM technology. Whenever

the garbage is full information can be sent to the concerned authority to clean the

bin.

• The main motto of this application is to inform the officials of the municipality.

when this garbage reaches an extreme level, which will be sensed by using an

ultrasonic sensor.

• Sensors are used to monitor the desired information related to the garbage for

different selected locations. This will help to manage the garbage collection

efficiently.

• Two sensors are used to indicate the different levels of the amount of the garbage

collected in the dustbin which is placed in a public area.

E. Cloud-based vs. blockchain-based IoT: a comparative survey and waIn this journal, they gave a taxonomy of the existing IoT infrastructure's obstacles, as well as a literature assessment with a taxonomy of the issues to expect in the future of the IoT after adopting blockchain as an infrastructure. The strengths and shortcomings of the two architectures are contrasted. Following that, a quick overview of ongoing key research endeavours in blockchain is presented, which will have a significant impact on solving the obstacles associated with blockchain's application in IoT. Finally, they presented a high-level hybrid IoT method that leverages the cloud, edge/fog, and blockchain together to avoid the constraints of each infrastructure, taking into account the challenges and issues in both infrastructures as well as recent research activities. Hybrid IoT overcomes the flaws in both infrastructures while also meeting the needs of the future IoT. For different types of applications, Hybrid IoT uses three communication configurations. Configuration 1 is a blockchain-based local area network that operates in conjunction with edge nodes and might be used in smart homes. Configuration 2 is a fog nodebased blockchain-based metropolitan area network that can be utilised to support a smart city environment. Configuration 3 can operate across the envisioned ecosystem's numerous tiers. y forward:

F. A survey on the adoption of blockchain in IoT: challenges and solutions :

In this journal recent breakthroughs in blockchain for IoT, blockchain for Cloud IoT, and blockchain for Fog IoT in the context of eHealth, smart cities, intelligent transportation, and other applications are examined. Obstacles are also discussed, as well as research gaps and potential solutions. Despite this, a number of technological and security challenges in the IoT remain unsolved. Several obstacles to implementing blockchain technology in the IoT area are identified, and solutions are offered. Existing blockchain and IoT articles are examined for a variety of characteristics in order to demonstrate their strengths and weaknesses. The overview also contains a general description of blockchain components as well as various common

G.LSB: A Lightweight Scalable Blockchain for IoT security and anonymity :

They proposed a Lightweight Scalable Blockchain (LSB) that is optimised for IoT needs while also providing end-to-end security in this paper. Decentralization is achieved by building an overlay network where high-resource devices collaborate to control the blockchain. The overlay is arranged as discrete clusters to reduce overheads and the cluster chiefs are responsible for monitoring the public blockchain. They propose a Distributed Time-based Consensus (DTC) algorithm to reduce mining processing overhead and delay. Cluster heads use a distributed trust strategy to gradually minimise the processing overhead for verifying new blocks. The Distributed Throughput Management (DTM) algorithm in LSB ensures that the blockchain throughput does not deviate significantly from the network's total transaction load. Qualitative arguments show that their technique is resistant to a variety of security threats. When compared to relevant baselines, extensive simulations show that packet overhead and delay are reduced, and blockchain scalability is boosted.

H.Blockchain for IoT-based smart cities:

Recent advances, requirements, and future challenges In this journal they examined the function of blockchain in enabling IoT-based smart cities in depth. First, they discussed how blockchain technology has evolved in terms of constituent technologies, consensus algorithms, and blockchain platforms. Second, they examined and analysed a variety of blockchain-enabled smart applications. Third, they presented real-world blockchain implementation in smart cities as case studies. Fourth, they discussed the most important needs for integrating blockchain with smart cities. Finally, they discussed open research difficulties, their root causes, and potential remedies.

I. IOT Based Smart Garbage Monitoring System Using ESP8266 with GPS Link Real-time monitoring and alerts are included in their suggested system, which is an IoT-based smart waste monitoring system with a GPS link. Previously designed systems were inefficient in terms of cost. They are large in size due to the use of Raspberry-Pi modules, GSM modules, GPS antennas, and other components. They have removed all of the hardware pieces from their purpose system in order to reduce the size of the circuitry, which will lower the system's cost. In addition, they use a solar panel for power generation, with a battery backup for cloudy days. Over the previous solutions, it will provide a more efficient solution to the waste management problem. This will reduce the health related issues and put the best example for a real time garbage management system.

J. A Study on Privacy Issues in Internet of Things (IoT):

As iot is an interconnected wireless network where smart nodes (IoT devices) interact with each other in order to exchange data through the communicating medium. loT has rapidly increased in popularity, demand, and commercial availability within the past several years. Various IoT applications generate a huge amount of data from different types of resources, including smart cities, manufacturing industries, health institutions, and governments. Due to the pervasive nature of IoT and the limitless opportunities that this technology provides, security and privacy become two key concerns for the users of these smart offerings. Most of the privacy threats disclose the private information to unwanted parties and give rise to serious implications in various IoT applications. Thus, this paper will analyze existing literature related to various privacy threats in IoT, privacy issues in different applications of IoT and present summary of the study.

K) A survey on the adoption of blockchain in IoT: challenges and solutions:

Data from sensors is streamed through Fog devices to a centralised Cloud server in traditional Internet of Things (IoT) ecosystems. Privacy concerns arise as a result of third-party Cloud server administration, single points of failure, a bottleneck in data flows, and difficulty in frequently updating firmware for millions of smart devices from a security and maintenance standpoint. Blockchain technology eliminates the need for trusted third parties while also preventing single points of failure and other problems. This has prompted experts to look into the use of blockchain in the IoT environment. Recent breakthroughs in blockchain for IoT, blockchain for Cloud IoT, and blockchain for Fog IoT in the context of eHealth, smart cities, intelligent transportation, and other applications are examined in this article. Obstacles and knowledge gaps and potential solutions are also presented.

L)Study of integration of block chain and Internet of Things (IoT): an opportunity, challenges, and applications as medical sector and healthcare

Internet of Things (IoT) is a crucial component of the fastest-growing communication technologies, both in terms of maturity and infancy. Large data transmission using wireless communication has rapidly developed (grown). As a result, it is necessary to manage the system and fully meet the market demand for practical use. Many contemporary IoT architectures are highly centralised and have numerous technical restrictions. Cyber assaults are an example of these limits. As a result, new strategies for improving data access while protecting security and privacy must be developed. The solution to this problem is to combine the Internet of Things with block chain, which ensures the integrity of sensing data. The combination of IoT with block chain produced an immutable, comprehensive, and secure log easy access. Here, this paper carried out the study of integration of IoT and block chain in relation with different issues, opportunities and application area

M)Blockchain for IoT Applications: Taxonomy, Platforms, Recent Advances, Challenges and Future Research Directions

The Internet of Things (IoT) has quickly grown in popularity as a computing technology paradigm. Through a range of uses, it is increasingly being used to aid human life processes.Smart healthcare, smart grids, smart finance, and smart cities are just a few examples. Interoperability, scalability IoT applications must deal with challenges such as security, privacy, and trustworthiness. Blockchain Recently, solutions have been developed to assist in the resolution of these issues. The goal of this study is to to conduct a survey and lesson on blockchain's application in IoT systems The significance of blockchain technology.The technology is explored in terms of capabilities and benefits for constituents of IoT applications. We based on the most important aspects, present a blockchain taxonomy for IoT applications Furthermore, We look at the most extensively utilised blockchain technology.

N)Bubbles of Trust: A decentralized blockchain-based authentication system for IoT

There is no doubt that Internet of Things (IoT) occupy a very important role in our daily lives. Indeed, numerous objects that we use every time, are being equipped with electronic devices and protocol suites in order to make them interconnected and connected to the Internet. In IoT, things process and exchange data without human intervention. Therefore, because of this full autonomy, these entities need to recognize and auth.enticate each other as well as to ensure the integrity of their exchanged data. Otherwise, they will be the target of malicious users and malicious use. Due to the size and other features of IoT, it is almost impossible to create an efficient centralized authentication system. To remedy this limit, in this paper, we propose an original decentralized system called *bubbles of trust*, which ensures a robust identification and authentication of devices. Furthermore, it protects the data integrity and availability. To achieve such a goal, our approach relies on the security advantages provided by blockchains, and serves to create secure virtual zones (*bubbles*) where things can identify and trust each other. We also provided a real implementation of our mechanism using the *C++* language and *Ethereum* blockchain. The obtained results prove its ability to satisfy IoT security requirements, its efficiency, and its low cost..

O) A SMART WASTE MANAGEMENT SYSTEM USING IOT AND BLOCKCHAIN TECHNOLOGY

Blockchain technology and Internet of Things are two of the most popular technologies today. IoT is an interconnection of devices that has the capability to sense, measure, process the state of environmental indicators as well as themselves and actuate based on the input provided. It can help create smart solutions that can enhance the quality of life of people. Likewise, blockchain is distributed database systems that promise high level of security and availability of data with least transaction overhead. In this thesis, we attempt to bring together these two technologies to develop a Smart Waste Management System (SWMS). The SWMS is weight-based i.e., users have to pay for use of services as per the amount of waste they produce. Payments are made using a custom cryptocurrency regulated by Smart Contracts and the entire SWMS can be funded by a DAO through a totally automate, highly secure process. Blockchain can help lower the penetration and service cost which can be especially beneficial to developing countries where governments are not very resourceful. This thesis attempts to establish a proof of concept through measurement of performance and assessment of applicability of such a system.

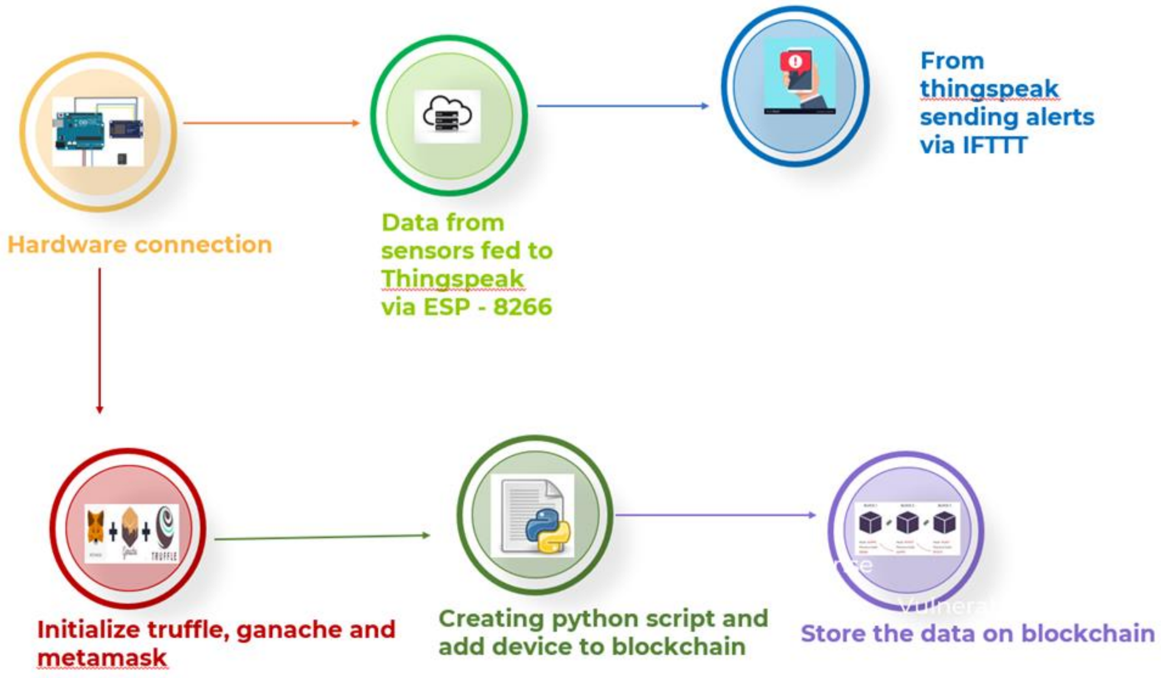
Gaps of the existing system, based on the gaps you have proposed a new or a modified technique:

The existing system is not secure, as it is very vulnerable attacks. Our proposed system used blockchain technology to ensure security. All the informatio about the garbage level, location of the garbage is sent to Thinkspeak server. A python code is run which stores all the information from the cloud securely in blockchain.

Methodology:

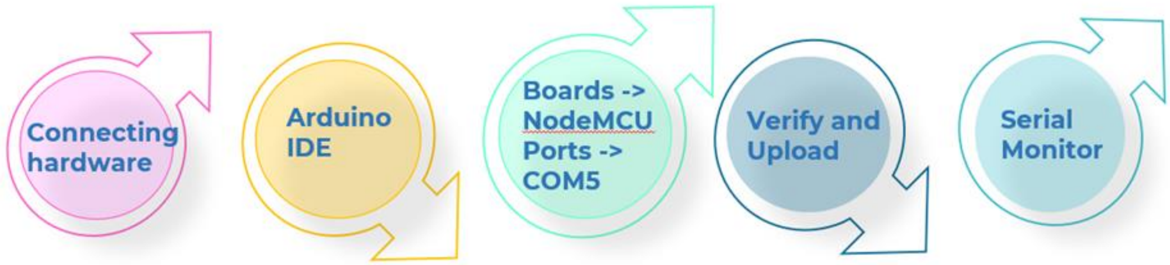
This project focuses on the creation of a smart garbage monitoring system that can measure waste levels in garbage bins in real time and send SMS notifications to the municipality in specific instances. This project includes an Ultrasonic sensor to measure the level of the bin, a GPS module to get the bin's location, a GSM module to send a message to the appropriate authorities, and a Node mcu to control the entire operation. When the waste bin is full or about full, it is expected to create and send SMS warning messages to the municipality so that the garbage may be collected immediately. This can assist the responsible authorities in cleaning and maintaining the environment. We also employ blockchain technology to increase the privacy and security of IoT data by storing data acquired from sensors in tamper-proof blocks. The use of blockchain technology for privacy and security aids in the creation of a decentralised structure, as well as lower costs, visibility, and traceability. Hardware connection, data storage on thingspeak and sending alerts through IFTTT, initialize truffle, ganache and metamask, creating python script and add device to blockchain , store data on blockchain are the six different modules used.

Architecture:



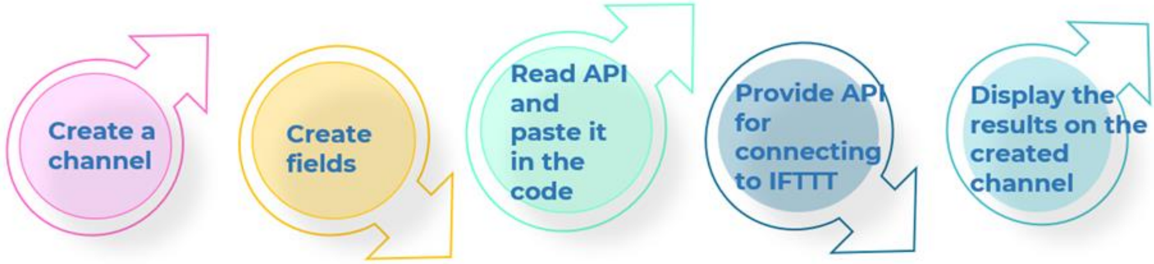
Module 1: Hardware connection

After connecting the Arduino, nodemcu, wifi module, gps module, we have to connect the arduino to laptop through a Microbot USBcable and nodemcu with a USB cable. And we have to install Arduino IDE on the laptop and provide settings with board as NODE MCU and port as connected NODE MCU port(i.e COM5). After finishing the connection we have to verify and upload the code without any errors. And after opening the serial monitor we can see the latitude and longitude printing and Weight of the garbage bin.



Module 2: Data sent to Thingspeak server

To connect thingspeak server and Arduino, first we have to create a channel in thingspeak website and create fields and copy paste the read API in the code. For connecting the IFTTT provide API and results get displayed on the created channel.

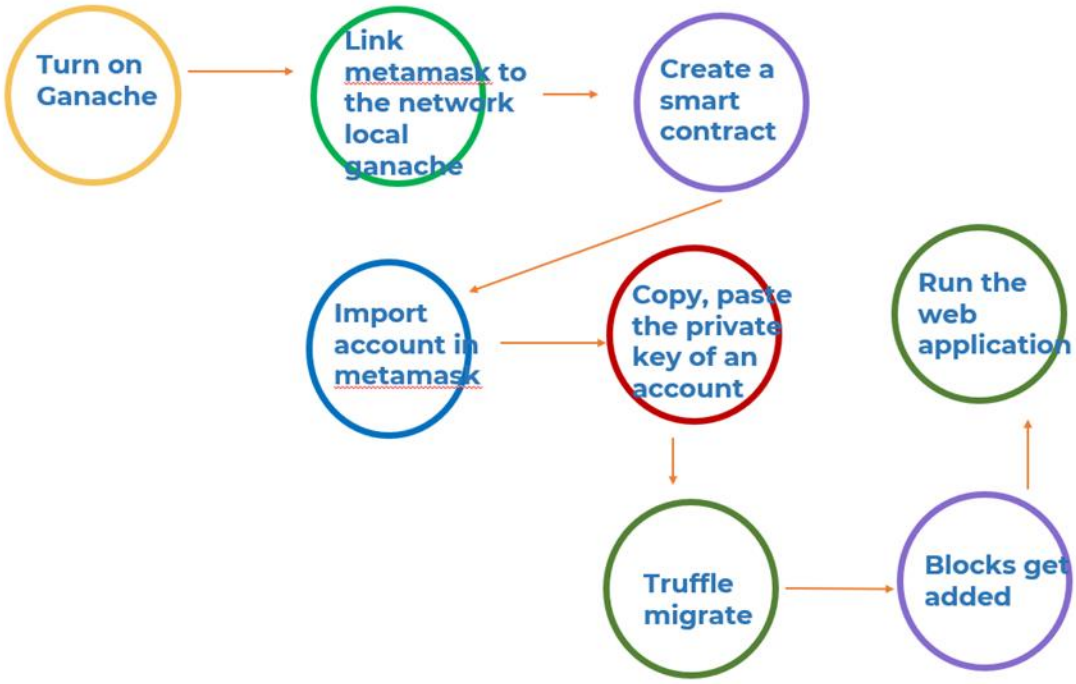


Module 3: From Thingspeak sending alerts via IFTTT

To send alerts to the authorities, create an account on IFTTT and create a webhook by giving a condition if and then and provide email id and phone number to which alerts must be sent.

Module 4: Initialize truffle , ganache and metamask

To connect blockchain to the project. Turn on the ganache and link metamask to the local ganche and import an account from ganache and copy paste the private key in the metamask and truffle migrate to transfer ETH from the account, then we can acknowledge blocks get created in the ganache. And run the web application by giving command “npm run dev”

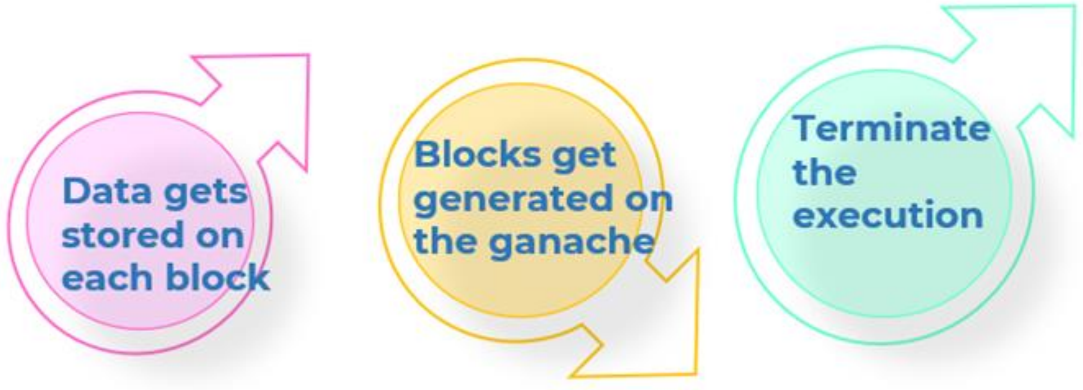


Module 5: Create a python script and add device to blockchain

To store the sensor collected data on blockchain, first we have to connect python script to the Serial monitor port and sensed data gets simultaneously displayed on the terminal and serial monitor. And this data gets stored on the webpage store feed section.

Module 6: Store the data on blockchain

Data gets stored on the created blocks of ganache. Then we can terminate the execution.



Arduino Code:

```
#include <ESP8266WiFi.h>

//#include <NewPing.h>

#include <LiquidCrystal.h>

#include <SoftwareSerial.h>

#include <TinyGPS.h>

float lat = 28.5458,lon = 77.1703;

SoftwareSerial gpsSerial(3,4);

TinyGPS gps;

String apiWritekey = "PXXGISH432AP4DQC"; // replace with your THINGSPEAK WRITEAPI key here

const char* ssid = "Vyshnavi"; // your wifi SSID name

const char* password = "1234567890" ;// wifi pasword


const char* server = "api.thingspeak.com";

const int trigPin = D1;

const int echoPin = D2;

long duration;
```

```
int distance;
int safetyDistance;
WiFiClient client;
 //NewPing sonar(trigPin, echoPin, distance);
void setup() {
  Serial.begin(9600);
  gpsSerial.begin(9600); // connect gps sensor
  WiFi.disconnect();
  delay(10);
  WiFi.begin(ssid, password);

  Serial.println();
  Serial.println();
  Serial.print("Connecting to ");
  Serial.println(ssid);

  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.print("    ESP8266WiFi ( BIJEN ADHIKARI ) connected to wifi...    ");
  Serial.println(ssid);
```

```
  Serial.println();
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
pinMode(echoPin, INPUT); // Sets the echoPin as an Input

}

void loop() {



// Clears the trigPin
digitalWrite(trigPin, LOW);
delayMicroseconds(2);

// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);

// Reads the echoPin, returns the sound wave travel time in microseconds
duration = pulseIn(echoPin, HIGH);

// Calculating the distance
distance= duration*0.034/2;
```

```
if (client.connect(server,80))
{
  String tsData = apiWritekey;
        tsData +="&field1=";
        tsData += String(distance);
        tsData += "\r\n\r\n";

   client.print("POST /update HTTP/1.1\n");
   client.print("Host: api.thingspeak.com\n");
   client.print("Connection: close\n");
   client.print("X-THINGSPEAKAPIKEY: "+apiWritekey+"\n");
   client.print("Content-Type: application/x-www-form-urlencoded\n");
   client.print("Content-Length: ");
   client.print(tsData.length());
   client.print("\n\n");  // the 2 carriage returns indicate closing of Header fields & starting of data
   client.print(tsData);

   Serial.print("    Amount of Garbage wastage in dustbin : ");
   Serial.print(distance);
```

```
//Serial.print(",");

//Serial.print(distance);

Serial.println("   uploaded to Thingspeak server....");

 while(gpsSerial.available()){ // check for gps data

if(gps.encode(gpsSerial.read()))// encode gps data

{

gps.f_get_position(&lat,&lon);

Serial.print("Position: ");

Serial.print("Latitude:");

Serial.print(lat,6);

Serial.print(";");

Serial.print("Longitude:");

Serial.println(lon,6);

Serial.print(lat);

Serial.print(" ");


}

client.stop();


Serial.println("   Waiting to upload next reading...");

Serial.println();
```

// thingspeak needs minimum 15 sec delay between updates .... NOw lets upload the program to wifi module....

// IN this connection i have used arduino board to give 5V to ultrasonic sensor. and echo and trigger pin from ultrasonic sensor are connected to the wifi module .and ultrasonic sensor and wifi module are

```
  // grounded repectively, COM5 is for wifi module...
  delay(15);


}
  }
  String latitude = String(lat,6);
  String longitude = String(lon,6);
Serial.println(latitude+";"+longitude);
delay(1000);
}
```

Experimental Results:

Snapshots -

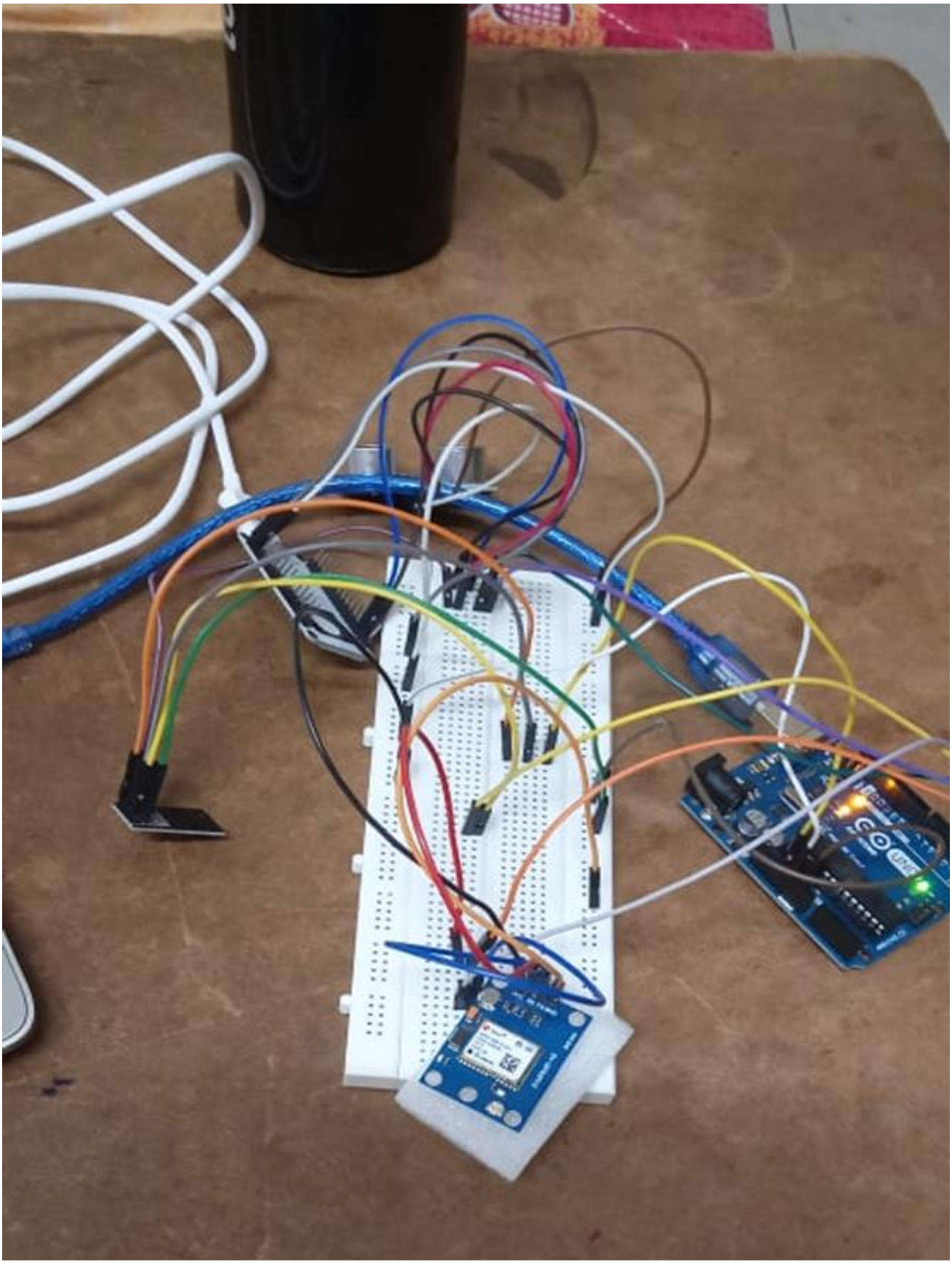


Fig 1: Arduino Hardware Connections

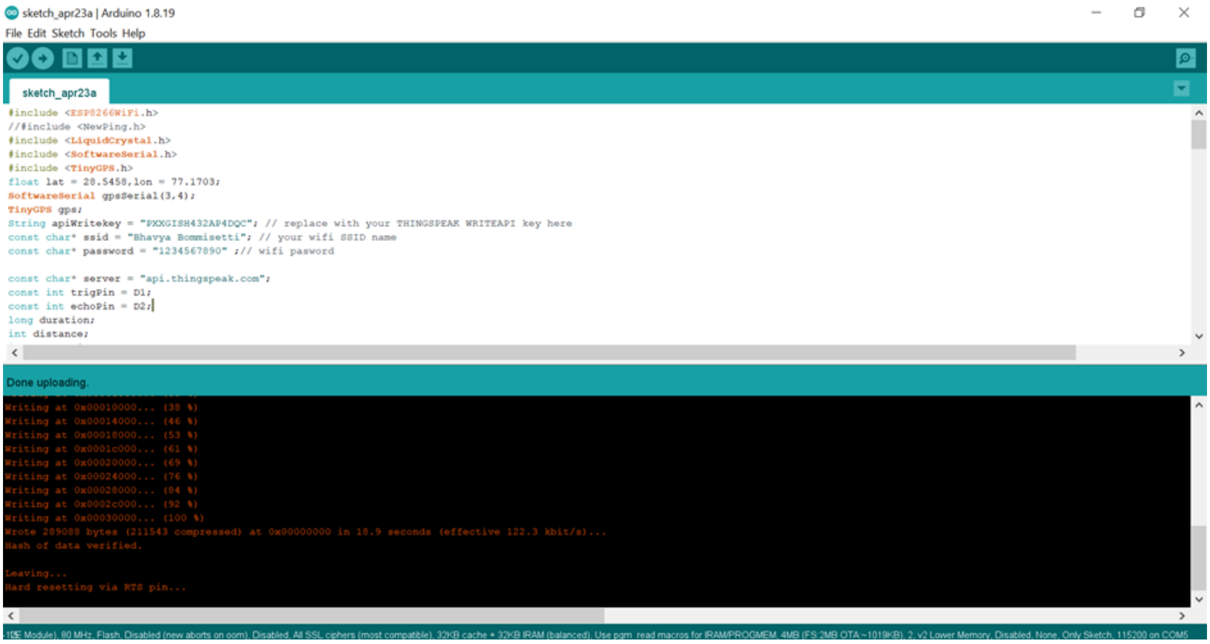


Fig 2: Arduino Code verified

Fig 3: Sensed data displayed on serial monitor

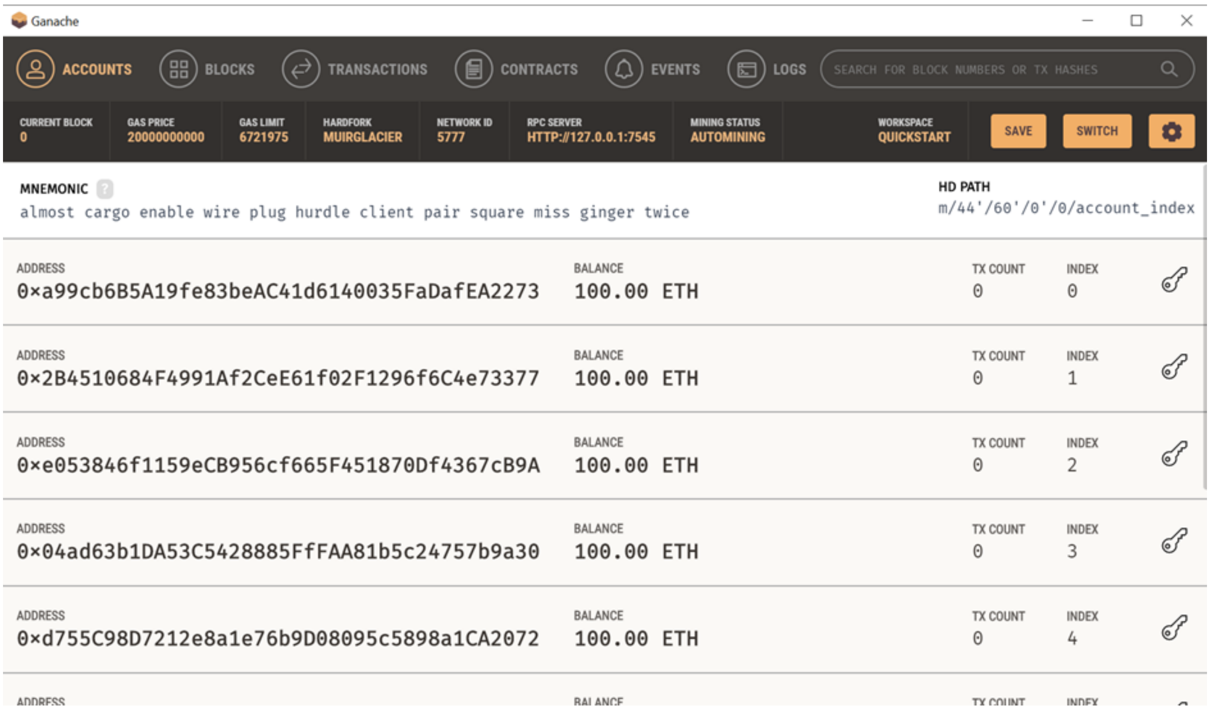


Fig 4: Turn on ganache

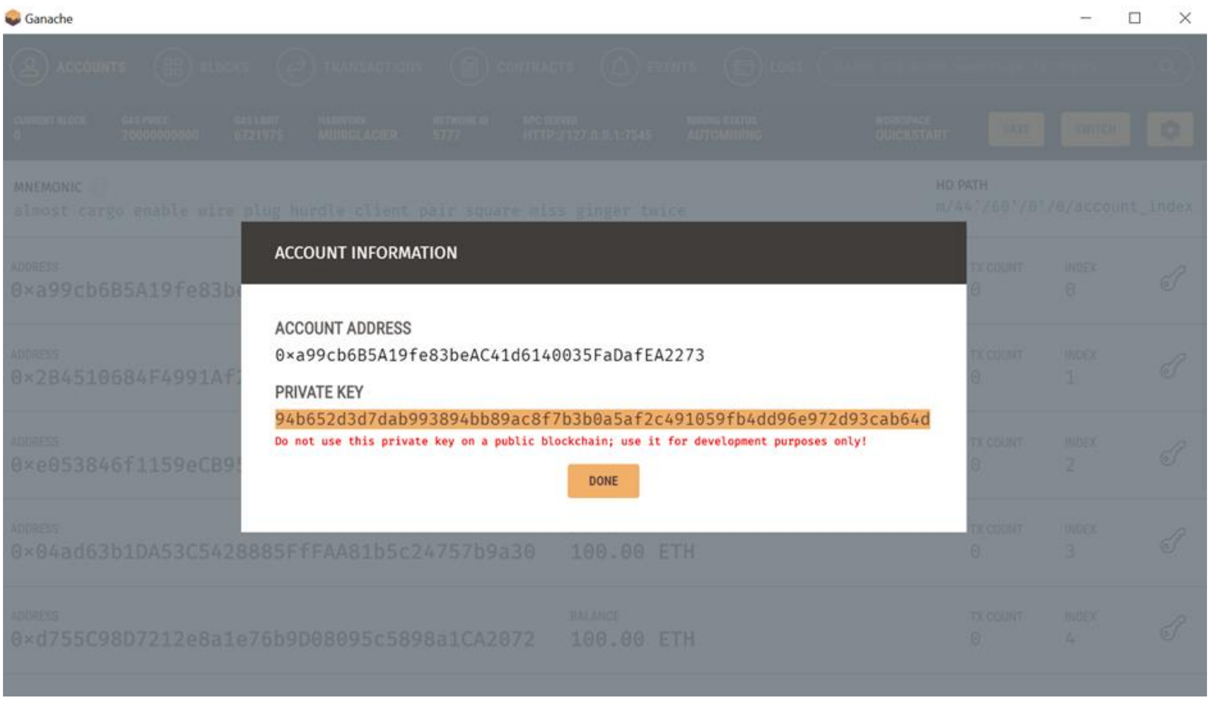


Fig 5: Copy the private key

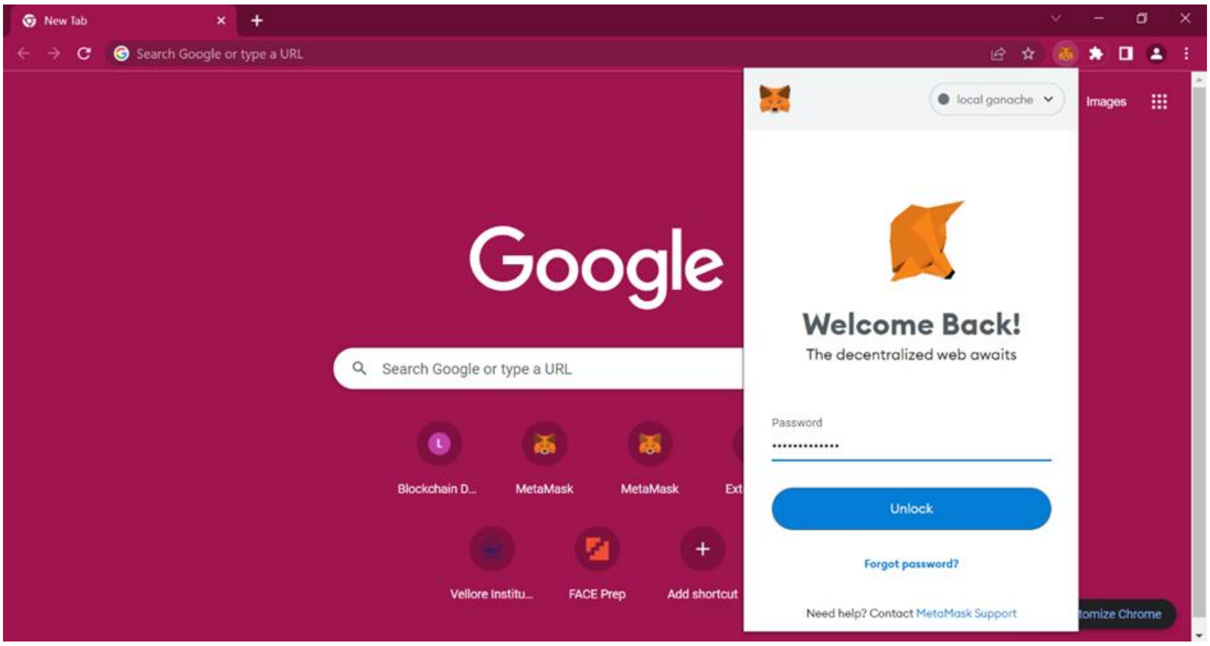


Fig 6: Turn on Metamask

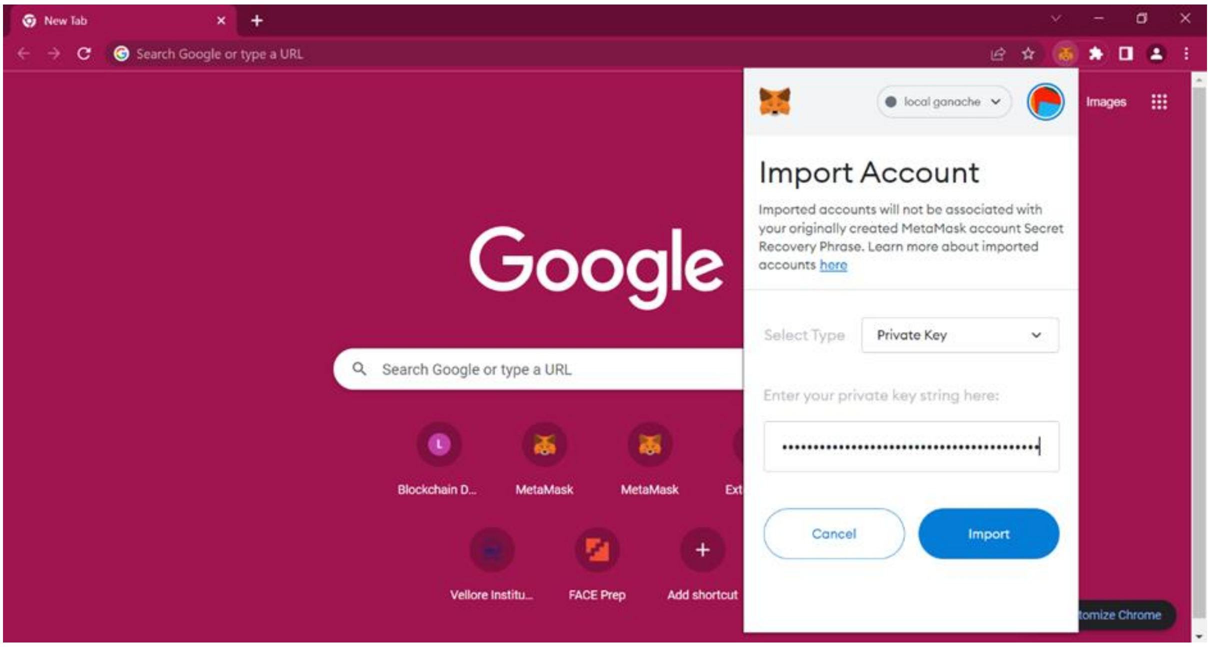


Fig 7: paste the private key in the metamask

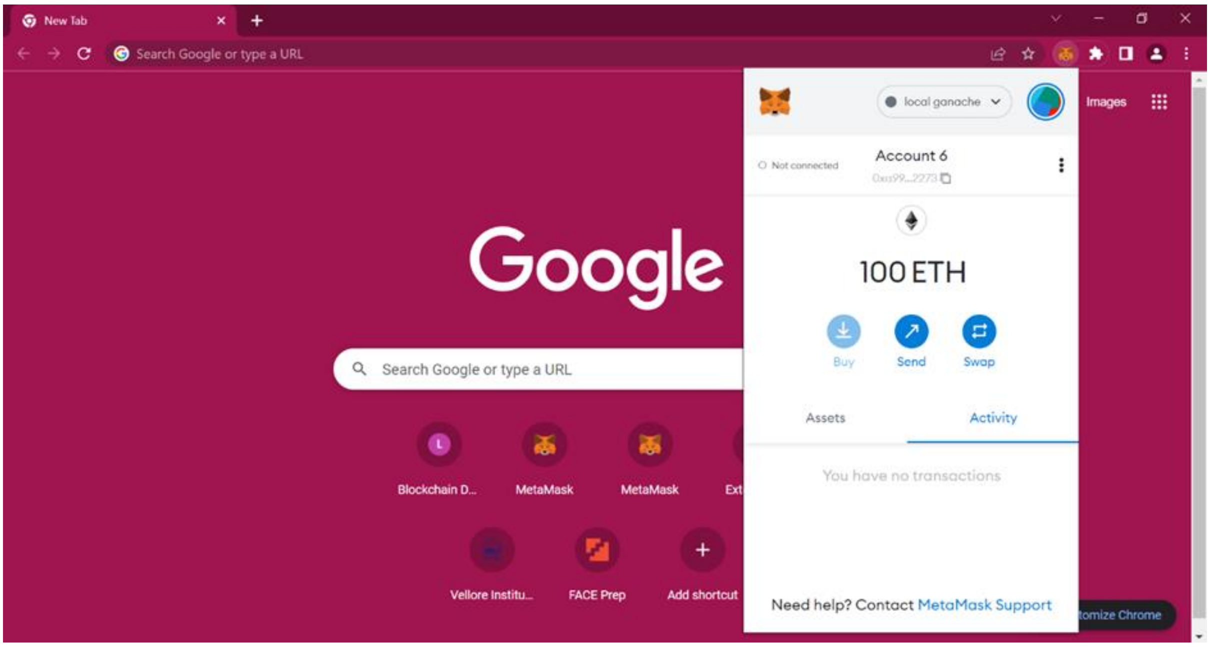


Fig 8: Account created

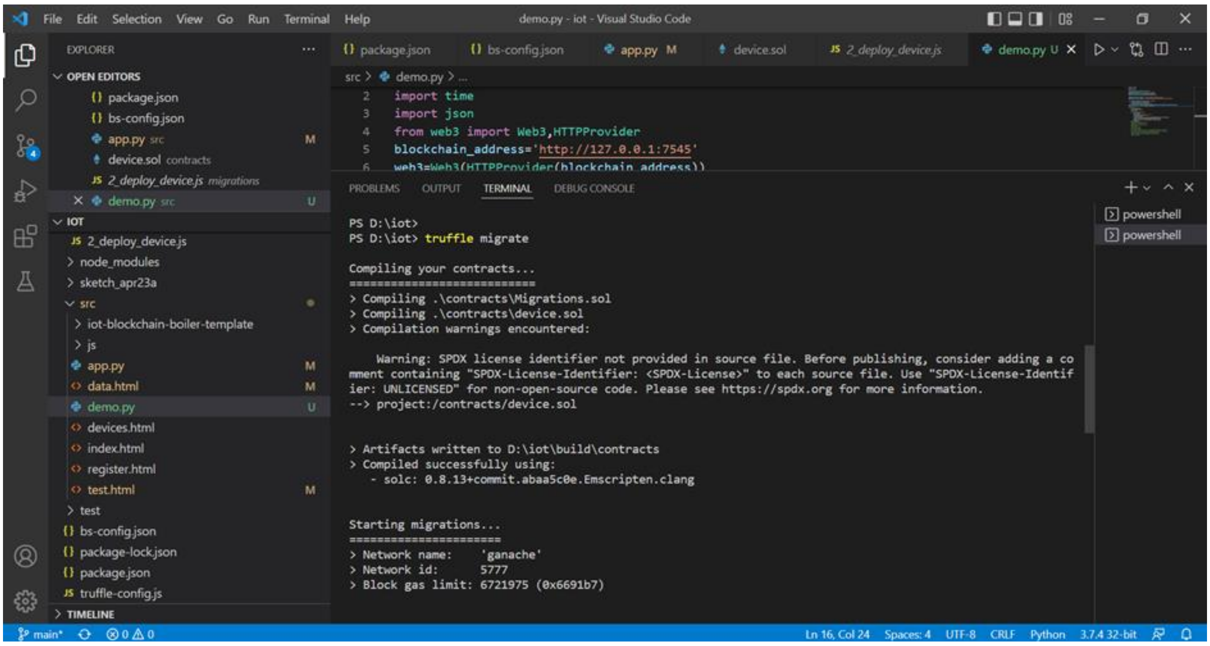


Fig 9: truffle migrate

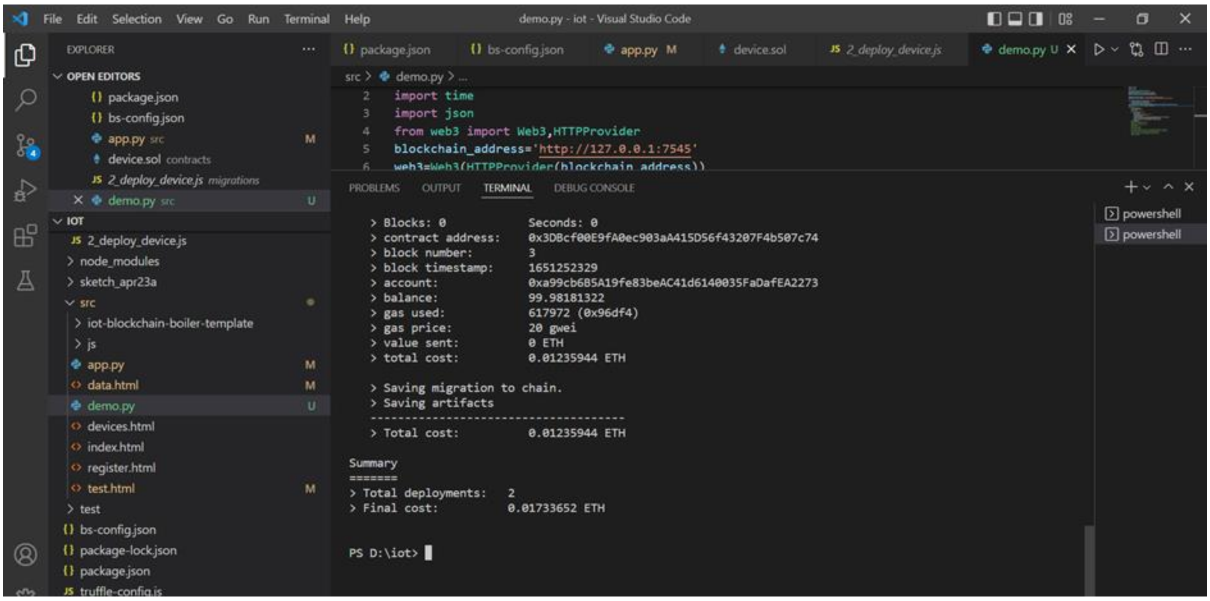


Fig 10: Blocks get created

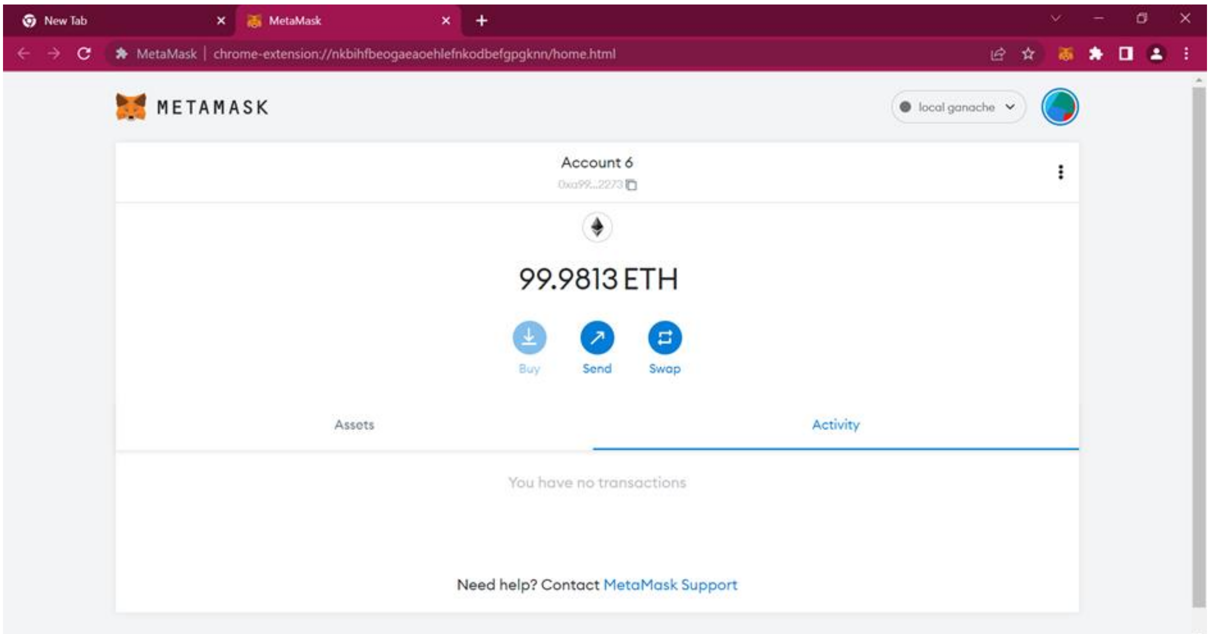


Fig 11:Ethereum present in the account

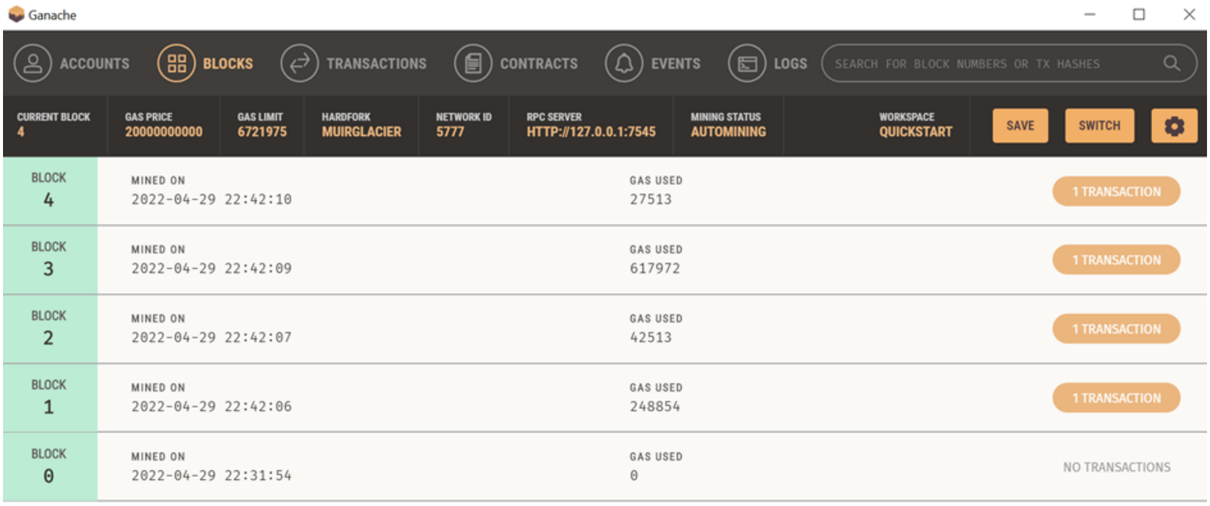


Fig 12:Blocks creation

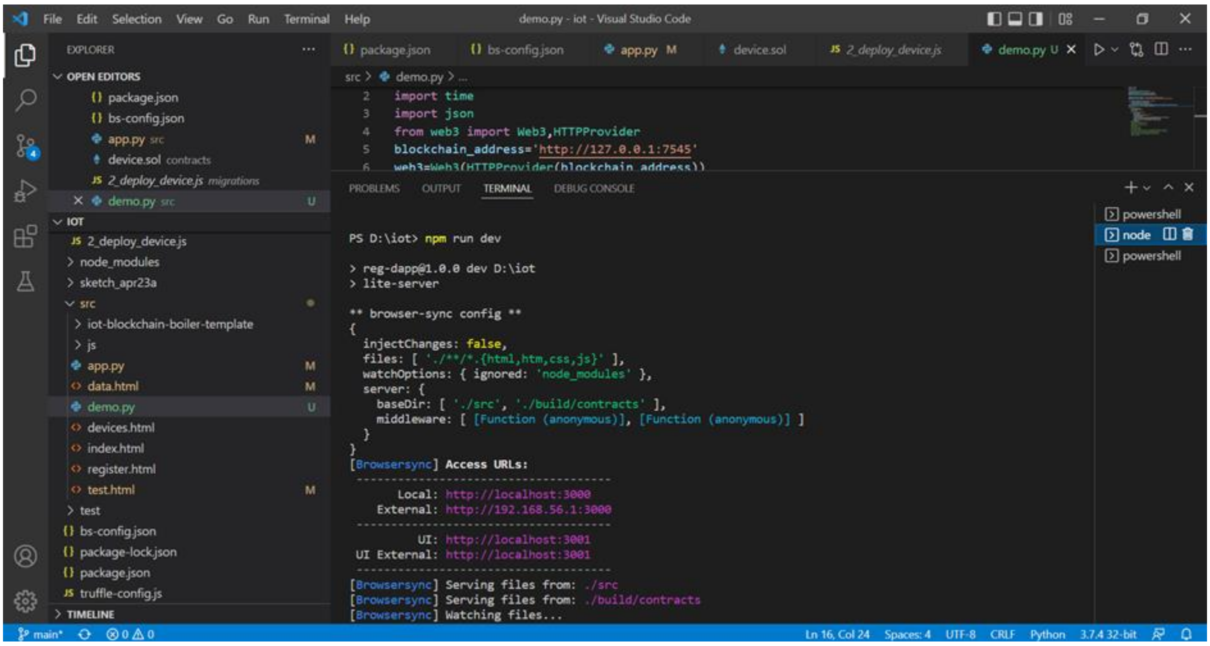
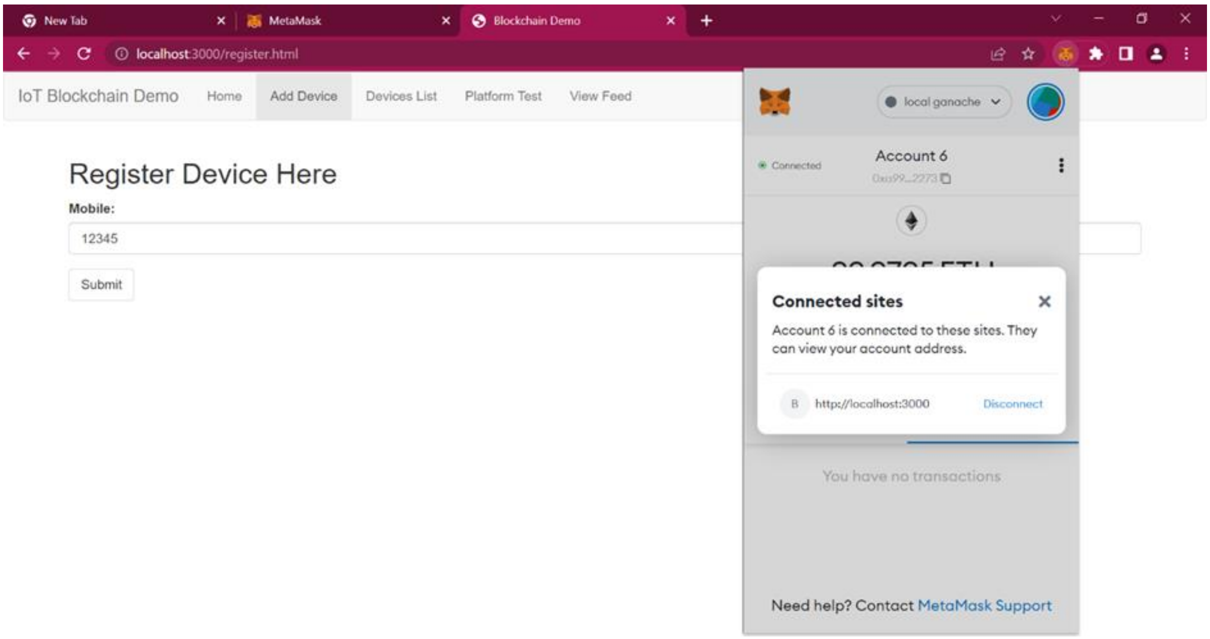


Fig 13:Run the web application



'Fig 14: Connect the account to the website running

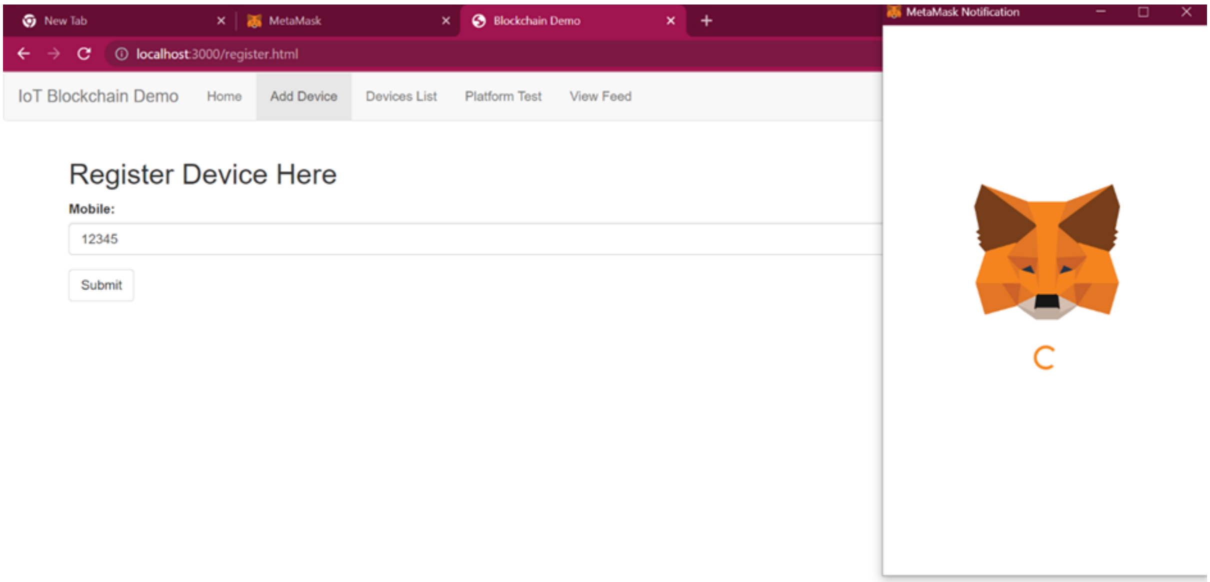


Fig 15: Register with a phone number

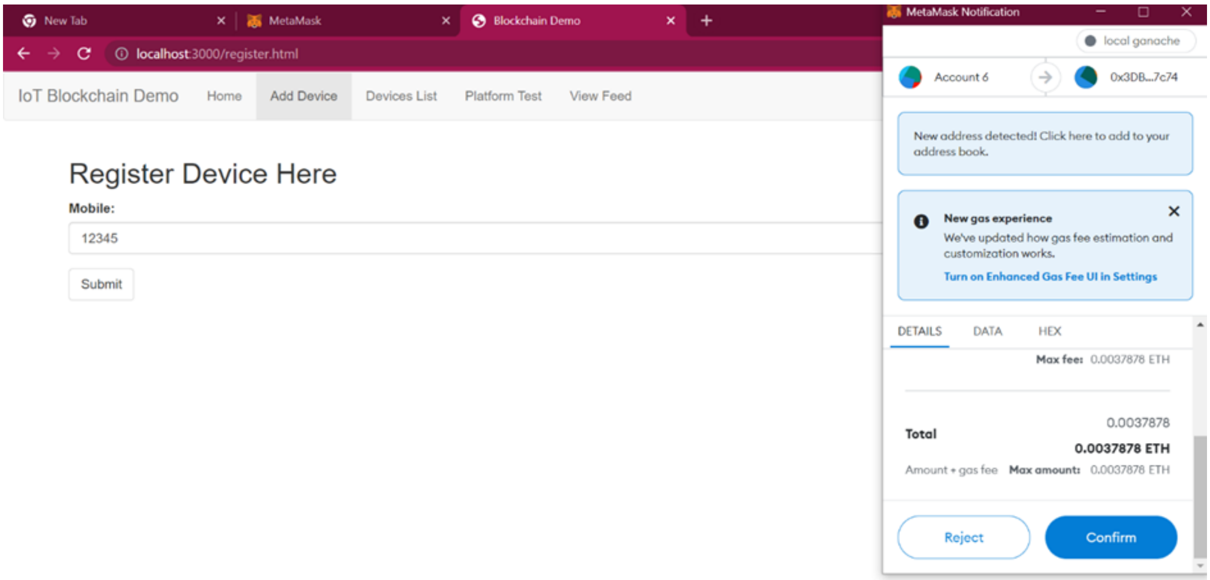


Fig 16: Metamask asks for a confirmation

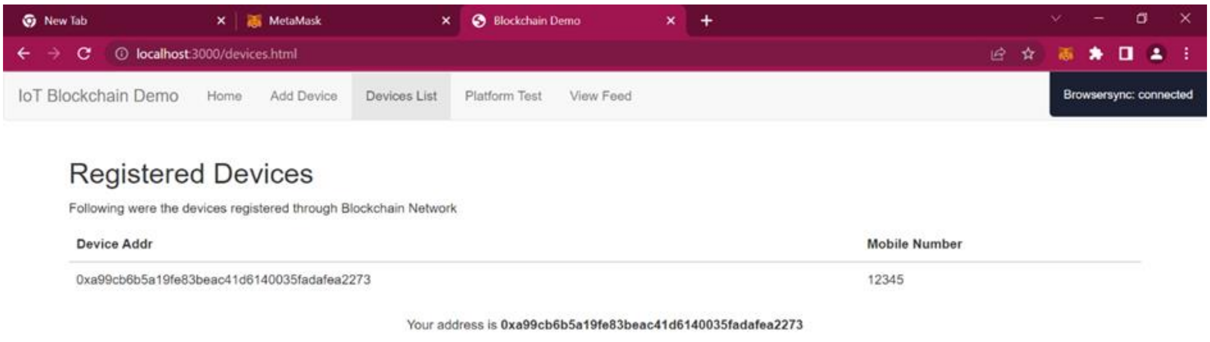


Fig 17: Device gets added

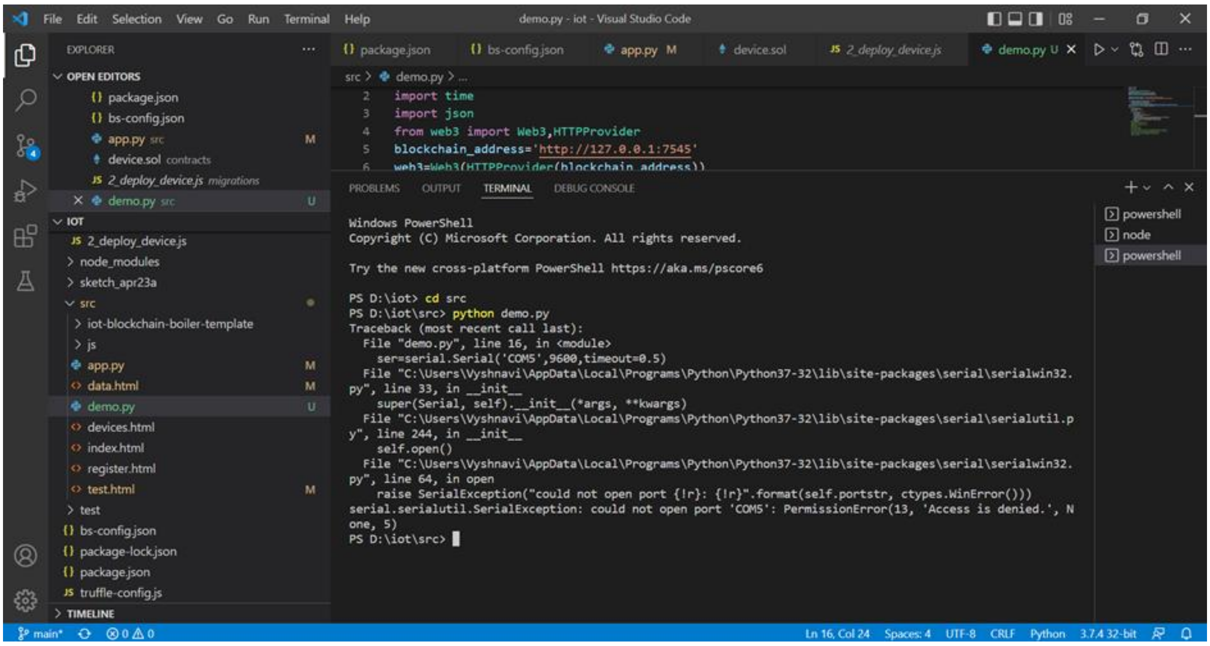


Fig 18: Run the python code

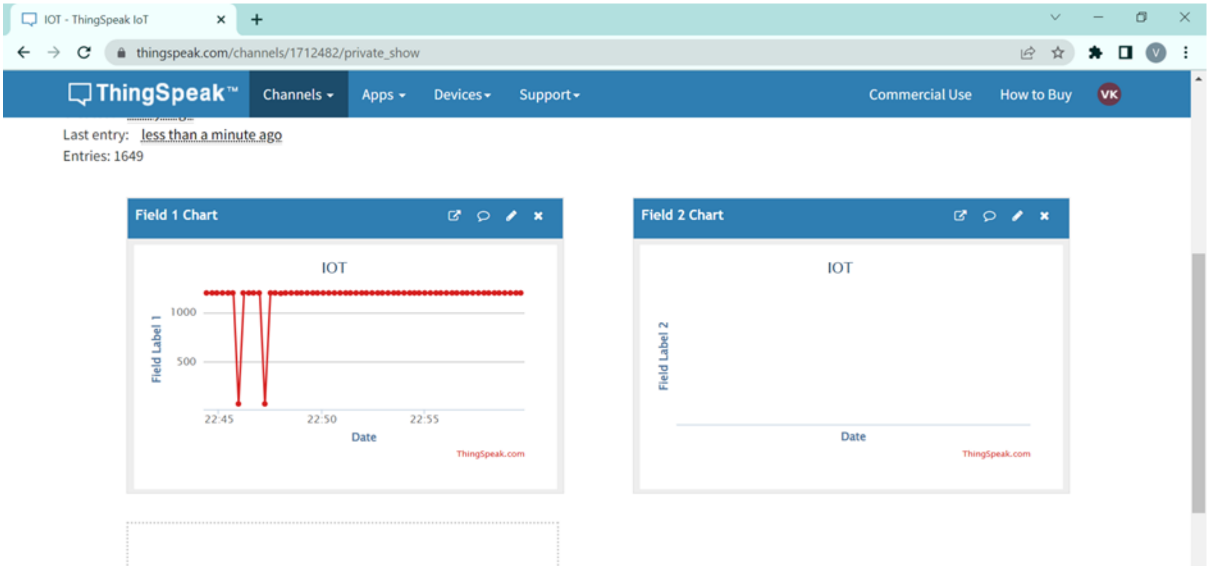


Fig 19: Sensed data gets stored in the field chart

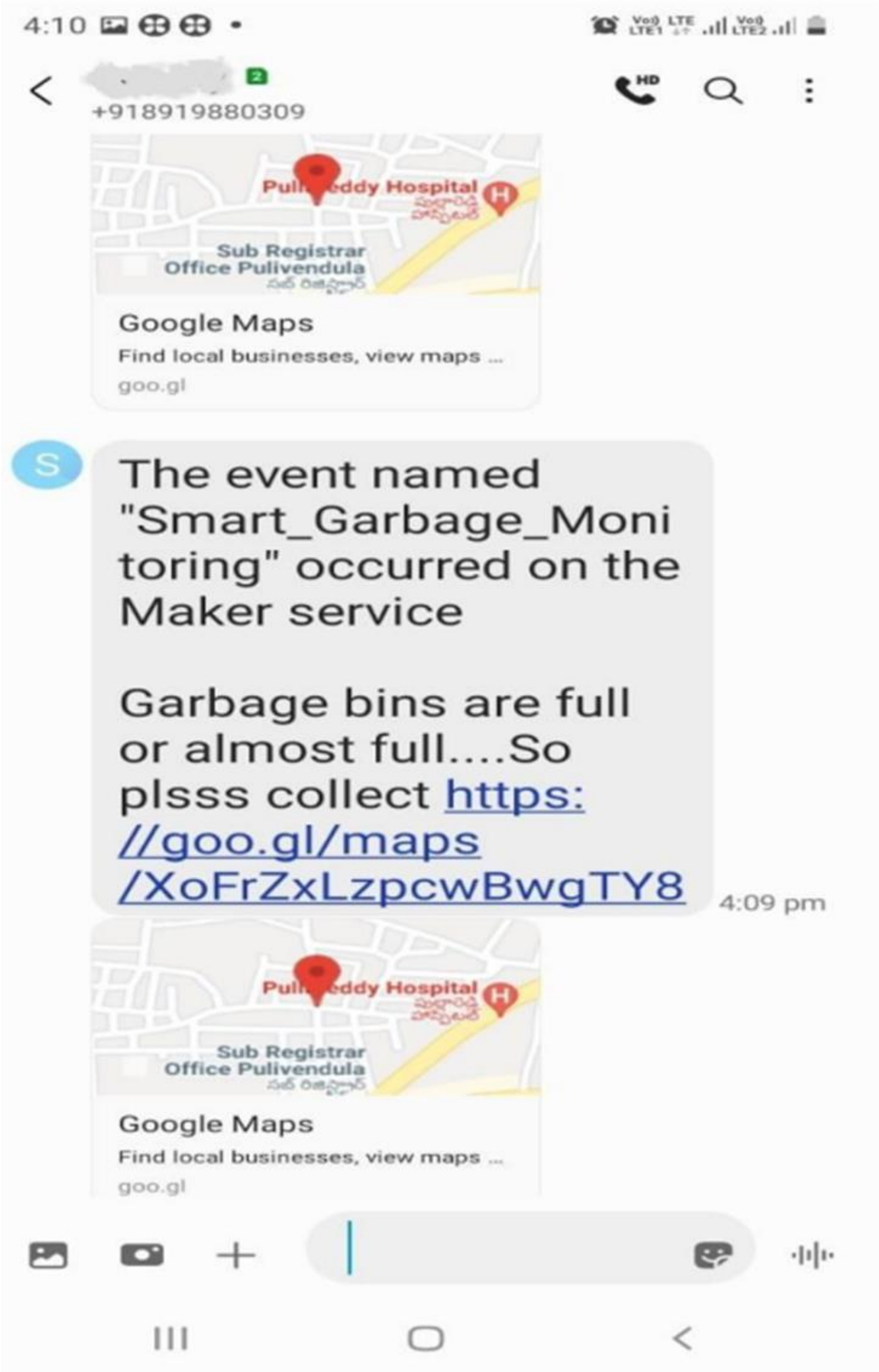


Fig 20: SMS sent to registered mobile number

Explanation and Interpretation of Results -

Basically we provided the security to the data collected through the sensor, through blockchain by initialising the ganache, truffle. And analysing the data on thingspeak and sending alerts to the authorities if the garbage bin is full.

Performance Evaluation:

In this research, we provided evidence of the concept, we used blockchain to design a smart contract-based system to regulate the flow of solid waste. The principle of design behind the solution is to provide free access to waste management information. The aim is to remove existing barriers and mitigate environmental threats by carefully and transparently
monitoring the waste supply chain, considering it to be a valuable resource, enabling transparency and access to relevant information in real time, and supporting the implementation of the circular economy concept.

The proposed system also ensures that liability is charged and the parties are punished when the terms specified in the Smart Contract are met. The system model was also developed using Solidity, Ganache and Truffle. This framework can be useful in the proper implementation of waste management laws. The waste management system based on keychain can be expanded and integrated with data science technology to complement the concept of artificial intelligence.

Furthermore, if the waste management system is properly backed by technology, factual data regarding the waste and consumption behaviour can be obtained that can be used in planning investments and allocating resources for improvement of existing problems. . In developed countries, most of the existing waste management systems include multiple third party waste collectors that transport the waste disposed in waste bins to a recycle plant or landfill sites. The major cost in waste management system in developed countries is spent in disposing of waste. In case of developing countries, this is the opposite. Most of the budget for waste management is spent on collection of waste and only a small fraction is spent on disposal.

Conclusion –

Smart Garbage Monitoring System focuses on how we can measure the waste levels in garbage bins in real time and send SMS notifications to the municipality in specific instances. This project includes an Ultrasonic sensor to measure the level of the bin, a GPS module to get the bin's location, a GSM module to send a message to the appropriate authorities, and a Node mcu to control the entire operation. When the waste bin is full or about full, it is expected to create and send SMS warning messages to the municipality so that the garbage may be collected immediately. This can assist the responsible authorities in cleaning and maintaining the environment. We also employ blockchain technology to increase the privacy and security of IoT data by storing data acquired from sensors in tamper-proof blocks. The use of blockchain technology for privacy and security aids in the creation of a decentralised structure, as well as lower costs, visibility, and traceability. This methodology promotes dynamic scheduling and routing of the garbage collection. By comparing to the conventional static scheduling and routing, this dynamic scheduling and routing are said to allow operational cost reduction, by reducing the number of trucks, the manual labour cost and the transport mileage savings. Further limitations could be storage capacity on storing a large amount of data on thingspeak and on blocks.

References:

[1] Prof. Dr. Sandeep M. Chaware, Shriram Dighe , Akshay Joshi, Namrata Bajare , Rohini Korke,"Smart Garbage Monitoring System using Internet of Things (IOT) ",Vol. 5, Issue 1, January 2017,International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering.

[2] Chakole, Sonal, et al. "Real time smart city garbage collection and monitoring system using GSM and GPS." International Research Journal Engineering and Technology 4.3 (2017): 1226- 1229.

[3] K.S. Mamatha, Dr.S.A.K. Jilani,"Smart Real Time Garbage Management System",INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 9, ISSUE 03, MARCH 2020

[4] Putra, Riyan Hadi, et al. "IoT: smart garbage monitoring using android and real time database." Telkomnika 17.3 (2019): 1483-1491.

[5] Memon, R.A., Li, J.P., Ahmed, J. et al. Cloud-based vs. blockchain-based IoT: a comparative survey and way forward. Front Inform Technol Electron Eng 21, 563–586 (2020). https://doi.org/10.1631/FITEE.1800343

[6] Md Ashraf Uddin, Andrew Stranieri, Iqbal Gondal, Venki Balasubramanian, A survey on the adoption of blockchain in IoT: challenges and solutions,Blockchain: Research and Applications, Volume 2, Issue 2,2021,100006,ISSN 2096-7209, https://doi.org/10.1016/j.bcra.2021.100006. (https://www.sciencedirect.com/science/article/pii/S2096720921000014)

[7] Ali Dorri, Salil S. Kanhere, Raja Jurdak, Praveen Gauravaram, LSB: A Lightweight Scalable Blockchain for IoT security and anonymity, Journal of Parallel and Distributed Computing, Volume 134,2019,Pages 180-197,ISSN 0743-7315, https://doi.org/10.1016/j.jpdc.2019.08.005. (https://www.sciencedirect.com/science/article/pii/S0743731518307688)

[8] Umer Majeed, Latif U. Khan, Ibrar Yaqoob, S.M. Ahsan Kazmi, Khaled Salah, Choong Seon Hong, Blockchain for IoT-based smart cities: Recent advances, requirements, and future challenges, Journal of Network and Computer Applications, Volume 181,2021, 103007, ISSN1084-8045,https://doi.org/10.1016/j.jnca.2021.103007.(https://www.sciencedirect.com/science/article/pii/S1084804521000345)

[9] Tarone, Anjali V., et al. "IOT based smart garbage monitoring system using ESP8266 with GPS link." Int. Res. J. Eng. Technol 5 (2018): 5-6.

[10]Naqliyah Zainuddin; Maslina Daud; Sabariah Ahmad; Mayasarah Maslizan; Syafiqa Anneisa Leng Abdullah. "A study of privacy issues in internet of things" 8-10jan 2021 ,DOI: 10.1109/CSP51677.2021.9357592.

[11] https://www.sciencedirect.com/science/article/pii/S0167404818300890

[12]https://lutpub.lut.fi/bitstream/handle/10024/143751/PERCCOM_MASTERS_THESIS_ManishLamichhane_20170720_final.pdf?sequence=2

[13] Patrick llyod" Introduction to the MQTT Protocol on NodeMCU",All about circuits[2015]

[14] Shachar Siboni, Vinay Sachidananda, Yair Meidan, Michael Bohadana, Yael Mathov, Suhas Bhairav, Asaf Shabtai, Yuval Elovici " Security Testbed for Internet-of-Things Devices"

[15]Abdelzahir Abdelmaboud 1,* , Abdelmuttlib Ibrahim Abdalla Ahmed 2 , Mohammed Abaker 3 , Taiseer Abdalla Elfadil Eisa 4 , Hashim Albasheer 5,6 , Sara Abdelwahab Ghorashi 7 and Faten Khalid Karim,"Blockchain for IoT Applications: Taxonomy, Platforms, Recent Advances, Challenges and Future Research Directions ",electronics

[16]Ahmed Ali Talib Al-Khazaali,Sefer Kurnaz"Study of integration of block chain and Internet of Things (IoT): an opportunity, challenges, and applications as medical sector and healthcare"springer link[2021]

[17]Md AshrafUddin,AndrewStranieriIqbal,GondalVenkiBalasubramanian"A survey on the adoption of blockchain in IoT: challenges and solutions",https://doi.org/10.1016/j.bcra.2021.100006

[18]Ahmed, E.; Yaqoob, I.; Hashem, I.A.T.; Khan, I.; Ahmed, A.I.A.; Imran, M.; Vasilakos, A.V. The role of big data analytics in Internet of Things. Comput. Netw. 2017, 129, 459–471.

[19] Kshetri, N. Blockchain's roles in strengthening cybersecurity and protecting privacy. Telecommun. Policy 2017, 41, 1027–1038.

[20] Buterin, V. A next-generation smart contract and decentralized application platform. White Pap. 2014, 3, 1–36

[21]Lu, Y. The blockchain: State-of-the-art and research challenges. J. Ind. Inf. Integr. 2019, 15, 80–90.

[22]Ferrag, M.A.; Derdour, M.; Mukherjee, M.; Derhab, A.; Maglaras, L.; Janicke, H. Blockchain technologies for the internet of things: Research issues and challenges. IEEE Internet Things J. 2018, 6, 2188–2204.

[23]Khan, M.A.; Salah, K. IoT security: Review, blockchain solutions, and open challenges. Future Gener. Comput. Syst. 2018, 82, 395–411

[24]Viriyasitavat, W.; Anuphaptrirong, T.; Hoonsopon, D. When blockchain meets internet of things: Characteristics, challenges, and business opportunities. J. Ind. Inf. Integr. 2019, 15, 21–28.

[25]Lo, S.K.; Liu, Y.; Chia, S.Y.; Xu, X.; Lu, Q.; Zhu, L.; Ning, H. Analysis of blockchain solutions for IoT: A systematic literature review. IEEE Access 2019, 7, 58822–58835