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Automatic Greenhouse Monitoring System

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A B S T R A C T

The purpose of this study is to design an automated system for a greenhouse and to monitor, control the system from a device through wired or remote access. This project addresses some of the issues in traditional farming. Issues like incapability of agriculture due to small and fragmented land holdings, risk in using manures and pesticides, lack of mechanization. The main part of the project is the module which will be referred to as AGMS (Automatic Greenhouse Monitoring System) and it consists of all the electronics and sensors needed for the work. There are also two more segments, one being the cloud and the other, the monitoring of data and control of the module which will be at the end user. It also discusses the various technical aspects of the module mainly focusing on the cloud and the end user also referring to the flexibility of the module itself.

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INTRODUCTION

As we know, agriculture is the main requirement above anything else and the traditional practices are just degrading over time. By the report presented by Forbes, till 2050 populace of the world will be more than 9.6 bilion thus prompting 70% expansion in nourishment utilization. Since there is constrained arable land the best way to conquer this emergency is to design astutely. It's now occurring, as the enormous enterprise are gathering information from crop yields, compost application, soil mapping, climate sway and so forth. A few undertakings are being accomplished for the practicality of PLF from lab to the homestead, which as of now has been demonstrated powerful in the lab. In Precision Livestock Farming (PLF), sensors are utilized for checking and early identification of multiplication occasions and wellbeing issue in animals.

Organic farming is advised as a more productive type of agriculture by observing the expanding effect of nourishment created by utilizing inorganic composts on wellbeing we are presently moving towards regular cultivating. As the efficiency is less in natural cultivating the requests of shrewd cultivating increments in this field. The latter is the smart agriculture which will be done by the means of sensors and automation. It can be called a climate smart agriculture. Climatic condition and GHG prompts littler efficiency yet we can build profitability at some degree whenever arranged appropriately, improved adjustment strength to climatic change.

In, addition, barren soil can be made rich by investigating its structure. Innovation like Water seer can be utilized at the spot of dried land which produces 11 gallons of water for every day with no work or outside vitality. The cloud is the crucial part of the module. It will include API, server, encryption techniques, social media platforms and general-purpose applications like IFTTT for simpler usage.

The main effort on the cloud will be the data transmission at a very low data rate so that this project is reachable to any part of the country. The end user part will be simple taking into consideration that farmers can use this with zero effort. The cloud will address the problems mainly the monitoring and control of any automated system without the need of human intervention.

LITERATURE REVIEW

The applications of the AGMS can be made use of in various methods of agriculture mainly being Aquaponics and Aeroponics. Aquaponics, which is widely used is a technique where plants can be grown on the surface of water without the need of soil. All the required nutrients will be externally provided. For this method to work, there will be a dire need of an automated system to regularly monitor the plants and the process. The problems in aquaponics like water flow control, regular plant humidity and soil moisture monitoring, greenhouse temperature, pH level of water, amount of nutrients in the water, food for the fish and many more will be rectified by this project. The project is divided into three main divisions' main module, cloud and end user.

The module has a MCU (Microcontroller Unit) as its heart and the MCU used is Arduino Mega. It is a fully programmable module will GPIO ports that can connect to and control multiple sensors. The different sensors used are for measuring Soil moisture, Temperature, Humidity, Water level, light intensity etc. Output devices such as Resistive touch screen, Node MCU (ESP8266), Buzzer, Micro SD card are also used. The main function of this module is to get the information from all the sensors at the regular time intervals (that provided in the code) and to transmit the data to the touch screen and through the cloud via the Wi-Fi module.

The whole module will be enclosed in a rugged waterproof case to protect the electronics in case of any mishaps like sudden rise in humidity or temperature. Each sensor will be modular i.e. they can be easy disconnected and replace when needed. The sensors will be connected to the ports of the module casing and can even be made wireless with the help of any Bluetooth or Wi-Fi module. The Wi-Fi module will be supporting 2.4 GHz as well as 5 GHz. The touch screen will be able to switch the sensors on and off and monitor the sensor data in the form of graphs.

METHODOLOGY

The monitoring system for this project is designed for two different applications. The first application is any hydroponics system up to 2m, this is ideal to implement inside homes or on a small terrace. This specific application does not need much data analysis and visualisation as the system will always be available for the user, also there will be a low flow of data. For this system Arduino, along with a Node MCU is used as the microcontroller unit and HTTP/ MQTT protocol is used. This system will be easy to maintain for any novice or anyone new to hydroponics. The advantages of this system are it is simple and cost-efficient. However, there are some drawbacks. To update any code or include any sensors, it will become difficult for anyone new as it requires plugging in the Arduino to a PC and uploading the code. So, it is safe to say that this particular design is not advisable to be modified. Also, it uses all opensource software, which helps to keep the costs low. The second application is for anyone serious about growing and maintaining the system and also who is interested to grow everything needed for home. This supports any area from a terrace to an acre of farming. This application requires a little knowledge about programming and is also not so easy to maintain. However, there is a lot of flexibility in this application. This flexibility is due to the use of cloud services such and Google Firebase, Amazon Web Services and custom Linux servers. This system will also take logs and save the data so that it can be used as Machine Learning data sets in the future. The main motive of this project is linked to this particular application. This also gives flexibility to include other sophisticated systems such as Machine Learning and Artificial Intelligence to predict the crop growth and pests. Also, it can be interfaced with much complex sensors such as spectrometers to study the plant quality down to its cellular level. There is no limit as to what to embed to this application in the future. The reason for considering two different systems is to really explore the area of Internet of Things and also include as much as software learning as possible to the system. This will truly help to unleash the power of IoT as once a software system is made in IoT, it can be linked with any hardware of the same architecture with just some tweaks.

1. Monitoring System with Thingsboard

For this, Arduino Mega and Node MCU are used as the main Microcontroller sub-system. The data is sent from Node MCU through HTTP/ MQTT (both cases tested). This uses the simplicity and flexibility of the Node MCU.The sensor data is picked up by the Node MCU and sent over to Things Board.

Now, to visualize data we can login to the dashboard and see the graphs in real-time.The data is visualised using a custom webpage built for the incoming data of thingsboard. Here, the inbuilt dashboard of thingsboard is not used. A new one is created using simple CSS (using Bootstrap 4) and Node JS.

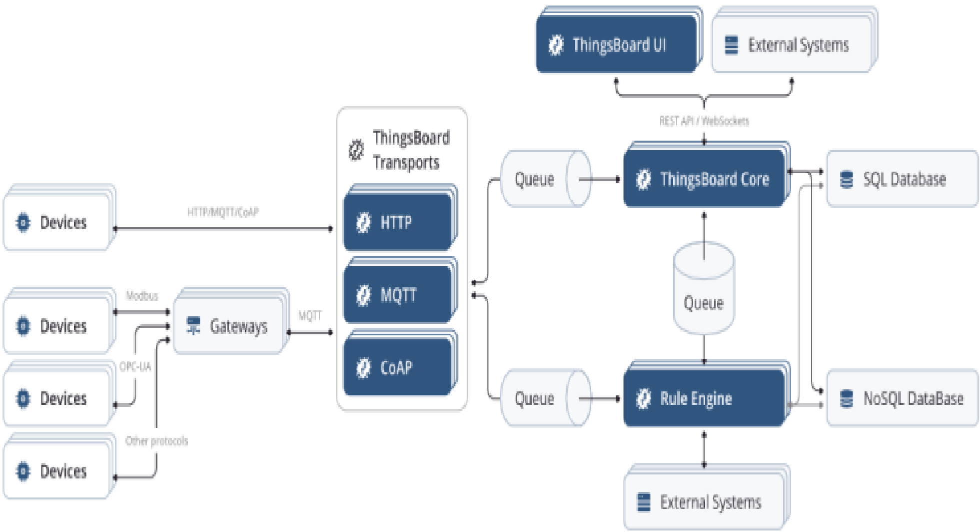

Figure 1. Block Diagram of the Monitoring System with Thingsboard

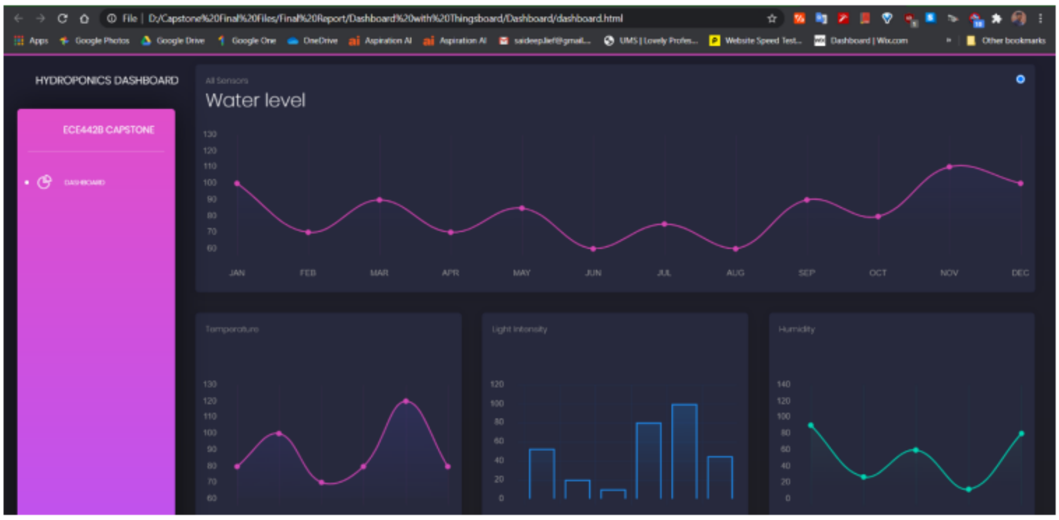

Figure 2. Dashboard of thingsboard

The devices, in this case our microcontroller is connected to a transport network directly which supports HTTP/ MQTT and CoAP. MQTT is used in this case. Then the data is queued one after the other till it reaches the IoT core. There, the data is processed and saved in a database and further, it is displayed through Thingsboard UI. With thingsboard, the data can be collected and visualized from the devices. The incoming data can be analysed along with the trigger alerts. There is also an option to control the devices using RPC (Remote Procedure Calls). Even workflows can be built which are based on REST API, RPC etc. The dashboards provided by them are also dynamic and responsive. Finally, the data can be pushed into other systems.

2. Monitoring System with Cloud Integration

This is the second monitoring system developed in this project. It really explains the motive of the project to minute details. This system is all about less hardware and more software. There is not any argument of software overpowering hardware because this is an IoT system, and in an IoT system, both have to co-exist. The hardware used as a Microcontroller is a Node MCU. A Node MCU is a low cost IoT platform with ESP8266 inbuilt and is open source. The reason of using a Node MCU is that it can directly connect to analog sensors and also, it supports burning into any Operating System. It also supports MQTT.The Operating system used with Node MCU is Mongoose OS. The system is developed using AWS. For this, many services of AWS are used. Such as Amazon S3, EC2, Dynamo DB, IAM and IoT core. Also, third party services such and Node RED and MQTTfx are used.

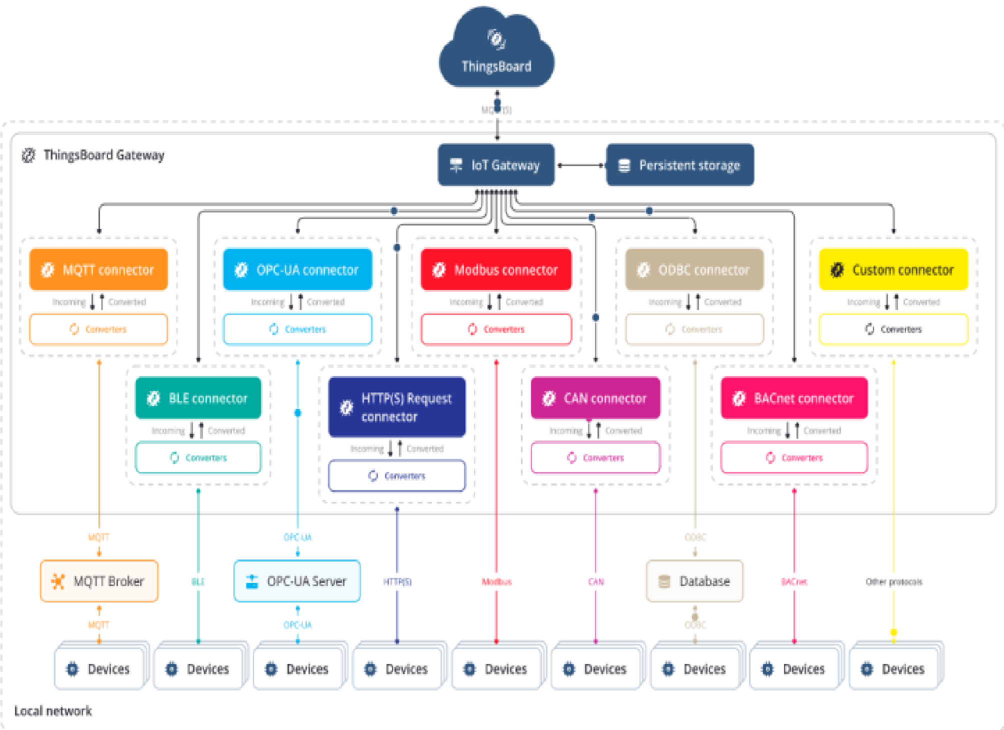

Figure 3. Block Diagram of Monitoring System with Cloud Integration

The whole thing works like this. First, a port on Node MCU is triggered with a changing value of a sensor. Then, the sensor value is transmitted through MQTT to the node specified in Node Red. Node Red forwards the packet to AWS IoT core which checks for the certificate and stores the data. This data can be accessed through the monitor tab of AWS or through embedding the HTML source code in any webpage. The main advantage of this system is that the updates of code to the project can be uploaded to Node MCU through OTA. Which means, here is no need of any physical connection from Node MCU to upload the code. It can be done through the Internet

RESEARCH RESULT AND DISCUSSION

As discussed earlier, the most crucial component of the project will be the cloud. The cloud is divided into three sub parts server, API, networking devices. The APIs used will help the interfacing of the hardware to the server. The server used will be an online cloud server which will run on Linux for good processing power. The specifications of the server will start from a minimum as 2GB of memory, 10GB of storage, minimum operating data rate as required. A domain will be given for the operation of the end user which will consist of a custom-made HTML page. The networking devices used for this project will be the Wi-Fi modules and any networking supported Micro Controller Units (when required).

For the simplicity of usage of the end-user, the data will be sent through a HTML website or a web-app. The data for each sensor will be displayed in the form of graphs and the alerts will be given in case if any sensor crosses the threshold. In case of any updates for the graphs or the software itself, they will be given Over the Air. Every individual sensor can be controlled through the friendly web interface i.e. they can be switched ON and OFF and the sensitivity of each sensor can be changed based on the type of crop production. The following figure depicts the block diagram of the AGMS.

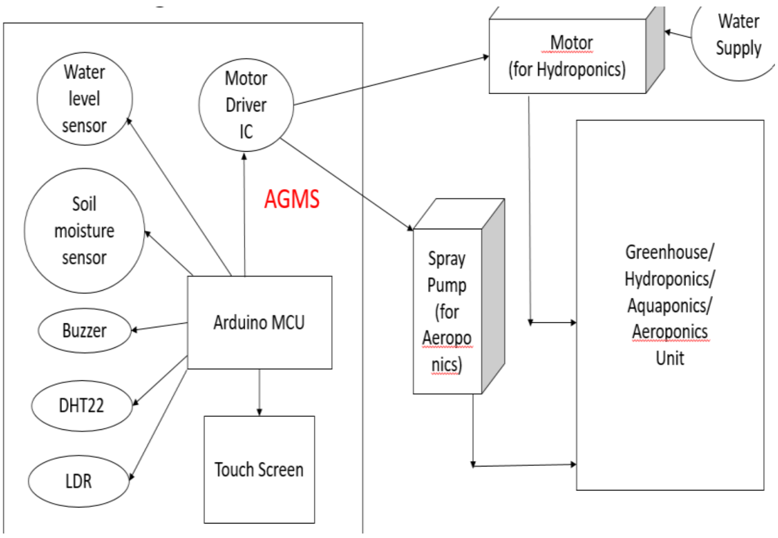

Figure 4. Block Diagram of the AGMS

Each sensor data is individually sent to the cloud without any cross dependancy. Every sensor fulfills it's significance. Starting from the water level sensor, which is the most crucial in aquaponics. Because, the water level of the base should be constant. If the level is more and crossing the root og the plant, then the plant dies. Same happens if the water level is less. Water level sensor also helps in controlling the water flow accordingly by a motor driver IC.The motor driver IC used will be a simple L293D breakout. It will be connected to the submersible water pump which will pump the water continuously to the main tube.

The soil moisture sensor helps in applications other than aquaponics, where soil will be used. For example, organic vegetable farming. It will help control the moisture level in the soil by alerting any crossover on the threshold value. This is an analog sensor which will require a conversion to digital values for the visual reading. An alerting device such as buzzer or a programmable speaker unit will be used in case of any alerts like crossing the threshold, failure in any sensor, over running of water etc. All the data will be visualized right on the main module using a touch screen display. This display will also help to control the behaviour of each individual sensor like turning them on or off and using them depending on the requirement. It will also show all the sensor data, both individual and combined in the form of graphs and any other specified output. It will also tell the internet speed, latency and the charging left in the module along with the module standby time and usage time left.

The cloud will run on servers from organisations like Digital Ocean and require a technical coding for maintenance. It will require python for networking, linux for server, secure shell in case of any other networking device.The end user will have a website and a web app, not an android due to simplicity. Those will be programmed in HTML, Java Script. Any updates for the website or the app will be pushed through OTA. The following are example of APIs used for the data visualisation of LDR sensor in Bolt IoT.

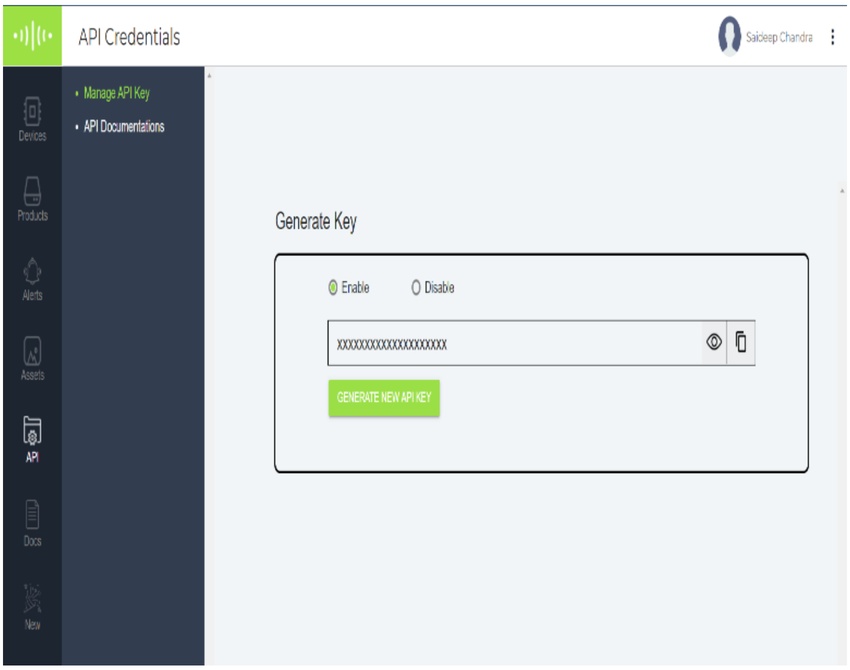

Figure 5. Data Visualisation of LDR Sensor in Bolt IoT

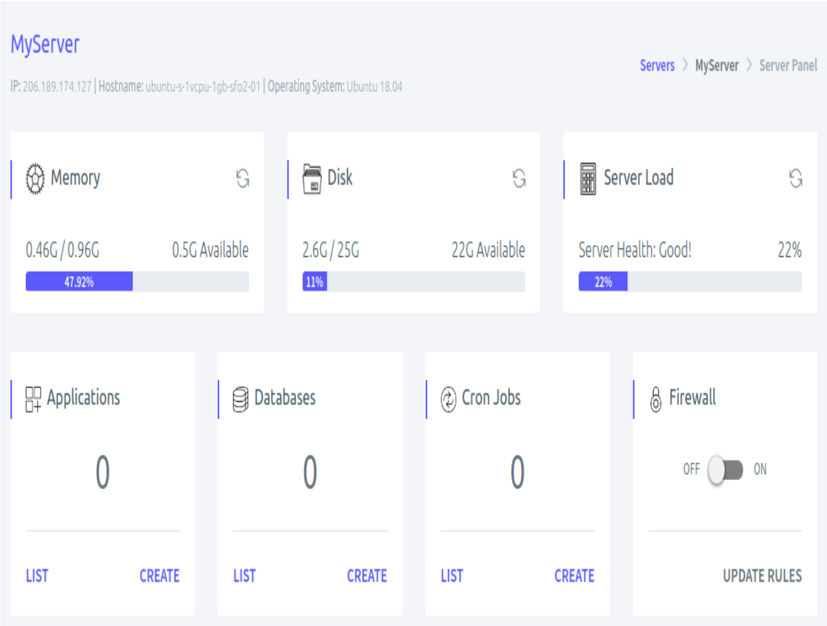

Figure 6. The Description of a Server in Digital Ocean

Digital Ocean has a feature called as droplets, and each droplet can be used as a separate function. They also have one click apps, various distributions and custom images. Distributions include Ubuntu, CentOS, Debian, Fedora, CoreOS and FreeBSD. One clicks apps such as Docker, MongoDB, MySQL and Node JS are also available. These will give a full functionality of the server. Also, third party apps such as IFTTT can be used to easily interface the sensor data for alerts on the phone as well as social media such as WhatsApp and Twitter.

Designing of Monitoring System

The monitoring system for this project is designed for two different applications:

1. The first application is any hydroponics system up to 2m, this is ideal to implement inside homes or on a small terrace. This specific application does not need much data analysis and visualization as the system will always be available for the user, also there will be a low flow of data. For this system Arduino, along with a Node MCU is used as the microcontroller unit and HTTP/ MQTT protocol is used. This system will be easy to maintain for any novice or anyone new to hydroponics. The advantages of this system are it is simple and cost-efficient. However, there are some drawbacks. To update any code or include any sensors, it will become difficult for anyone new as it requires plugging in the Arduino to a PC and uploading the code. So, it is safe to say that this particular design is not advisable to be modified. Also, it uses all open source software, which helps to keep the costs low.
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CONCLUSIONS AND RECOMMENDATIONS

Agriculture was the first occupation of human being, it is the foundation for all the Industries. The world population is increasing day by day and there is a requirement of food is increasing day by day. In India 3000 children die every day due to malnutrition. Government should take measures for encouraging new farming techniques like Aquaponics, hydroponics, Aeroponics, which have a high yielding rate which can beat the food crisis government should provide subsidy for the equipment and electricity.

The crop which was grown by the farmers should be sold for a reasonable cost and these steps should be taken by the government because the farmers are losing interest in farming.

The greenhouse monitoring system gives the flexibility of growing crops in any seasons. This enhances the moderate cost and availability of seasonal vegetables throughout the year. The crops which are grown with the techniques like hydroponics and aquaponics are free from pesticides which are now a day's called organic food. The techniques of Aquaponics and hydroponics gives the flexibility of soil because these process doesn't require any soil so any crop can be grown in any part of the world and the greenhouse has constructed anywhere in the world so import and export will be quite less any fresh vegetables will be available The greenhouse monitoring system, Aquaponics, Hydroponics, gives the employment to many people. This creates so much enthusiasm about the farming because the technology used in the modern techniques are very innovative so children and even the technology-based students show great interest in the society. The technology can be updated and increased by them. Agriculture should be a religion in the world. Everyone should respect the art of farming. Because everyone in this world who ever it may be should any powerful person in the country, but he also should eat the food what farmer grows.

ADVANCED RESEARCH

In writing this article the researcher realizes that there are still many shortcomings in terms of language, writing, and form of presentation considering the limited knowledge and abilities of the researchers themselves.

Therefore, for the perfection of the article, the researcher expects constructive criticism and suggestions from various parties.

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