AN IOT FRAMEWORK FOR SOIL BORNE DISEASES DETECTION SYSTEM

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering

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Declaration

We, hereby, declare that the work presented in this thesis is the outcome of the investigation performed by me under the supervision of Dr. Ahmed Wasif Reza, Associate Professor& Chairperson, Department of Computer Science and engineering, East West University. I also declare that no part of this thesis/project has been or is being submitted elsewhere for the award of any degree or diploma. This thesis complies with the regulations of this University and meets the accepted standards with the respect to originality and equality. We hereby release this thesis to the public. We also authorize the university or other individuals to make copies of this thesis as needed for scholarly research.

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Letter of Acceptance

The thesis entitled "AN IOT FRAMEWORK FOR SOIL BORNE DISEASES DETECTION SYSTEM" submitted by Amit Hasan, ID 2013-1-60-069 & Firuz Ahmmed, ID 2013-2-60-008 to the department of Computer Science & Engineering, East West University, Dhaka 1212, Bangladesh is accepted as satisfactory for partial fulfillments for the degree of Bachelor of Science in Computer Science & Engineering in December 2017.

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Abstract

Now a days Internet of things (IOT) is pairing up with our daily life. The Internet of Things helps to peek into the virtual world of digitization where every smart device, every sensor is connected with the internet and therefore can be accessed all over the world. This paper propose a secure IoT framework with multiple sensor nodes that sends data to the web cloud server and allows users to access those data via a mobile application through a unique user id and password or API's. In this paper, we have built an IOT framework for detecting soil borne diseases SBDDS by using pH, temperature and moisture sensor. Soil borne diseases can create serious damage without showing any visible symptoms. Our device can sense the soil condition through the sensors and send data to the web cloud. After that our own build android application can process those various data and based on classification algorithm can generate result whether the soil contain disease or not. Among these factors pH value is the most sensitive and important factor for detecting exact disease. Different type of pH value represent the health of soil and present of bacteria, fungus or nematode. When soil is affected by these then the pH, moisture and temperature also get changed and create damage to the seeds, roots and soil nutrition. So this framework is highly efficient to detect the soil borne disease and prevent the damage.

Acknowledgements

As it is true for everyone, we have also arrived at this point of achieving a goal in our life through various interactions with and help from other people. However, written words are often elusive and harbor diverse interpretations even in one's mother language. Therefore, we would not like to make efforts to find best words to express my thankfulness other than simply listing those people who have contributed to this thesis itself in an essential way. This work was carried out in the Department of Computer Science and Engineering at East West University, Bangladesh.

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We would like to thank "Salah Uddin" for his helpful suggestions in solving tricky technical problems. Last but not the least, We would like to thank our parents for their unending support, encouragement and prayers.

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Firuz Ahmmed
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Amit Hasan
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CHAPTER 1
INTRODUCTION

1.1 Background

IoT has really become a reality on a massive scale. The IoT is no longer just about a handful of high-end Internet-connected appliances. Now, it's common for all types of devices, from TVs to thermostats to cars, to connect to the Internet. The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. A thing, in the Internet of Things, can be a person with a heart monitor implant, a farm animal with a biochip transponder, an auto mobile that has built-in sensors to alert the driver when tire pressure is low -- or any other natural or man-made object that can be assigned an IP address and provided with the ability to transfer data over a network. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS), micro services and the internet. The convergence has helped tear down the silo walls between Operational Technology (OT) and information technology (IT), allowing unstructured machine-generated data to be analyzed for insights that will drive improvements. So we can help the farmer with the help of IoT as modern technology and can show the exact problems for destroying or damaging their crops, seeds, plant roots so that they can proper steps to prevent or cure the disease problem. As android are available in everywhere so they can afford the cost and can be benefited. Besides this framework and android application is built in such way that they can use it easily. So By using this IoT framework Soil Borne Disease can be easily identified.

In this paper [2], author works on Wireless Sensors Network (WSN) are used to build decision support systems (DSS) to overcome many real-world problems. Nowadays, one of the most popular fields that needs DSS is precision agriculture (PA). In general, this paper presents WSN as an alternative and efficient way to solve the farming resources optimization and decision making. Precision agriculture systems based on the internet of things (IOT) technology is explained in detail especially on the hardware and network architecture and software process control of the precision irrigation system. The system collect, analyze and monitors data from the sensors in a feedback loop which activates the control devices based on pre-calculated threshold value.

In this paper [3], author says that Grape cultivation has social and economic importance in India. In India, Maharashtra ranks first in grapes production. Over the last few years the quality of grapes has degraded because of many reasons. One of the important causes is diseases on grapes. To prevent diseases farmers spray huge amount of pesticides, which result in increasing the cost of production. Also farmers are unable to identify the diseases manually. The diseases are identified only after the infection, but its takes up a lot of time and have adverse effects on vineyard. The proposed work is to develop a monitoring system which will identify the chances of grape diseases in its early stages by using Hidden Markov Model provides alerts via SMS to the farmer and the expert. The system includes temperature, relative humidity, moisture, leaf wetness sensor and Zig-Bee for wireless data transmission.

Another paper [4], they represent that Automation has gained the most famous and biggest attention in the industrial world lately. This is because it causes less man involvement, higher accuracy and money and time savings, unlike the conventional methods. Thus, the “Internet of Things” (IoT) concept came to the picture. This research paper reveals an implementing method of IoT concept for a manufacturing line to inspect and control an automatic storing and retrieval system (ASRS) with powerful features. Remote system controlling, Data processing and Record keeping are some of them. The system is synced to an online cloud database and it stores every action done by ASRS. Also the system is capable of categorizing the products into specific order. This is useful for production floors which has more than one product in a production line. Moreover, anyone can view the processes and the history of the system through a user interface. The simple and animated user interfaces are designed for personal computers and for android devices. The simplicity of the concept makes the system speed and it consumes minimum resources. Simply, the automatic product storing and retrieval system can be viewed and controlled from anywhere in the world. A prototype application system is developed to verify the proposed method in this research paper. This paper suggests very flexible cloud based ASRS system.

In this paper [5] India is one of the countries with scarcest water resources in the world; due to poor utilization of the water resources, some parts of our country are facing the risk of draught. In order to conserve existing water resources and efficiently manage it for agriculture, recent advances in technology can be used. Internet of Things is one of such new technology which can help our country to reduce the overall impact of faulty water management in agriculture sector. In this paper, we have designed and developed a new framework for multilevel farming in urban area where cultivation space is limited. We have provided local node for each level with its individual local decision making system, sensors and actuators which is customized to the selected crop. These local nodes communicate to a centralized node via wireless communication. This centralized node is connected to a Cloud Server where the received data will be stored and processed. Cloud based data analysis and monitoring allows the user to analyze and monitor the irrigation system through internet providing ubiquitous access. Our Experimental results show reduced water consumption and better power utilization.

1.2 Problem Statement

We are going to propose a system where we can deal with continuous data from sensor values. We also propose a generalized framework that will work for any diseases. We want our build software will make diseases detection based on pH, moisture and temperature value.

The main challenge about sensor data is pH data is so much sensitive than moisture and temperature data. Any misreading can create wrong detection. So we have develop our data normalization algorithm to calculate the result accurately.

Another problem is as we are using IoT platform as backend in our application. That means our data is passing is lot of nodes and router. So there is possibility to loss the data or different data receive.

Finally there is one more challenge is data parsing. We have used RESTful API's to communicate between android application and IoT platform. Data have been passed through JASON format. Then we parsing the JASON format data and collect in variables. Server Authorization and HTTP protocol have done this communication. This was quite challenges to manage the communication and parsing without losing or receiving wrong data.

1.3 Research Objectives

I. To develop an IoT framework for real time data visualization.
II. To analyze and detect Soil Borne Diseases from the data provided by the system.

1.4 Thesis Organization

The following is an overview of the contents of the chapter that presented in this research:

Chapter 2 Chapter 2 provides an overview of the literature survey on soil borne disease, the important factors of soil that will be collected for data, the introduction of IoT and IoT related previous work. It also provides the overview of the IoT device, sensors, communication protocol and restful API's.

Chapter 3 Chapter 3 discuss our proposed methodology, describe the whole proposed system How its work and also give the algorithm and mathematical equations related to this research. This chapter also provides the whole working architecture and connection layout. It includes the data visualization part, data collection and parsing, data normalization and data storage.

Chapter 4 In this Chapter, we provide the experimental result of our research using different test Scenarios for fungus, bacteria and nematode. We have shown the comparison between the results and the performance evaluation.

Chapter 5 Chapter 5 is the overall concluding chapter that describes the summary of this thesis which is visualization by analysis and we also provide some recommendations for further research and future works.

CHAPTER 2
LITERATURE REVIEW

2.1 Communication Protocol

There are several communication protocol used by IoT. They are

1. Infrastructure (ex: 6LowPAN, IPv4/IPv6, RPL)
2. Identification (ex: EPC, uCode, IPv6, URIs)
3. Comms / Transport (ex: Wifi, Bluetooth, LPWAN)
4. Discovery (ex: Physical Web, mDNS, DNS-SD)
5. Data Protocols (ex: MQTT, CoAP, AMQP, Websocket, Node)
6. Device Management (ex: TR-069, OMA-DM)
7. Semantic (ex: JSON-LD, Web Thing Model)
8. Multi-layer Frameworks (ex: Alljoyn, IoTivity, Weave, Homekit)

In our project we have used MQTT protocol to connect the device with Thinger.io as cloud. And we also use HTTP protocol for transferring data between android application and cloud by using GET and Post method. We have send our HTTP request with authorization HEADER that was TOKEN provided by the IoT platform Thinger.io.

2.2 IoT Hardware

To build an IoT framework there are need some hardware combination. For this microcontroller, Ethernet shield, sensors are one of them. The short description about hardware are given below-

Microcontroller: We have used most popular Arduino UNO as a microcontroller. Arduino Uno has some specific I/O pin. It includes Power, GND, Serial Pin, Analog Pin, Control, INT, Physical Pin, Port Pin, Pin function, Internet Pin, PWM Pin, Port Power. The figure 2.2.1 shows the full pin diagram. Here the Pin diagram is given below-

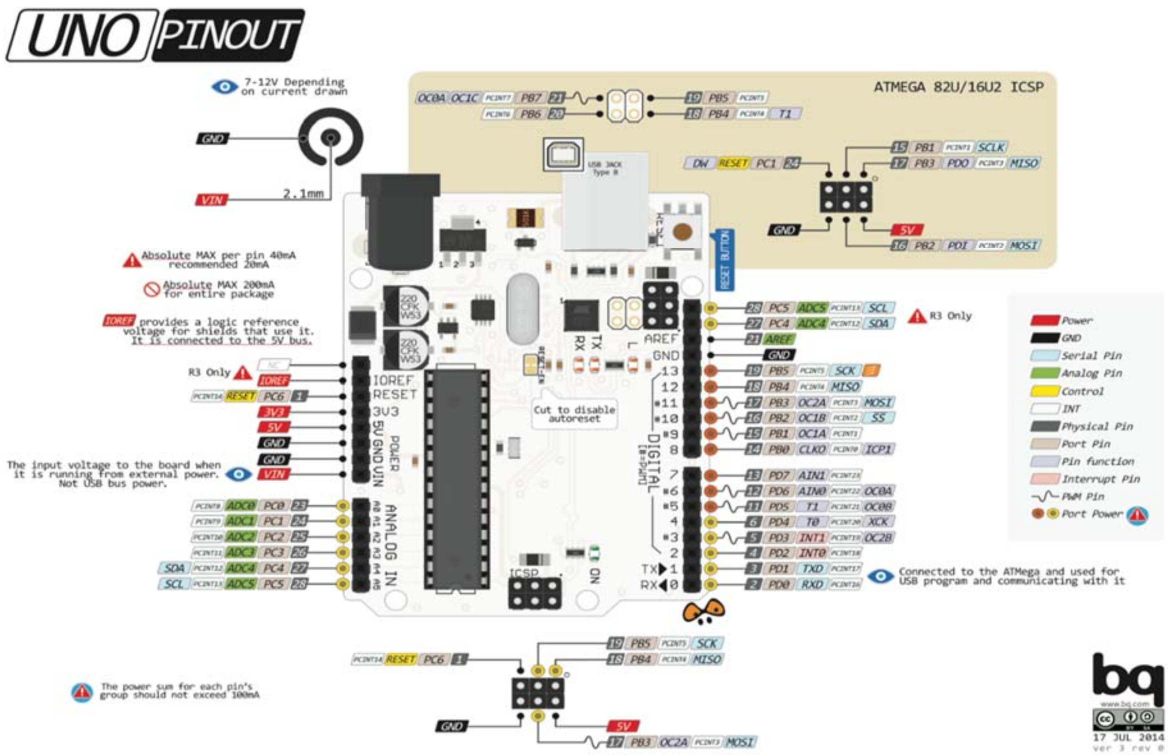


Fig 2.1: Arduino Uno PINOUT Diagram

Arduino Uno Ethernet Shield: We have used Arduino ETHERNET as an Ethernet shield. Arduino Ethernet shield has some specific I/O pin. It includes Power, GND, Serial Pin, Analog Pin, Control, INT, Physical Pin, Port Pin, Pin function, Internet Pin, PWM Pin, Port Power. The figure 2.2.2 shows the full pin diagram [9]. Here the Pin diagram is given below-

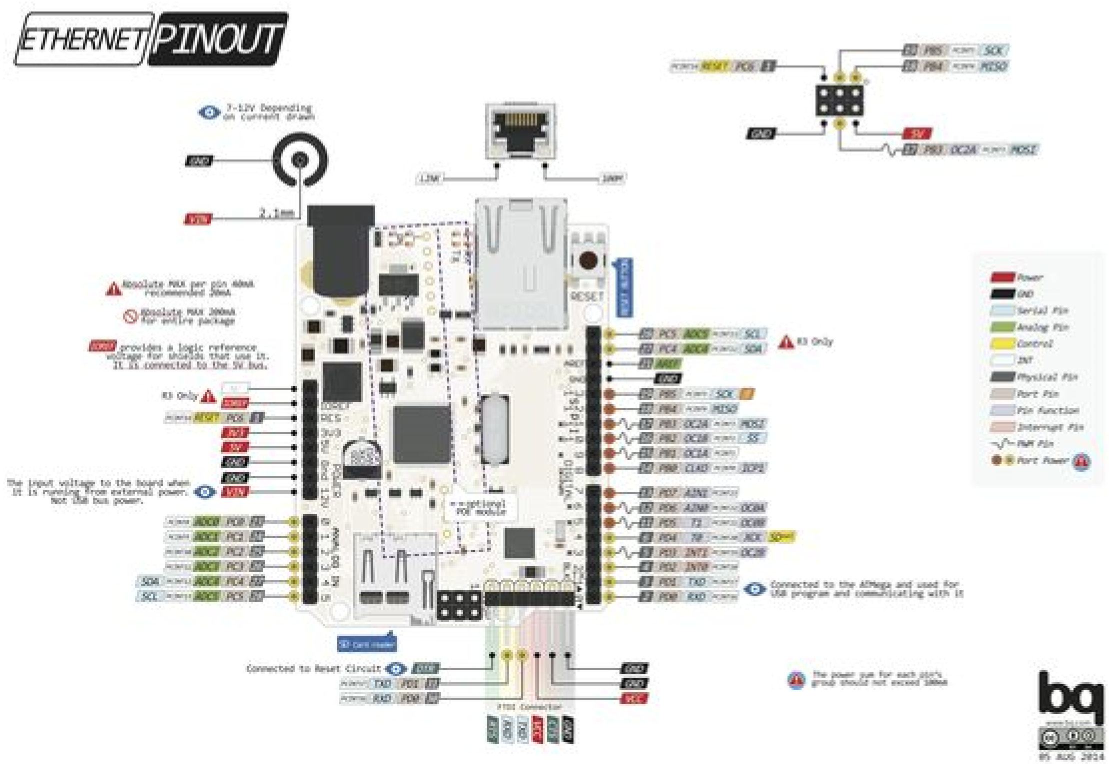


Fig 2.2: Arduino Ethernet PINOUT Diagram

pH sensor:

A pH meter is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as pH**.** A pH meter has two basic component, one with a pointer that moves against a scale or a digital meter which takes value from the resources and display numeric value through circuit board. In our project we have a pH sensor for test the soil acidity which is a digital meter. We make a circuit board and it's attach to an Arduino. In Arduino has some code for work pH meter.

Fig 2.3: pH sensor

Soil Temperature sensor:

Temperature sensor is designed to measure ambient temperatures**.** The sensing element consists of a semi-conductor integrated circuit that provides a linear output voltage proportional to the temperature of the environment it is placed into.

Fig 2.4: Temperature Sensor

Soil moisture sensor:

Soil moisture sensors measure the volumetric water content in soil. Soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. In our project, we have a soil moisture sensor for measure the soil water content. The soil moisture sensor is inserted in the soil. Depending on the quality of the sensor, it must be inserted near the roots of the plant. The soil moisture sensor measures the conductivity of the soil. Wet soil will be more conductive than dry soil. It works through an electric circuit board and Arduino.

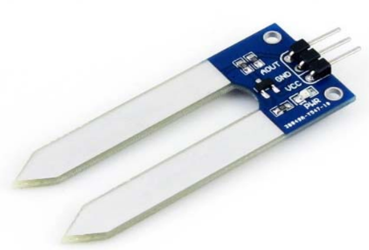


Fig 2.5: Moisture Sensor

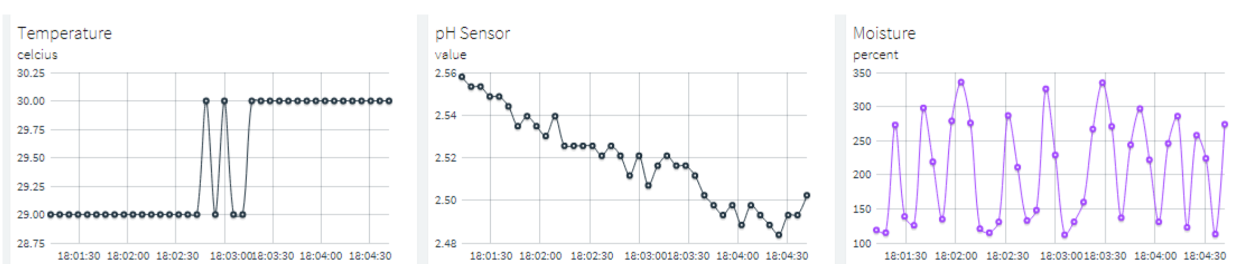
2.3 IoT Platform

There are lot of IoT platform available as cloud. Every cloud platform provide different type of services. Among all of them we choose Thinger.io as our IoT platform. Thus it provide RESTful API's so that we can transfer data through web and application. Some services are given below-

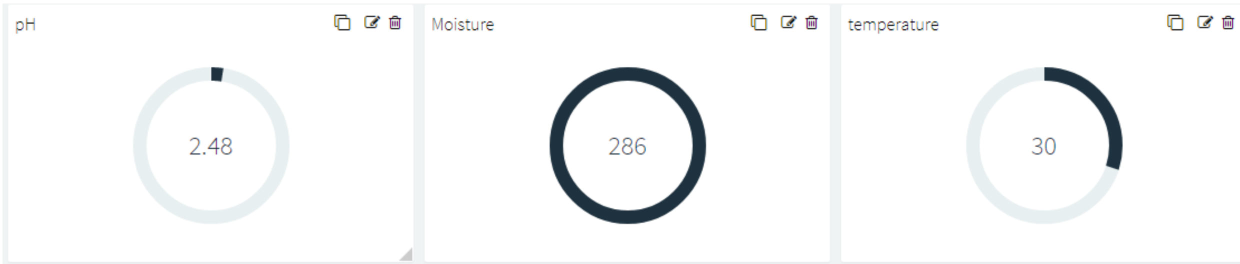
Dashboard:

Thinger.io provide real time dashboard services where some important useful gadget are available which can be customizable according to the user choice based on resource output. Some dashboard gadget list are given below

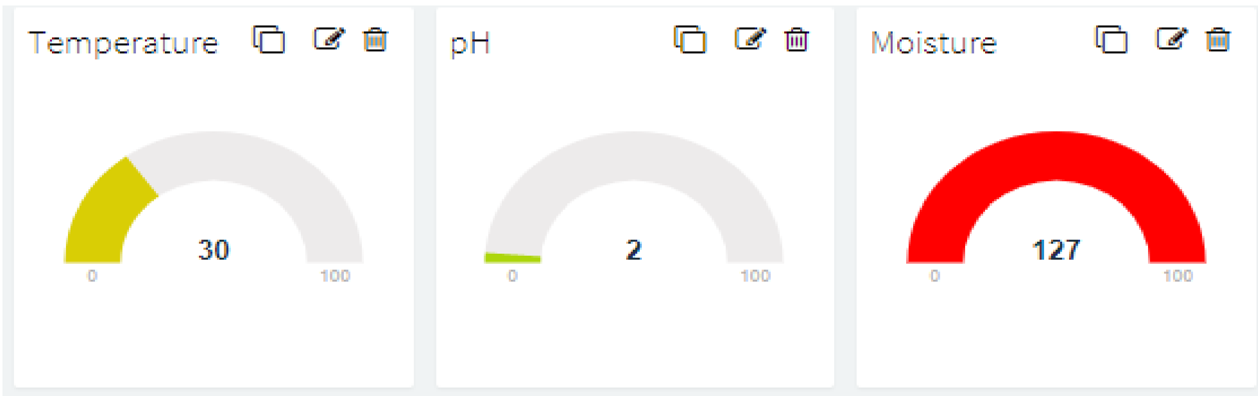
1. Time series chart
2. Donut chart
3. Progress bar
4. Gauge
5. Google map
6. Text / Value
7. Clock



(a)



(b)

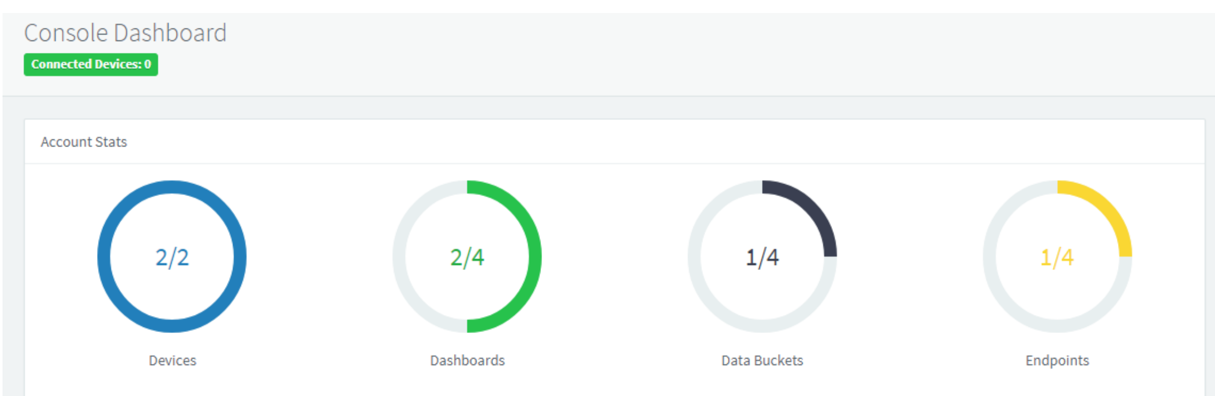


(c)

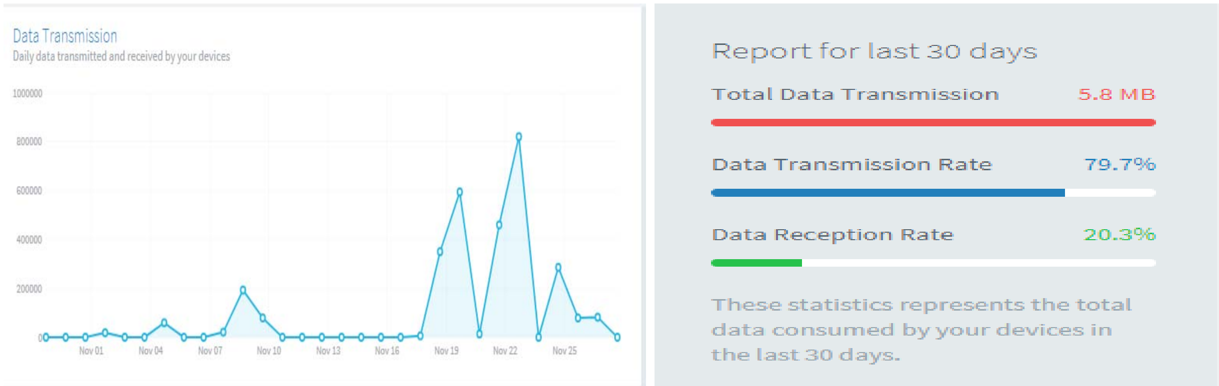
Fig 2.6: (a),(b),(c) shows IoT platform's Dashboard

Statistics:

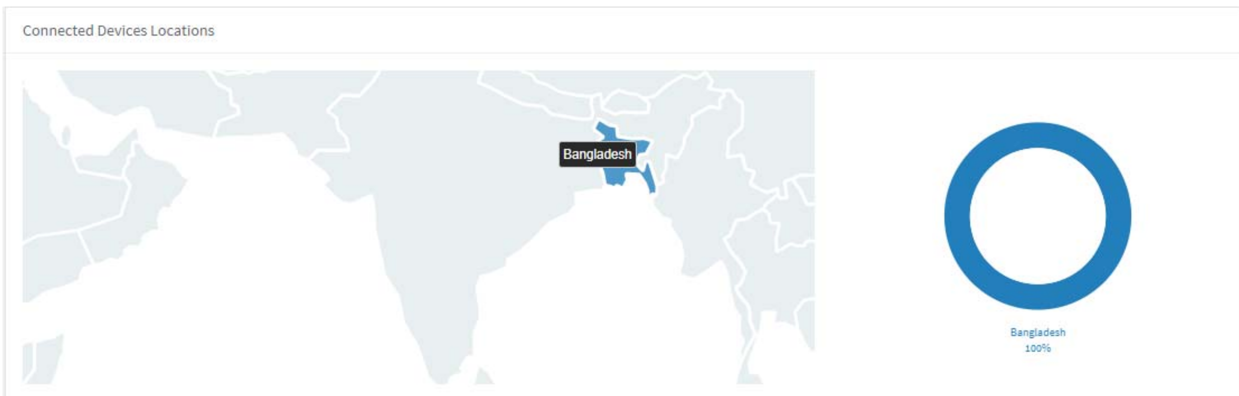
In Statistics section we can monitor overall information about IoT devices, console dashboard, IoT device Location, Data Transmission and report for last 30 days.



(a)



(b)

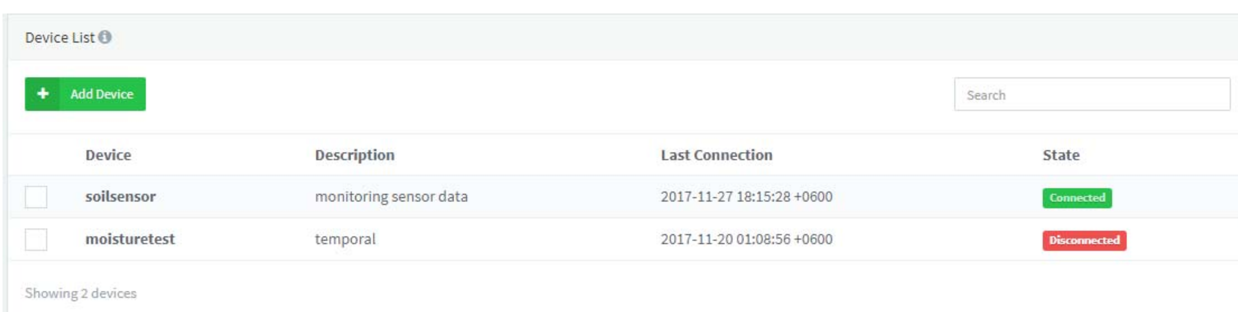


(c)

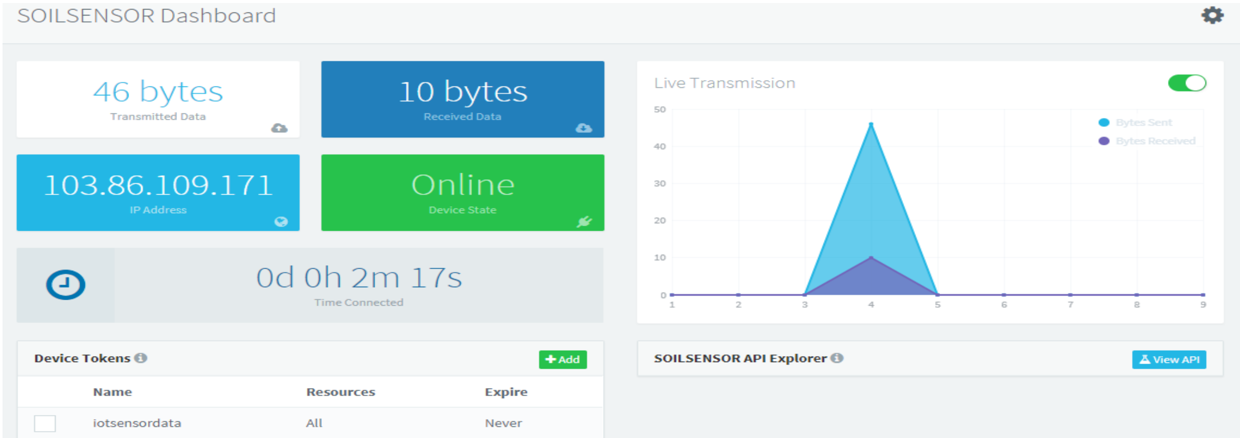
Fig 2.7: (a),(b),(c) shows IoT platform's Dashboard IoT platform's Statistics

Devices:

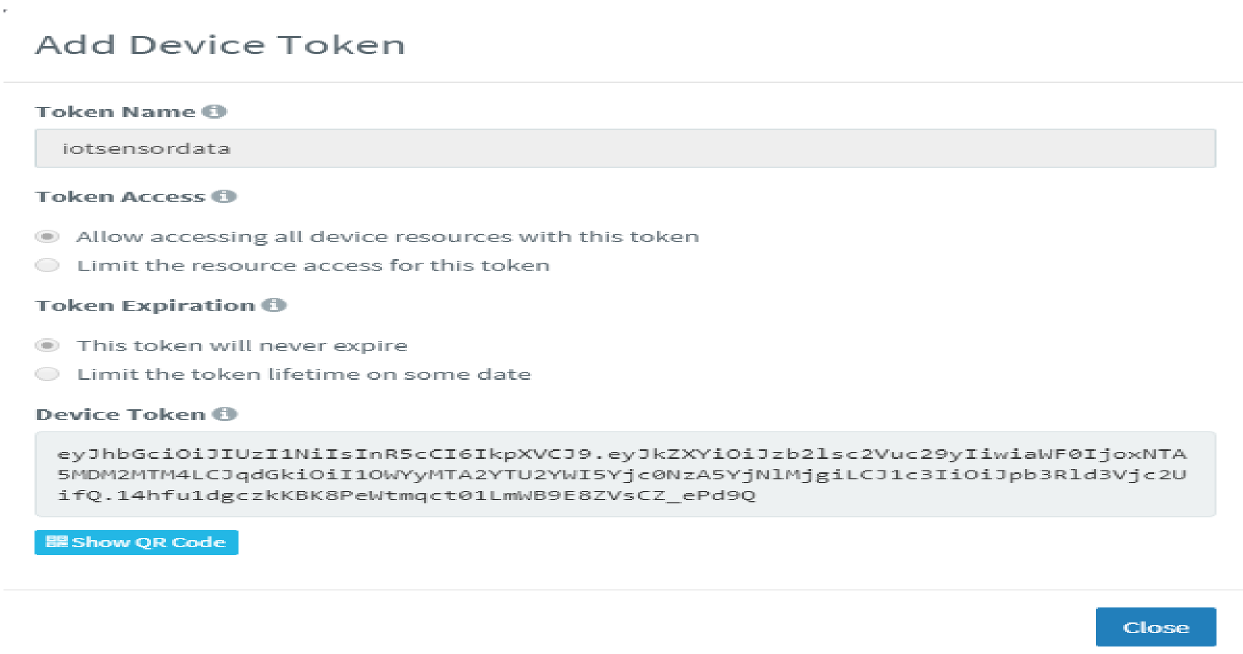
Thinger.io provide us to manage at most two devices live. We can create multiple device with unique device id. Every device has their own Device token to identify themselves.



(a)



(b)



(c)

Fig 2.8: (a),(b),(c) shows IoT platform's Device Control Panel

Data Bucket:

In data bucket we can store data by setting fixed number of limits.

Bucket List

Add Bucket

Search

	Bucket	Name	Description	State	Enabled
	tbucket	sensor data	test	Normal	Enabled

Showing 1 bucket

(a)

Bucket Explorer

Date	humidity	moisture	pHValue	temperature	voltage
2017-11-08T13:38:57.092+0600	38	351	10.8354	33	3.09583
2017-11-08T13:38:02.570+0600	38	593	10.8233	33	3.09236
2017-11-08T13:37:08.036+0600	38	142	10.821	33	3.09172
2017-11-08T13:36:13.505+0600	38	640	10.8314	33	3.09468
2017-11-08T13:35:18.976+0600	38	253	10.8233	33	3.09236
2017-11-08T13:34:24.450+0600	38	148	10.8233	33	3.09236
2017-11-08T13:33:29.920+0600	38	179	10.8318	33	3.0948
2017-11-08T13:32:35.395+0600	38	73	10.8399	33	3.09712
2017-11-08T13:31:40.850+0600	40	638	0	32	0
2017-11-08T13:02:48.263+0600	40	603	10.8687	32	3.10534

Refresh

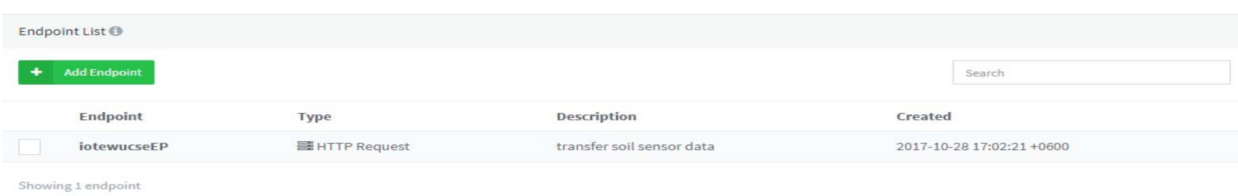
Viewing 0 to 99 items

(b)

Fig 2.9: (a),(b) shows IoT platform's Data Bucket

End points:

Thinger.io provides endpoints to manage the transfer authorization and sending data format.



Endpoint List

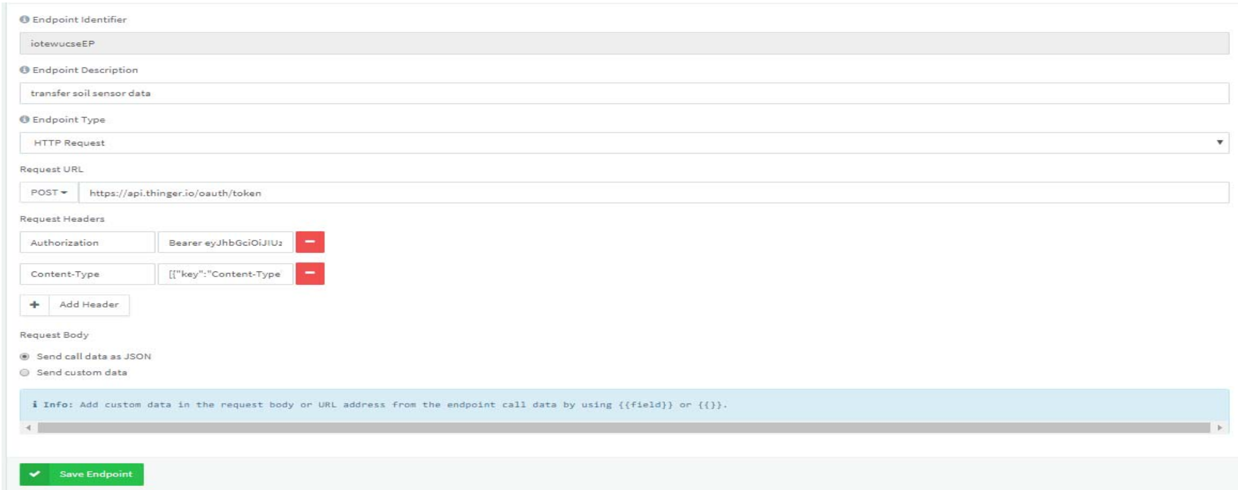
Add Endpoint

Search

	Endpoint	Type	Description	Created
	iotewucseEP	HTTP Request	transfer soil sensor data	2017-10-28 17:02:21 +0600

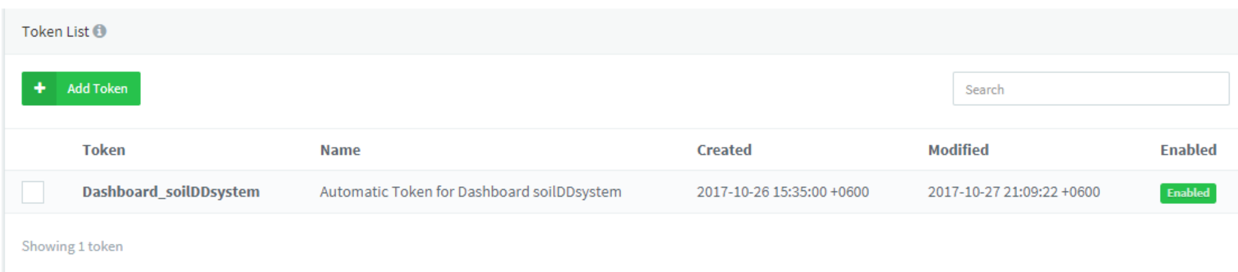
Showing 1 endpoint

(a)

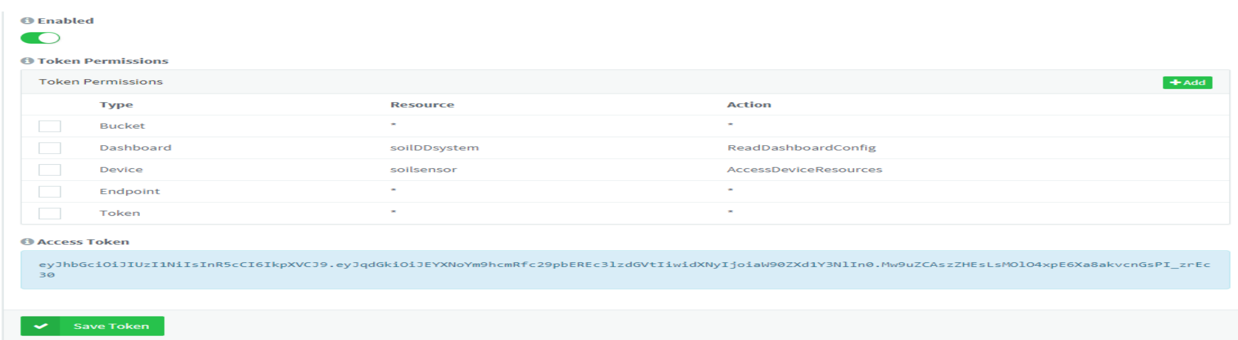


(b)

Access Token:



(c)



(d)

Fig 2.10: IoT platform's End point (a)&(b) and Access token (c)&(d)

RESTful API's:

API HOST:

```
https://api.thinger.io
```

(a)

REST API AUTHENTICATION:

```
Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJleHAiOjE0ODYwNDkxNTcsImlhdCI6MTQ4NjA0MTk1NywidXNyIjoianQifQ.pkyG43xiEhDtUHLxuyCYV156FGuvM
```

(b)

REST API Explorer:

(c)

Curl example:

```
curl \
  -H "Content-Type: application/json;charset=UTF-8" \
  -H "Authorization: Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9..." \
  -H "Accept: application/json, text/plain, */*" \
  -X POST \
  -d '{"in":"New customer: 101 today!"}' \
  https://api.thinger.io/v2/users/alvarolb/devices/nodemcu/command
```

(d)

Fig 2.11: (a)(b)(c)&(d) represent the RESTful's API

2.4 Soil Borne Disease Classification and Analysis

Bacteria:

Bacteria are the most abundant of the soil organisms (>100 million per gram or teaspoon of soil) and the most important within the top 6 inches of soil. Bacteria are very small single-celled microorganisms that reproduce by cell division. Most bacteria are classified into four categories. Great diversity exists among bacteria: some species are aerobic, some anaerobic, some autotrophs and some heterotrophs. Compared to cultivated agricultural soils, bacteria populations are generally greater in grassland soils because of higher root densities, available nutrients and organic matter content. Like many soil organisms, bacteria are influenced by soil temperature, water content and PH. Soil bacteria populations, therefore, fluctuate with the season, with largest populations in the spring, early summer and fall. Due to a quick generation time (as fast as 20 minutes between cell divisions), bacteria can quickly colonize and exploit organic materials once conditions become favorable for growth. Bacteria are responsible for many key biological reactions such as nitrogen fixation and sulfur oxidation, which make these nutrients available to plants. Also, bacteria are instrumental in the breakdown of cellulose and other structural components of thatch. In turf grasses, heterotrophic bacteria are responsible for decomposition of organic materials and regulation of soil organic matter. However, not all bacteria are beneficial; some are pathogenic to plants and animals.

Streptomyces:

Streptomyces’s are the most widely studied and well known genus of the actinomycete family. Streptomyces’s usually inhabit soil and are important decomposers. They also produce more than half of the world's antibiotics, and are consequently invaluable in the medical field. Streptomyces’s resemble fungi in their structure. Their branching, filamentous arrangement of cells form a network called a mycelium. They are able to metabolize many different compounds including sugars, alcohols, amino acids, and aromatic compounds by producing extracellular hydrolytic enzymes. Their metabolic diversity is due to their extremely large genome which has hundreds of transcription factors that control gene expression, allowing them to respond to specific needs. Because Streptomyces's inhabit soil, they are mainly phytopathogens, known for attacking root vegetables, such as potatoes, beets, radishes, rutabaga, turnips, carrots, and parsnip. Most commonly found on potatoes, Streptomyces scabies creates a condition known as "common scab," which manifests itself as sores on the external surface of the potato. The scabs do not harm the meat on the inside of the potato but create an extremely unpleasant appearance that devalues the potato.

Fungi:

Fungi are not the most abundant of the soil organisms, but they account for the greatest amount of living mass in soil. (Scientists now believe the largest living things are soil-inhabiting fungi. There are reports of individual fungi that extend through several acres of soil.)

Fungi are multicellular and do not contain chlorophyll; therefore, they cannot manufacture their own food. Familiar examples include mildews, molds, rusts and mushrooms. Although fungi can be pathogenic to turf grasses, they can also benefit turf by improving soil aggregation and decomposing complex organic residues. Some fungi enter into a mutually beneficial (*symbiotic)* relationship with roots of plants. This is well-documented with mycorrhizal fungi and trees. Scientists believe mycorrhizal fungi obtain carbohydrates from the plant and the plant uses fungi for greater nutrient and water accumulation. Mycorrhizal relationships in turf grasses are not well understood, but high numbers of mycorrhizae have been reported in turf grass soils.

Mycorrhizae also may provide some resistance to various stresses by increasing available soil volume for water and nutrient acquisition.

Pythium ultimum:

Pythium ultimum is a plant pathogen. The effect of soil acidity on the occurrence and severity of diseases caused by Pythium ultimum .It causes the damping-off and root rot diseases of hundreds of diverse plant hosts including corn, soybean, potato, wheat, fir, and many ornamental species. P. ultimum belongs to the peronosporalean lineage of oomycetes, along with other important plant pathogens such as Phytophthora spp. and many genera of downy mildews. P.ultimum is a frequent inhabitant of fields, freshwater ponds, and decomposing vegetation in most areas of the world. The pH level of 5 was the best for plant growth but not to both pathogens. Pythium ultimum have an optimum growth pH level of 6 and 7 and grew well at pH level of 5 and slightly at pH level of 4 and 8 but no growth at pH levels of 2, 3, 9 and 10 Contributing to the widespread distribution and persistence of P. ultimum is its ability to grow saprotrophically in soil and plant residue. This trait is also exhibited by most Pythium spp. but not by the related Phytophthora spp., which can only colonize living plant hosts.

Nematodes:

Nematodes are microscopic roundworms that can comprise as much as 90 percent of the multicellular invertebrates in soil. Millions of nematodes can inhabit a few square feet of soil. Nematodes reproduce by eggs and are most prevalent in warm, moist, sandy soils. They are essential in the soil food web, especially in the recycling of soil nutrients.

Like many other microorganisms, nematodes can positively affect soil. However, some species can be detrimental to plants. Of the thousands of nematode species so far identified, only about 50 feed on turf grass roots. Sting, ring, stubby root, lance, root-knot, spiral and others are important parasitic nematodes on turf grass roots. Detrimental populations are most likely found in irregular patches of the root zone. This is to be expected, because most parasitic nematodes are root feeders and require plant roots to thrive and reproduce.

Meloidogne:

Root-knot nematodes, (Meloidogyne) are main pathogens. The genus includes more than 90 species with some species having several races. .

Meloidogyne spp. were first reported in cassava by Neal in 1889. Damage on cassava is variable depending on cultivar planted, and can range from negligible to serious. Early-season infection leads to worse damage. In soil, meloidogyne grow well in value of pH 5-6, temperature value $(20\text{-}25)^0$C and moisture value 0.815 in the scale of 1. In most crops, nematode damage reduces plant health and growth in cassava, though, nematode damage sometimes leads to increased aerial growth as the plants try to compensate.

Heterodera humuli:

Heterodera humuli is a plant pathogenic nematode, the hop cyst nematode. It is an obligate parasite and infests hop plants, Humulus lupulus. The female hop cyst nematode is white and lemon-shaped with a body length of 0.3 to 0.7 mm and a width of 0.3 to 0.6 mm. The male is transparent and vermiform with a body length 0.7 to 0.96 mm. The eggs are oval, 0.09 x 0.04 mm and the first two instar larvae are vermiform. The second instar larvae are mobile in damp soil and invade suitable roots. Here they develop further and become sedentary, burying their heads in cells and feeding on the cell sap. The central part of their body's swells, and after molting again they develop into bottle-shaped third instar larvae and then thicker lemon-shaped fourth instar larvae. At this stage they either become male or female depending on the food supply. The swollen larval bodies break out of the root and the mobile males travel through the soil while the females remain attached to the root tissues by their heads. After insemination, the females continue feeding and lay eggs. These remain inside the bodies of the females which die and turn into cysts. A single generation lasts 34 to 56 days depending on environmental conditions.

Antinomies:

Actinomycetes are believed to be an evolutionary transition between bacteria and fungi because they have characteristics of both organisms. Actinomycetes are single-celled microorganisms lacking chlorophyll. Based on numbers, they are second to bacteria in abundance in soils. Actinomycetes are considered to be slow growing, “late colonizing” organisms responsible for degradation of complex molecules like chitin, lignin, cellulose and phospholipids. Actinomycetes produce antibiotics and volatile substances that give soil a sweet, rich, “earthy” aroma. They are especially sensitive to pH changes, with populations being greatest at pH values above 6.0 and almost nonexistent at pH 5.0. Their exact roles in turf grass soil biosphere are poorly understood.

Protozoa:

Generally found in the upper 6 inches of soil, protozoa are the most abundant of the soil-inhabiting organisms that can be considered “animal” life. Protozoans include amoeba and paramecium, which feed on organic matter and other soil microbes. Little is known of soil protozoa, but they are thought to regulate bacterial populations through predation and competition. There are no known diseases of turf grass as a result of protozoa.

Algae:

Algae are multicellular organisms with chlorophyll and, therefore, are autotrophic in their nutritional requirements. Thus, they must reside near the soil surface where light for photosynthesis is abundant. Examples include cyanobacteria (formally known as blue-green algae), green algae and diatoms. Algae reproduce by simple cell division and have cell walls similar to higher plants. Considered “early colonizing” organisms in natural habitats, algae are important in initial stages of soil formation. However, algae also can form crusts or mats that seal the soil surface, effecting water infiltration, water retention and soil/air gas exchange and influencing (mostly preventing) seed germination. Buried algae mats have also been associated with the physical, chemical and biological condition called *black layer*.

Algae especially can become a problem on golf putting greens where water is readily available and heights of cut are very low, allowing sunlight to reach the soil surface. Algae are a difficult problem to overcome on greens once established.

Soil Borne Disease's factor Analysis:

To identify the soil borne disease the factors must be well known. Here are given some factor analysis below-

Table 2.1: Major elements, their sources and functions in bacterial cells.

Element	% of dry weight	Source	Function
Carbon	50	organic compounds or CO_2	Main constituent of cellular material
Oxygen	20	H_2O, organic compounds, CO_2, and O_2	Constituent of cell material and cell water; O_2 is electron acceptor in aerobic respiration
Nitrogen	14	NH_3, NO_3, organic compounds, N_2	Constituent of amino acids, nucleic acids nucleotides, and coenzymes
Hydrogen	8	H_2O, organic compounds, H_2	Main constituent of organic compounds and cell water
Phosphorus	3	inorganic phosphates (PO_4)	Constituent of nucleic acids, nucleotides, phospholipids, LPS, teichoic acids
Sulfur	1	SO_4, H_2S, S^o, organic sulfur compounds	Constituent of cysteine, methionine, glutathione, several coenzymes
Potassium	1	Potassium salts	Main cellular inorganic

			cation and cofactor for certain enzymes
Magnesium	0.5	Magnesium salts	Inorganic cellular cation, cofactor for certain enzymatic reactions
Calcium	0.5	Calcium salts	Inorganic cellular cation, cofactor for certain enzymes and a component of endospores
Iron	0.2	Iron salts	Component of cytochromes and certain nonheme iron-proteins and a cofactor for some enzymatic reactions

Table 2.2: Major nutritional types of procaryotes

Nutritional Type	Energy Source	Carbon Source	Examples
Photoautotrophs	Light	CO_2	Cyanobacteria, some Purple and Green Bacteria
Photoheterotrophs	Light	Organic compounds	Some Purple and Green Bacteria
Chemoautotrophs or Lithotrophs (Lithoautotrophs)	Inorganic compounds, e.g. H_2, NH_3, NO_2, H_2S	CO_2	A few Bacteria and many Archaea
Chemoheterotrophs or Heterotrophs	Organic compounds	Organic compounds	Most Bacteria, some Archaea

Table 2.3: Common vitamins required in the nutrition of certain bacteria.

Vitamin	Coenzyme form	Function
p-Aminobenzoic acid (PABA)	-	Precursor for the biosynthesis of folic acid
Folic acid	Tetrahydrofolate	Transfer of one-carbon units and required for synthesis of thymine, purine bases, serine, methionine and pantothenate
Biotin	Biotin	Biosynthetic reactions that require CO_2 fixation
Lipoic acid	Lipoamide	Transfer of acyl groups in oxidation of keto acids

Mercaptoethane-sulfonic acid	Coenzyme M	CH_4 production by methanogens
Nicotinic acid	NAD (nicotinamide adenine dinucleotide) and NADP	Electron carrier in dehydrogenation reactions
Pantothenic acid	Coenzyme A and the Acyl Carrier Protein (ACP)	Oxidation of keto acids and acyl group carriers in metabolism
Pyridoxine (B_6)	Pyridoxal phosphate	Transamination, deamination, decarboxylation and racemation of amino acids
Riboflavin (B_2)	FMN (flavin mononucleotide) and FAD (flavin adenine dinucleotide)	Oxidoreduction reactions
Thiamine (B_1)	Thiamine pyrophosphate (TPP)	Decarboxylation of keto acids and transaminase reactions
Vitamin B_{12}	Cobalamine coupled to adenine nucleoside	Transfer of methyl groups
Vitamin K	Quinones and napthoquinones	Electron transport processes

Table 2.4: Minimal medium for the growth of Bacillus megaterium. An example of a chemically-defined medium for growth of a heterotrophic bacterium.

Component	Amount	Function of component
sucrose	10.0 g	C and energy source
K_2HPO_4	2.5 g	pH buffer; P and K source
KH_2PO_4	2.5 g	pH buffer; P and K source
$(NH_4)2HPO_4$	1.0 g	pH buffer; N and P source
$MgSO_4$ $7H_2O$	0.20 g	S and Mg^{++} source
$FeSO_4$ $7H_2O$	0.01 g	Fe^{++} source
$MnSO_4$ $7H_2O$	0.007 g	Mn^{++} Source
water	985 ml	
pH 7.0		

Table 2.5: Defined medium (also an enrichment medium) for the growth of Thiobacillus thiooxidans, a lithoautotrophic bacterium.

Component	Amount	Function of component
NH_4Cl	0.52 g	N source
KH_2PO_4	0.28 g	P and K source
$MgSO_4$ $7H_2O$	0.25 g	S and Mg^{++} source
$CaCl_2$ $2H_2O$	0.07 g	Ca^{++} source
Elemental Sulfur	1.56 g	Energy source
CO_2	5%*	C source
water	1000 ml	
pH 3.0		

Table 2.6: Complex medium for the growth of fastidious bacteria.

Component	Amount	Function of component
Beef extract	1.5 g	Source of vitamins and other growth factors
Yeast extract	3.0 g	Source of vitamins and other growth factors
Peptone	6.0 g	Source of amino acids, N, S, and P
Glucose	1.0 g	C and energy source
Agar	15.0 g	Inert solidifying agent
water	1000 ml	
pH 6.6		

Table 2.7: Selective enrichment medium for growth of extreme halophiles.

Component	Amount	Function of component
Casamino acids	7.5 g	Source of amino acids, N, S and P
Yeast extract	10.0 g	Source of growth factors
Trisodium citrate	3.0 g	C and energy source
KCl	2.0 g	K^+ source
$MgSO_4$ 7 H_2O	20.0 g	S and Mg^{++} source
$FeCl_2$	0.023 g	Fe^{++} source
NaCl	250 g	Na^+ source for halophiles and inhibitory

		to nonhalophiles
water	1000 ml	
pH 7.4		

Table 2.8: Minimum, maximum and optimum pH for growth of certain procaryotes.

Organism	Minimum pH	Optimum pH	Maximum pH
Thiobacillus thiooxidans	0.5	2.0-2.8	4.0-6.0
Sulfolobus acidocaldarius	1.0	2.0-3.0	5.0
Bacillus acidocaldarius	2.0	4.0	6.0
Zymomonas lindneri	3.5	5.5-6.0	7.5
Lactobacillus acidophilus	4.0-4.6	5.8-6.6	6.8
Staphylococcus aureus	4.2	7.0-7.5	9.3
Escherichia coli	4.4	6.0-7.0	9.0
Clostridium sporogenes	5.0-5.8	6.0-7.6	8.5-9.0
Erwinia caratovora	5.6	7.1	9.3
Pseudomonas aeruginosa	5.6	6.6-7.0	8.0
Thiobacillus novellus	5.7	7.0	9.0
Streptococcus pneumoniae	6.5	7.8	8.3
Nitrobacter sp	6.6	7.6-8.6	10.0

Table 2.9: Terms used to describe microorganisms in relation to temperature requirements for growth.

Group	Minimum	Optimum	Maximum	Comments
Psychrophile	Below 0	10-15	Below 20	Grow best at relatively low T
Psychrotroph	0	15-30	Above 25	Able to grow at low T but prefer moderate T
Mesophile	10-15	30-40	Below 45	Most bacteria esp. those living in association with warm-blooded animals
Thermophile*	45	50-85	Above 100 (boiling)	Among all thermophiles is wide variation in optimum and maximum T

Table 2.10: Minimum, maximum and optimum temperature for growth of certain bacteria and archaea.

Bacterium	Minimum	Optimum	Maximum
Listeria monocytogenes	1	30-37	45
Vibrio marinus	4	15	30
Pseudomonas maltophilia	4	35	41
Thiobacillus novellus	5	25-30	42
Staphylococcus aureus	10	30-37	45
Escherichia coli	10	37	45
Clostridium kluyveri	19	35	37
Streptococcus pyogenes	20	37	40
Streptococcus pneumoniae	25	37	42
Bacillus flavothermus	30	60	72
Thermus aquaticus	40	70-72	79
Methanococcus jannaschii	60	85	90
Sulfolobus acidocaldarius	70	75-85	90
Pyrobacterium brockii	80	102-105	115

Table 2.11: Optimum growth temperature of some procaryotes.

Genus and species	Optimal growth temp (degrees C)
Vibrio cholerae	18-37
Photobacterium phosphoreum	20
Rhizobium leguminosarum	20
Streptomyces griseus	25
Rhodobacter sphaeroides	25-30
Pseudomonas fluorescens	25-30
Erwinia amylovora	27-30
Staphylococcus aureus	30-37
Escherichia coli	37
Mycobacterium tuberculosis	37
Pseudomonas aeruginosa	37
Streptococcus pyogenes	37
Treponema pallidum	37
Thermoplasma acidophilum	59
Thermus aquaticus	70
Bacillus caldolyticus	72
Pyrococcus furiosus	100

Table 2.12: Hyperthermophilic Archaea.

Temperature for growth (degrees C)

Genus	**Minimum**	**Optimum**	**Maximum**	**Optimum pH**
Sulfolobus	55	75-85	87	2-3
Desulfurococcus	60	85	93	6
Methanothermus	60	83	88	6-7
Pyrodictium	82	105	113	6
Methanopyrus	85	100	110	7

2.5 Summery

From the literature review at first, we have a clear understanding on How IoT works and what are the requirements. We have gained idea about how we can communicate with the IoT server platform and android application. We are sure now how many sensor we need and what purpose it will use for. Then we have full concept about Thinger.io as IoT platform and its functionality. Now we can manage dashboard, device control, data bucket, end points and access token. Second we analyze about soil factor that gives us proper understanding which factor is most important and will be used for Detect soil borne diseases.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Propose System

In this research, we propose Soil Borne Disease Detection System (SBDDS) where we take sensor data as out data set from the affected soil. For this we have built an IoT device with set of sensors. The sensors are pH sensor, temperature sensor, moisture sensor. Then we send the code to the cloud and with help of REST API we get those live data and store for further processing. After that we execute those data into soil borne disease detection algorithm and analyze the data for generating result. So this IoT framework include IoT device, Cloud services and web application for real time data visualization and data analyzation.

Our proposed system can successfully handle the sensor data and maintain in cloud management such as dashboard and store data and can store data into data bucket. Our framework also can analyze different scenarios and can provide efficient result by executing algorithm.

So most of all this framework is successful for solving real life problem and can provide proper result for preventing soil borne disease as the problems.

IoT Device: To build an IoT device we have used an Arduino Microcontroller, an Arduino Ethernet Shield for Internet communication and set sensors for collecting data. The figure 3.1 shows the IoT device where pH sensor and moisture sensor are analog output and temperature is digital output:

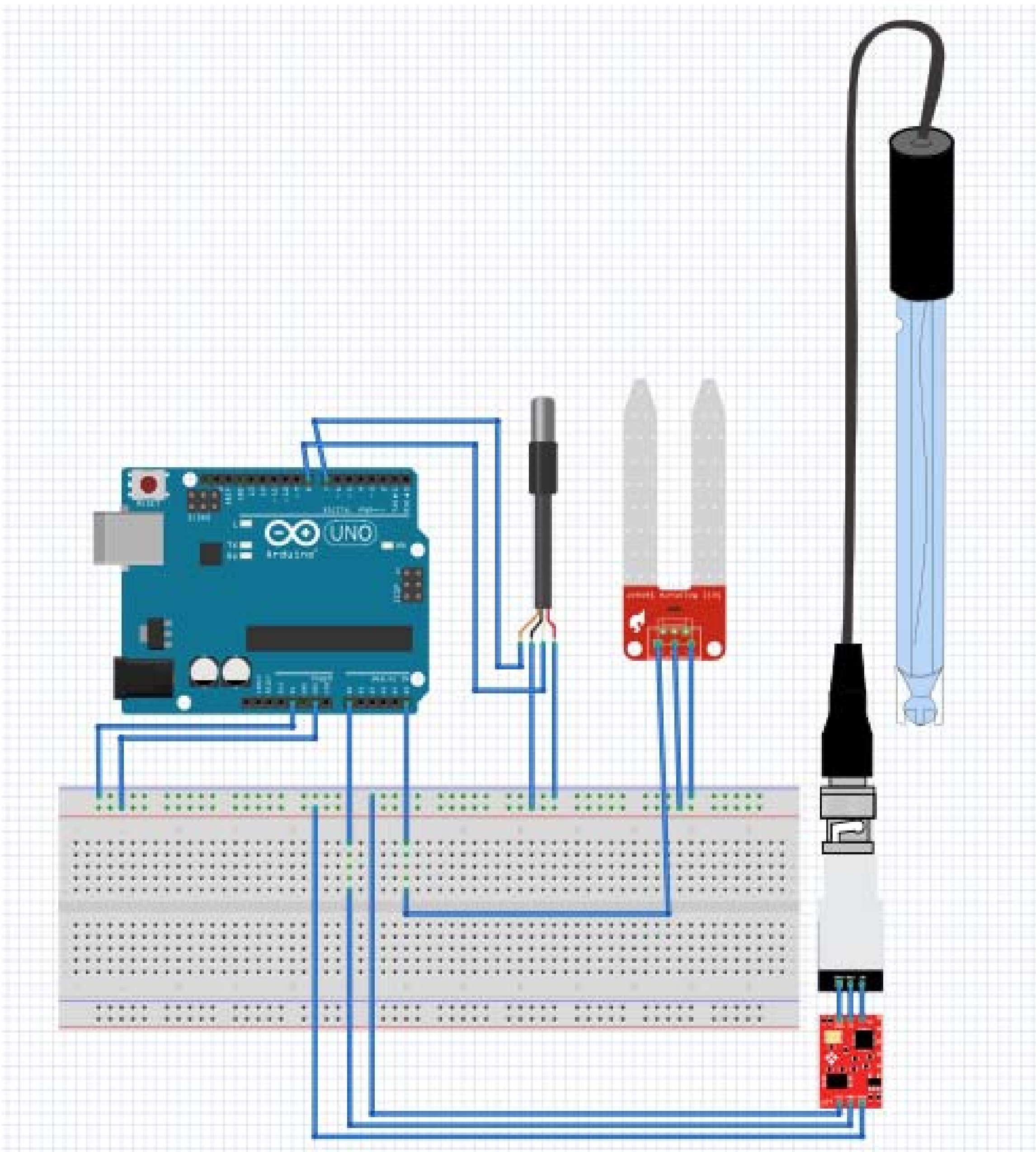


Fig 3.1: IoT device with microcontroller and sensors

3.1.1 Architectural Layout

In this section is representing the whole working flow from the sensors data collection to efficient result generation. The figure 3.1.1 shows the working flow diagram of the IoT framework for Soil Borne Disease Detection System:

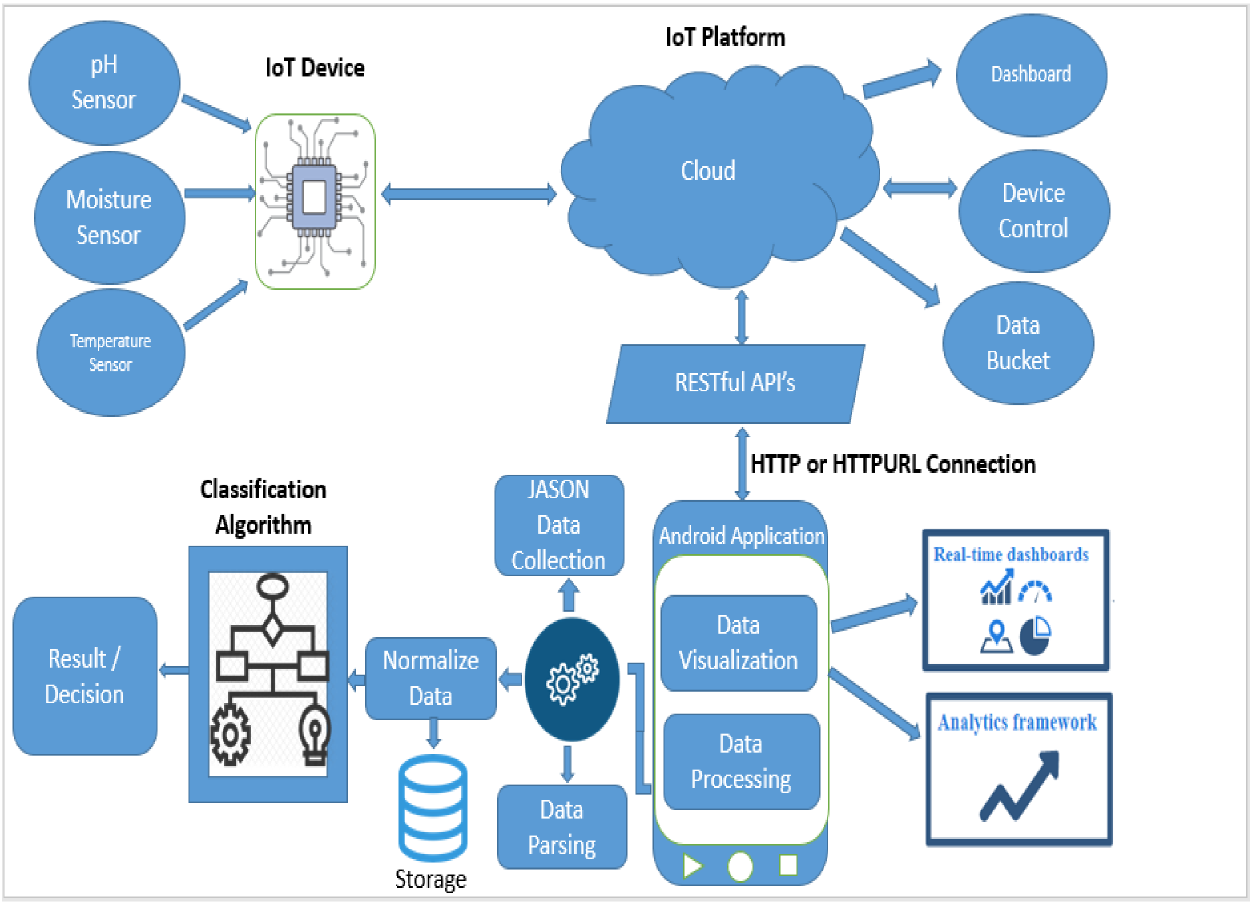


Fig 3.2: Working Flow Diagram of Soil Borne Disease Detection System

3.1.2 Connection Layout

In this section connection layout describe the connection protocol and connection architecture between web application and Thinger.io with the help of RESTful's API. The figure 3.2.2 shows the total connection architecture below-

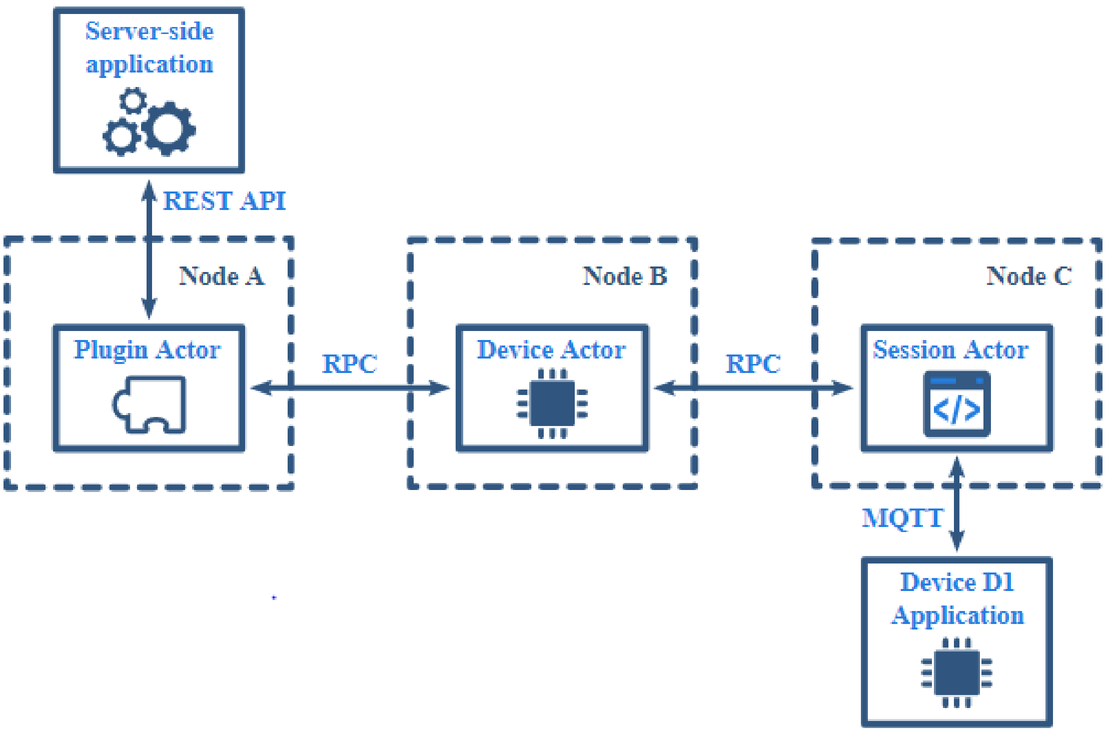


Fig 3.3: Connection Architecture for android application to Server

3.2 Working Procedure

In this section, the actual activity is presented through the section wise. Like how Arduino collect the raw data from the sensor and mapping the data. After that how the send to the cloud and which connection protocol have been used to setup and upload data to the cloud. Then how web application work and how web application use RESTful API's to GET data from the cloud. After the collect data in JASON data how it is parsing and normalize. And how data is applied to algorithm and generate efficient result.

We use several types of feature for different purposes. For the raw data visual confirmation we use Arduino serial monitor, for cloud data transfer activity we have dashboard and we also has android application we also has data visualization layout, beside we have our process monitoring console where we can see our working procedure and result of the algorithm.

3.2.1 Data Visualization

We have built data visualization layout for monitoring real time activity or data transfer activity. We have set update delay about 3 seconds for smooth visualization without losing any data. For visualization purpose we have used TextView for showing string data and MPandroid graph for real time updating.

Fig 3.4: android application Real time Dashboard

Here is the format of MPandroid Line graph chart control –

```
private void drawphLineChart(float yValues, String xValues) {


    phYData.add(new Entry(yValues, i));

    phXData.add(xValues);

    LineDataSet phlineDataSet = new LineDataSet(phYData, "Y data");
    phlineDataSet.setColor(Color.RED);
    phlineDataSet.setDrawFilled(true);
    phlineDataSet.setDrawCubic(true);
    phlineDataSet.setDrawValues(true);

    LineData phlineData = new LineData(phXData, phlineDataSet);
    phlineData.setValueTextSize(5f);
    phlineData.setValueTextColor(Color.LTGRAY);

    phlineChart.setData(phlineData);
    phlineChart.invalidate();
}
```

3.2.2 Data Collection and Parsing

Data collection and parsing is under the class JASONTASK class. Here is the class include class-

```
public class JSONTask extends AsyncTask<String,String,String>
```

Data Collection:

As IoT platform thinger.io send data as JASON format, so at first we have send GET request to the Thinger.io server for data with proper authorization. With the device ID, username and TOKEN we can request for specific continuous live data. Here is the working data collection steps.

Thread / Handler: Thread helps us to maintain continue data fetching. It is more like timer. It starts after as soon as the page hit. In thread we have sleep timer which handle the delay of fetching data. In the thread we have use JASON TASK method for calling the server connection call.

```
JSONTask().execute("https://api.thinger.io/v2/users/iotewucse/devices/soilsensor/Temphum");
```

HttpURLConnection: HttpURLConnection include several properties which helps to successful setup. They are-

1. HttpURLConnection Object
2. BufferReader Object
3. setRequestMethod("GET")
4. setRequestProperty("Authorization",token);
5. InputStream Object

JASON Data Parsing:

Thinger.io send the sensor data in JASON format. The figure 3.2.2 shows the JASON data format:

</> Response Body


```
{
  "out": {
    "temperature": 31,
    "humidity": 40,
    "moisture": 121,
    "pHValue": 3.96354
  }
}
```


Fig 3.5: JASON Data format

So we need to parse the Jason Object. Here Out object is holding the multiple attribute. They can be parsed as following-

```
String finalJason = buffer.toString();
JSONObject parentObject = new JSONObject(finalJason);
JSONObject databject = parentObject.getJSONObject("out");
int tempValue=databject.getInt("temperature");
t=tempValue;
int moistureValue = databject.getInt("moisture");
m=moistureValue;
double phValue=databject.getDouble("pHValue");
ph=String.valueOf(phValue);
StringBuffer finalBufferData = new StringBuffer();
finalBufferData.append(moistureValue+ phValue+ tempValue);
return finalBufferData.toString();
```

Data fetching Layout:

Here is the console layout of data fetching-

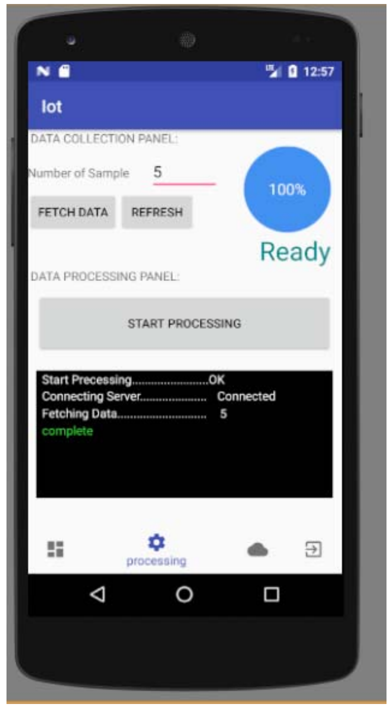


Fig 3.6: Data fetching Layout

3.2.3 Data Normalization

In this project we have taken some sample and store in a ARRAYLIST, then we take a average of those data for efficient result. The formula is

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Where $\bar{x}$ is the refine data and i is the sample number and n is the total number of sample.

3.2.4 Detection Algorithm

Soil borne detection algorithm have been developed based on soil factor that soil factor is collected by sensors. But among three factors it has two types-

1. Primary factors (pH)
2. Secondary factors(Moisture & Temperature)

Here is classification diagram:

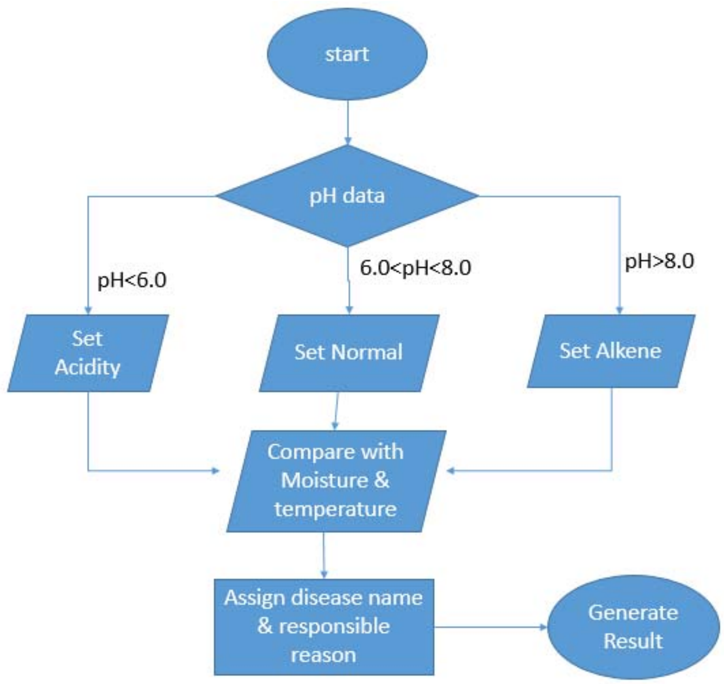


Fig 3.7: Flow chart of Detection Algorithm

3.2.5 Pseudocode of the Detection Algorithm

```
DetectionAlgorithm (pH, moisture, temperature):

Step 1: pH data = normalize pH data
Step 2: Moisture data = normalize Moisture data
Step 3: Temperature data = normalize Temperature data
Step 4: Check pH data with category range
            Step 4.1: If pH data < 6.0 then set category level to Acidity
                    4.1.1 set Disease name according to pH range
                    4.1.2 get confirmation with moisture data range
                    4.1.3 set more accurate with temperature data
        Step 4.2 Else If pH data > 6.0 and pH<8.0 then set category to Normal Level
                    4.2.1 skip the moisture and temperature comparison
        Step 4.3 Else If pH data> 8.0 then set category to Alkene Level
                    4.3.1 set Disease name according to pH data range
                    4.3.2 get confirmation with moisture data range
                    4.3.3 set more accurate with temp data
        END IF.
Step 5: Else set alert for INVALID data execution
END IF.
END Detection Algorithm.
```

Algorithm Execution Layout:

Start processing Button take data from array list and send data to algorithm. The figure 3.2.5 shows the algorithm execution layout-

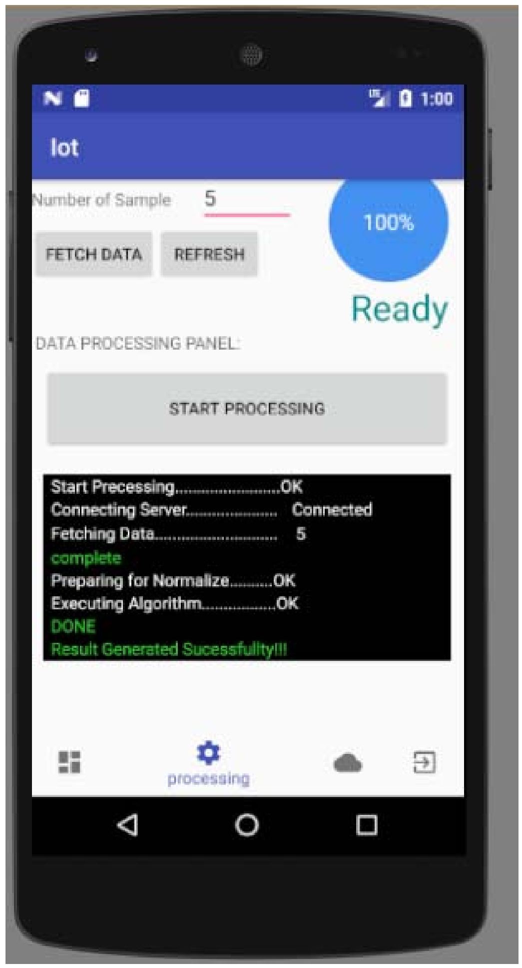


Fig 3.8: console layout of data processing

After execution the algorithm it set the result of category, Disease Name, Pathogens name and status about the result.

3.2.6 Data Storage

Data storage layout holds the data set that have been used generate the result. The storage panel is also can merge new data if we want to add to the data for generating new result. The figure 3.2.6 shows the data set in the data storage layout:

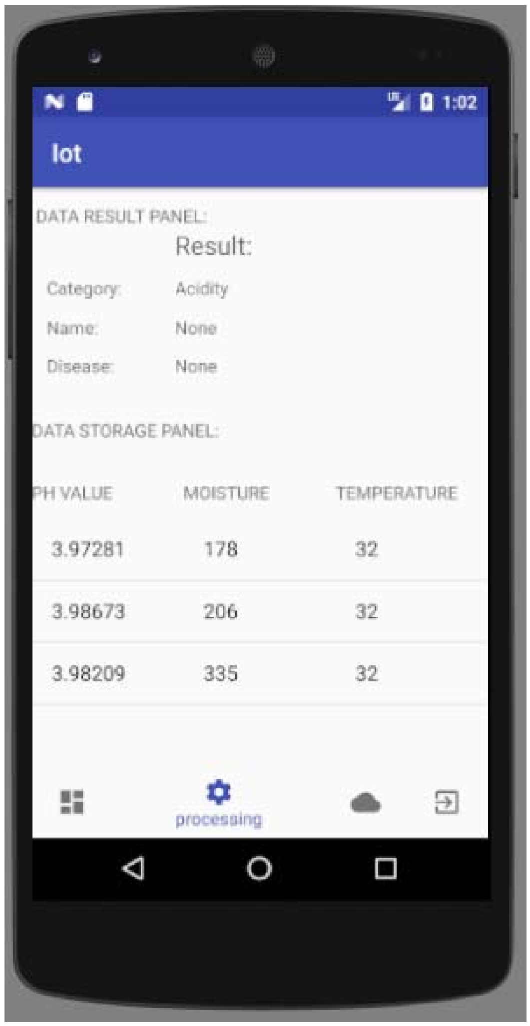


Fig 3.9: data storage layout of data processing

3.3 Summery

In this chapter, we discuss research methodology with a new proposed method. We have introduced our intelligent proposed system which can perform better for detecting Soil borne Disease. We describe how IoT is connected to this system. Also, describe the whole working flow of the proposed system in this section. For our experiment, we use the android application as web application and implement our detection algorithm. All mathematical terms are briefly described in algorithms and mathematical equations. We also have represented real time data visualization and data analysis in different type of layout.

CHAPTER 4
RESULT AND DISCUSSION

Experimental Scenarios and result:

In this chapter the result of the classification algorithm of Soil borne disease detection system are presented and also we tried evaluate the experimental result through analysis. For this we have shown the result through some scenario or cases. In every scenario we have taken the sensor data and put in an ARRAYLIST, then we have taken average value of that data then we push those data to algorithm and we have a result layout for that.

At the end of the result we also have shown the used data lists from the array list. And shown the category, its type, disease name, pathogens name and status. This test cases can successfully detect the soil borne disease for the fungus, bacteria and nematode related disease.

The pathogens list, sensor data list, graph representation and result are given below for different scenarios:

Scenario 01: Fungus (Damping OFF)

Description**:** The single term used to describe underground, soil line, or crown rots of seedlings due to unknown causes is damping-off. The term actually covers several soil borne diseases of plants and seed borne fungi. The pH range for damping of is 4.5 to 5.5.

Table 4.1: list of Fungus Disease Name and the Responsible pathogens Name.

Disease Name	**Responsible pathogen**
Rhizoctonia root rot	*Rhizoctonia solani*
Pythium Root Rot	*Pythium spp.*
Phytophthora root rot	*Phytophthora spp.*
Black root rot	*Thielaviopsis basicola*
Miscellaneous fungi	*Sclerotium rolfsii*

All these Disease are responsible for Damping-off. The collected data for this kind of soil from the sensors are given below:

Table 4.2: list of Fungus scenario's sensor data.

pH	**Moisture**	**Temperature**
4.7529	62%	22^0 C
4.8223	64%	22^0 C
4.9549	58%	22^0 C
5.0651	66%	22^0 C
5.2300	63%	22^0 C
4.9864	60%	22^0 C
5.1278	65%	22^0 C

Graph representation:

Fungus contained soil must have different type of characteristics and the figure 4.1.1 show the data representation below:

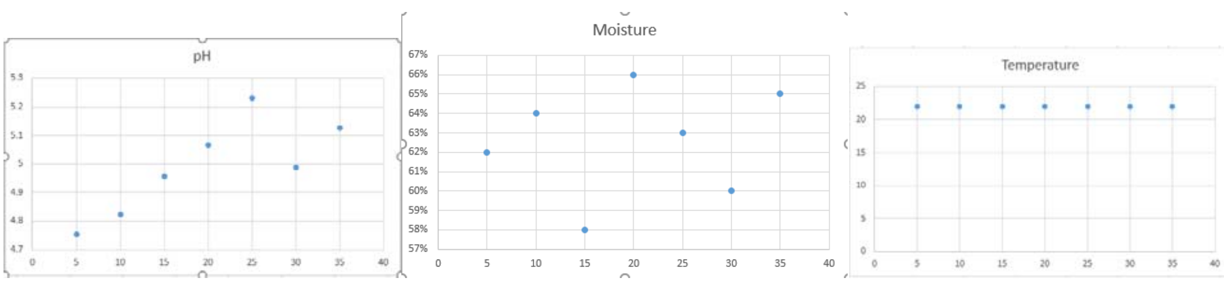


Fig 4.1: graph representation of Fungus contaminated sensor data in soil

Result: Based on pH data, moisture data and temperature data the result is following:

Category	Acidity
Type	Fungus
Disease Name	Damping-off
pathogen	*Thielaviopsis basicola*
Nature	harmful

Scenario 02: Bacteria

Description: though Bacteria is good for the soil but excessive bacteria and some of the kind really harmful. The pH range for harmful bacteria is 7.5 to 8.5

Table 4.3: Bacteria disease name list

Bactria Name
E. coli
Estroptomyces
Erwinia
Rizomous
Agrobacteria

All these Disease are responsible for Bacteria Disease. The collected data for this kind of soil from the sensors are given below:

Table 4.4: Bacteria scenario's sensor data

pH	**Moisture**	**Temperature**
7.8824	80%	24^0 C
7.9531	82%	24^0 C
7.9955	78%	24^0 C
8.2311	84%	24^0 C
8.0202	83%	24^0 C
7.9713	79%	24^0 C
7.9944	81%	24^0 C

Graph representation:

Bacteria contained soil must have different type of characteristics and the figure 4.1.1 show the data representation below:

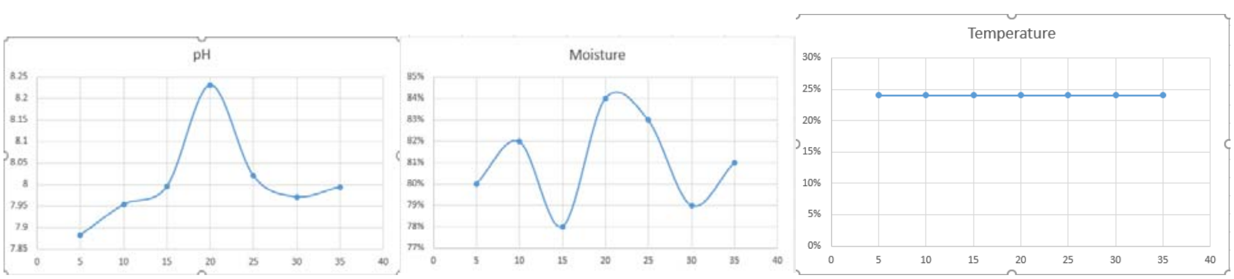


Fig 4.2: graph representation of sensor data of Bacteria contaminated in soil

Result: Based on pH data, moisture data and temperature data the result is following:

Category	Alkene
Type	Bacteria
Disease Name	Bacterial Wilt
Pathogens Name	Rizomous
Nature	Average harmful

Scenario 03: Nematode

Description**:** Nematode is also responsible for creating soil borne disease. The pH range for damping of is 6.5 to 7.5.

Table 4.5: Nematode disease name list

Responsible pathogen
Meloidogyne
Heterodera
longidorous
paratrichodorous

All these Disease are responsible for Damping-off. The collected data for this kind of soil from the sensors are given below:

Table 4.6: Nematode scenario's sensor data

pH	Moisture	Temperature
6.2325	75%	26^0 C
6.3598	72%	26^0 C
6.4512	71%	25^0 C
6.2939	74%	26^0 C
6.3345	72%	26^0 C
6.3741	76%	24^0 C
6.3077	70%	26^0 C

Graph representation:

Nematode contained soil must have different type of characteristics and the figure 4.1.1 show the data representation below:

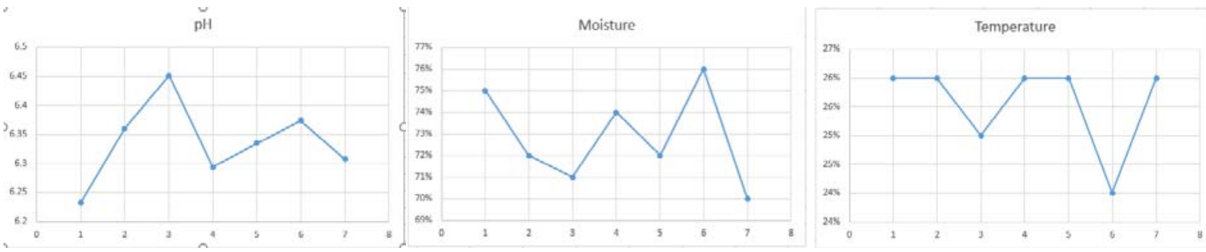


Fig 4.2: graph representation of sensor data of Nematode contaminated in soil

Result: Based on pH data, moisture data and temperature data the result is following:

Category	Alkene
Type	Nematode
Disease Name	Root Knot Nematodes
pathogen	*Heterodera*
Nature	Harmful

CHAPTER 5
CONCLUSION

5.1 Overall Conclusion

So therefore we can say that IoT has brought revolutionary change in monitoring, management and data analysis sector. Our framework can successfully detect soil borne disease for fungus, bacteria and nematode which will be great useful of agriculture sector. It is also efficient and cost effective. It is affordable. By using this framework sensor data can be stored and can be used for further analysis. Our classification algorithm provides result with great accuracy about 77.45% which is good for pH, moisture and temperature data. Besides we are successful in our test case scenario. We have successfully detect fungus, bacteria and nematode related disease in the soil and have shown the test result as evidence.

This framework provides services as we expected, though there is some lacking because every soil borne disease can’t be identified only based on this data. By implementing more set of sensors we can solve this problem and more features.

5.2 Future work

1. Image processing can be implemented with this system
2. Location based soil factor classification can be applied.

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