

AGRI-NET: Smart Agricultural Infrastructure to automate Agricultural Monitoring Processes.

Souradeep Atar
Department of CSE
Institute of Engineering and
Management
Kolkata, India.

Debaleena Ghatak
Department of CSE
Institute of Engineering and
Management
Kolkata, India.

Abstract-This article proposes a futuristic model of smart agriculture infrastructure and irrigation systems which combines IoT and machine learning technologies. The ecosystem consists of P2P networks, LoRa WAN, and cellular networks (4G LTE CAT 1) to achieve two objectives, i.e., optimum data moving and low cost hardware. Slave node devices, which are spread across crops, establish P2P networks as they are sending packets to the master node. The Master node bridges the data connection, sending requests to nearest or Cloud servers through available Cellular networks and LoRa WAN. This data can be used to provide a wide range of services, including the detection of crop failure, automated irrigation, and recommendation of fertilizer dosages. Emphasis is given to minimal hardware to achieve industrial grade results.

Keywords-Smart agriculture, IoT, Machine learning, Peer-to-peer network, LoRa WAN, Cellular network, Cost optimization, Crop Monitoring, Irrigation System.

I. INTRODUCTION

Smart farming achieves the best performance using high technologies and data analysis to optimize agricultural production. In this regard, smart agriculture relies on ICT, sensors, automation, AI, and data analytics as a foundation to monitor, manage and control all the key operational areas of farming. The goal of smart farming is to address and solve all concerns related to agriculture, increase output, sustainability, and profitability, reduce environmental degradation, and preserve natural resources. It is a boon to agriculture which may embody future farming with forward-looking technologies that improve the farming practice in an unexpected manner. Smart Farming already developed and worked upon for many decades has certain objectives and aims to follow. The primary goal of smart farming is to ensure that resources like water, fertilizers, pesticides and energy are exploited fully. This can be achieved by employing sensors, data analytics and precision farming techniques that will enable farmers to tailor inputs based on crop-species and soil specific requirements thus reducing waste produced as well as minimizing environmental effect. Another key objective of this type of farming is increasing efficiency and profits for businesses engaged in agriculture through reduction in inputs costs; raising outputs; decreasing labour requirements.

Our project aligns to the basics of Smart Agriculture. We plan to build the infrastructure in such a way so that the issues related to agriculture are solved yet the cost is also kept at checks. We aim at creating a Smart Agriculture Management System that is economically viable and that makes use of the sensors that obtain vital monitoring variables such as relative humidity, temperature, soil moisture, and water flow rate in the real time. The system will use sensors to monitor water consumption for minimizing wastage and should be sprinkled with drip irrigation for better nutrient distribution. We aspire to change the landscape of small-scale agriculture, where farming methods will improve crop yields, resource management, and sustainable practices will become easier, and at the same time; the technology will be made cheap and easy to use.



II. Current Challenges in Traditional Agriculture

As for conventional agriculture, it has been facing a series of problems. Being unable to maintain farm productivity, while ensuring the community's expectations, getting by with water limits, discovering new opportunities, depletion of natural resources, increased climate risks, gender inequality, livelihoods disruption, and urbanization are the challenges that the farmers in arid lands face. The crucial point is that the farming methods that used to be in charge of the production without taking into regard the consequences to the environment and society. It is not without difficulties when it comes to the swap between the two farming practices. Farmers have to deal with going after completely non-chemical input, drastic changes at the farm level, and adjustments in their attitudes. Additionally, certain countries' public policies are going for the highest amounts of broad scale farming and give no solutions for farmers' choices, resulting in environmental issues. The issues are very complex and continuously developing, which translates into a need for a multifaceted approach implementation of measures aimed at sustainable farming, research, further education, and policy changes that are supporting the sustainability movement. These

issues encourage Smart Farming and have been a major inspiration to work on this topic.



Fig1 and Fig 2: Depict the issues of Traditional Agriculture practices.

III. Smart Farming Discussion

(A) Importance of Smart Farming

Small farmers must manage their farms efficiently. Conventional farming often leads to crop failure, wasted soil nutrients, and water. This happens due to imprecision and lack of live monitoring. Agriculture also faces issues like limited growth, high labour needs, reliance on climate, poor resource use, and limited information access.

Benefits of Smart Farming: Smart Farming maximizes resource use by using sensors and data analytics for better water, fertilizer, and pesticide use. This targeted approach decreases waste and environmental harm. It helps farmers make informed decisions about planting, irrigation, and crop care. This leads to better crop management, increased yields, and improved quality. Smart Farming reduces running costs by using resources more efficiently. This reduces the need for human labour while also predicting and preventing crop loss.

(B) Challenges in Smart Agriculture

While Smart Agriculture can be a huge problem solver, it has several challenges that need to be sorted. The redundancies present include high initial investment, data management and privacy, access to connectivity, complexity of technology. Adopting smart agriculture technology, thereby, involves a range of upfront investments that involve sensors, drones, robotics as well as data analytics infrastructure as well. This may be a limitation for contract small scale farmers or the farmers in developing countries. Farming 4.0 leads to numbers of data from many areas including sensors, satellites, and drones. Managing, analysing, and securing the data in compliance with the farmers' information privacy is a very topical challenge currently. Several smart AG products are from different producers and maybe not work with each other. Making certain that the modelling, intercommunication, and integration of these technologies is flawless is crucial to ensure that they serve their purpose.

A certain segment of the farming community will probably find the technology complicated and/or cumbersome to utilize, especially those farmers with limited experience in computerization. Therefore, it is of great importance for smart agriculture ideas to have user friendly interfaces and simplified solutions to ensure ease of access by all types of farmers.

(C) Future prospects of Smart Agriculture

Sophisticated techniques are used in new smart farming to achieve optimal farming processes, and generate output and sustainability. Here we will explore the future prospects of Smart Agriculture.

A very important futuristic approach of smart agriculture is development of Smart Greenhouses and vertical farms mainly to promote sustainability. Smart greenhouses and vertical farming systems will likely improve by the year, providing aquiline crops all year round in environments tailored for plants. Tomorrow's smart greenhouses will have climate control systems using state-of-the-art technologies, perfect LED lighting for photosynthesis, and irrigation optimized with automated delivery systems. The real estate of the vertical farms will be high stacking of plants or hydroponic or aeroponic cultivation to bring the crops closer to consumers which will make production of crops possible even in urban areas. Other important prospects might include integrating robotics and automation in Agriculture, Advanced Hydroponics or Aerial Agriculture.

IV. Evolution of Smart Agriculture

In the first agricultural revolution, the era of agriculture was assembled in a traditional way, tasks were performed with animals and people. In the Second Agricultural Revolution, things changed a bit, although most of the work was still done by hand, again a time-killing process. During the third generation, new technologies came into the picture, which made the development of agricultural activities more profitable. However, lack of relevant knowledge and lack of experts lead to mismanagement of agricultural activities. Finally, the fourth generation emerged with many technologies such as blockchain, swarm computing, big data, machine learning, deep learning, Internet of Things, cyber-physical systems, robotics and autonomous systems, generative adversarial networks and cloud edge fog computing. changed the era of modern agriculture. Recent advances in smart agriculture are significantly different from traditional farming practices due to the use of equipment, technology, machinery and equipment, including sensors, information technology and computer vision. The agriculture of the future depends on very advanced tools and technologies such as GPS technologies, robots, moisture sensors and aerial images. As part of the development of an intelligent agricultural system, several technologies such as cultivation, food sharing, mass farming, real-time data collection and processing must be integrated. Therefore, intelligent agricultural change leads to the development of the entire ecosystem with modern farm management. A real-time decision support system can improve productivity, resource allocation, adaptability to climate change, improve the food chain and detect crop diseases. Recently, computer vision has made another revolution in agriculture 4.0. Several researchers are working to automatically diagnose diseases using computer vision. However, this remains a difficult and erroneous task, since different non-infectious and infectious pathogens can cause similar symptoms in many plant organs. Detection and classification of crop diseases through continuous monitoring has been the main interest of researchers and agronomists in the current scenario. In the last decade, several researchers have presented an overview of the technologies that have changed the entire agricultural system in different parts of the world.

Project Description of Agri-Net.

I. Proposed aim of our project

The key feature of our system is that it helps to fully automate the field processes using precision tactics. This automation frees the farmers from data scrutiny and absorption. Building a sensor-based device within it having different sensors connected and is applicable in measuring the soil water level, ambient temperature, air humidity, water flow rate, water volume, soil nutrients and alkalinity.

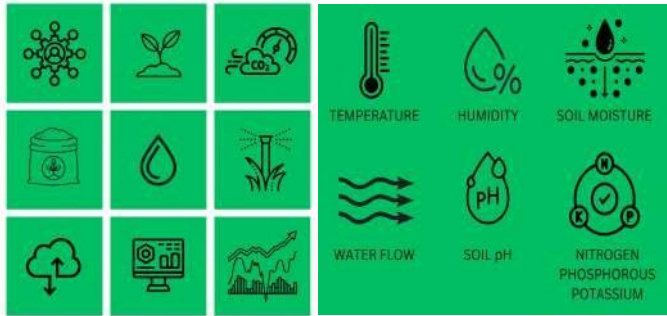


Fig 3 and 4: These pictures represent the aim of Agri-Net

employing several sensors and agricultural equipment to automate the farming process. If the moisture or mineral content is below the threshold value, it will automatically trigger the pumps and sprinklers, calculate and distribute the amount of fertilizers and pesticides, etc. Besides, the farmers can set a manual timer which will activate the irrigation equipment automatically at equal intervals. They can also access the entire data in the portable dashboard from their phones and personal computers and monitor the condition of each block. The app also helps educate farmers regarding the needs of different crops, the types and amount of fertilizers and manures to use, etc. The data is also collected in a central server for intelligent analysis and gives insights like early warnings of potential crop failures, Weather Forecast and fruitful recommendations.

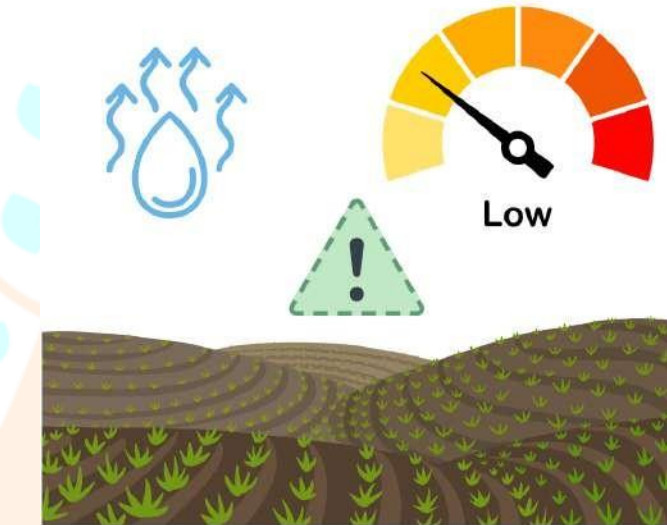


Fig. 6 and 7: These Figures depicts the automation of the field. When Soil Moisture level is critical, or to maintain an optimal water content, the pumps are automatically turned on, so human intervention is least necessary.



Fig 8: Shows a scene of many sprinklers watering the crops which is a form of precision agriculture.

II. Working of our Project

We have split big fields into several blocks and then adequate sensor node devices are installed in these blocks. These precision farming devices have sensors such as Temperature and Humidity sensor, Soil Moisture sensor, Fluid Flow Sensor, NPK Sensor, etc., along with the other control devices for regulating the on-field pumping, valves, and sprinklers.

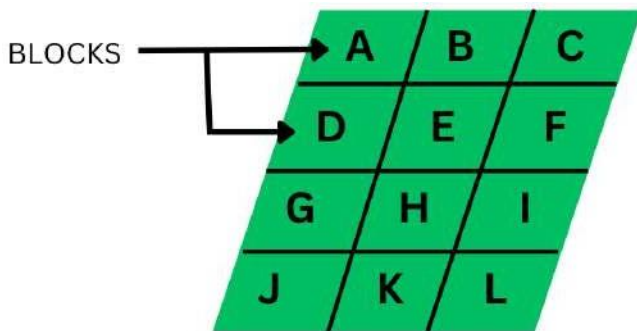


Fig 5: The above given figure represents a segment of the infrastructure being built. The above arrangement shows a big field being divided into small blocks.

WiFi has allowed the nodes to create a Peer to Peer(P2P) network which helps them to communicate and share data with one another. The main advantage of a P2P network is that it is decentralized, Fault Tolerant and highly scalable.

There is one Master Node and several sensor nodes scattered in each block. To save cost we have used just one node to act as a network internet gateway for all the sensor nodes using 4G LTE CAT-1 cellular network, and for places where there is no access to proper internet connectivity we have used LoRaWAN to forward the data to a distant data storage facility.

As many sensor nodes can be added to the existing infrastructure making it highly scalable and flexible, and also extremely cheap to operate.

The device provides a Real-Time administration of the field

III. System Architecture.

Like working principle, technology, aim of the project, our project Agri-Net has a layered system architecture that it follows. As we plan to create the project at an industrial scale, we have a structured format to build the project. We plan to create a network of node devices, create a storage server, transfer the data from the devices to a server and a Real-Time Dashboard and vice versa, using a suitable light weight protocol, which has low overhead and can work in low bandwidth conditions.

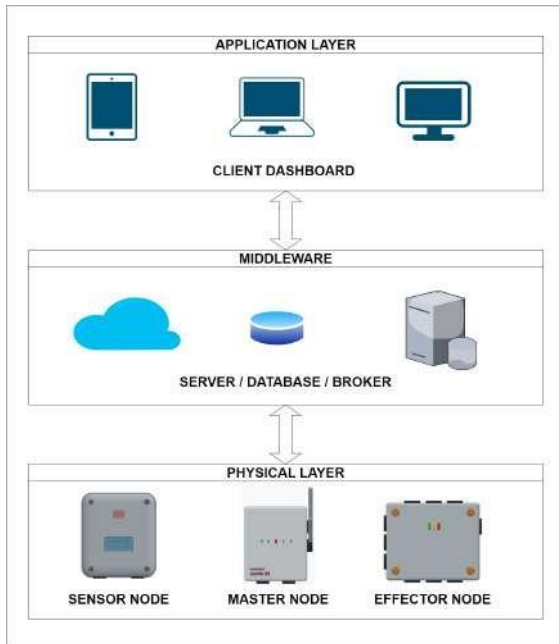


Fig 9: A Simplified Layered Representation of our project, which shows resemblance to the OSI-Model, starting from the Lowermost Physical Layer to the Topmost Application Layer.

Emerging technologies like IOT and machine learning along with other latest trends like 4G-5G connectivity and modern actuators and sensors are integrated to harmonize in a niche environment. Since we are using a 4G cellular network to access the internet, We are using a protocol based on the TCP/IP model, and is very reliable in terms of functioning on low power devices. The MQTT (Message Queuing Telemetry Transport) is a lightweight, publish-subscribe messaging protocol designed for IoT devices. It operates on top of TCP/IP, ensuring reliable communication over unstable networks.

| TCP/IP Layers | IoT Protocols |
|---------------|---|
| Application | CoAP, MQTT, HTTP, AMQP, Others |
| Transport | TCP, UDP, DTLS |
| Internet | TCP, 6LoWPAN, RPL |
| Network | IEEE 802.15.4, IEEE802.11/b/g/n/ac/ad/ah/ax, IEEE 802.3 Ethernet, GSM, LTE, LPWAN |

Fig 10: A reference presentation of the OSI-model, which shows all the protocol stacks in a layered format.

The figures 11 and 12 show the layers of the project's architecture. There is a master node which will act as the central hub of the infrastructure. The master node acts as a network internet gateway. The Master Node and multiple Sensor Nodes and Effector Nodes are arranged in a P2P network using WiFi to communicate with each other. The Sensor Node sends data packets to the Master node and the Effector node receives data packets which consist of commands and activation sequence of the agricultural equipment like pumps, valves and sprinklers. The master node publishes the received data packets to a Cloud MQTT Broker with a Topic name using MQTT protocol. The storage servers and dashboards can fetch these data by subscribing to the Topic name.

As our infrastructure is built on networks, we are deploying strategies used for establishing efficient P2P networks. These connections form the basis of the system architecture. Places where the availability of cellular networks is limited, technologies like LoRa WAN are used to form the network. Local and cloud servers are integrated for ease of use.

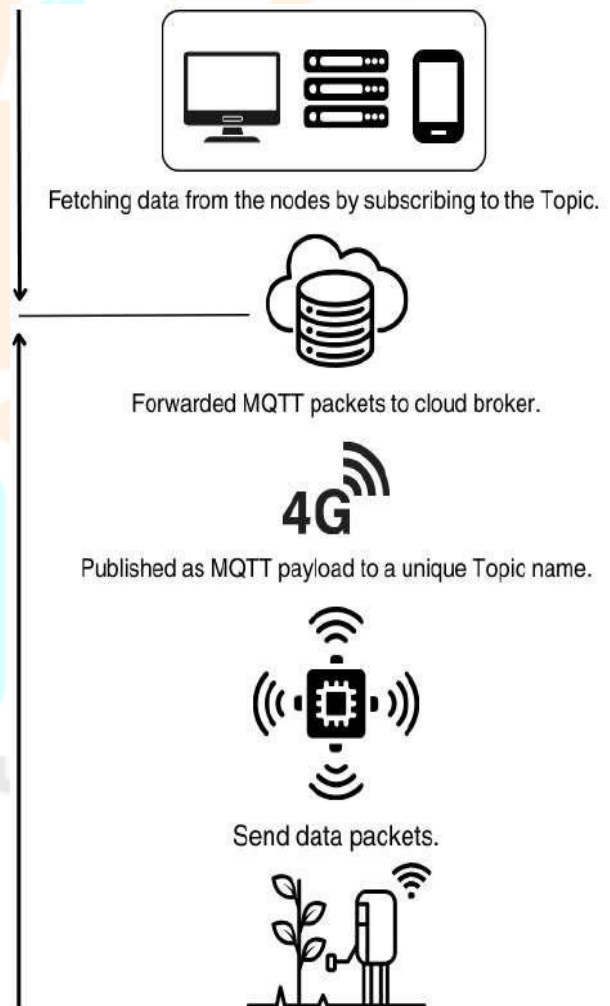


Fig 11: A simplified view of the system architecture.

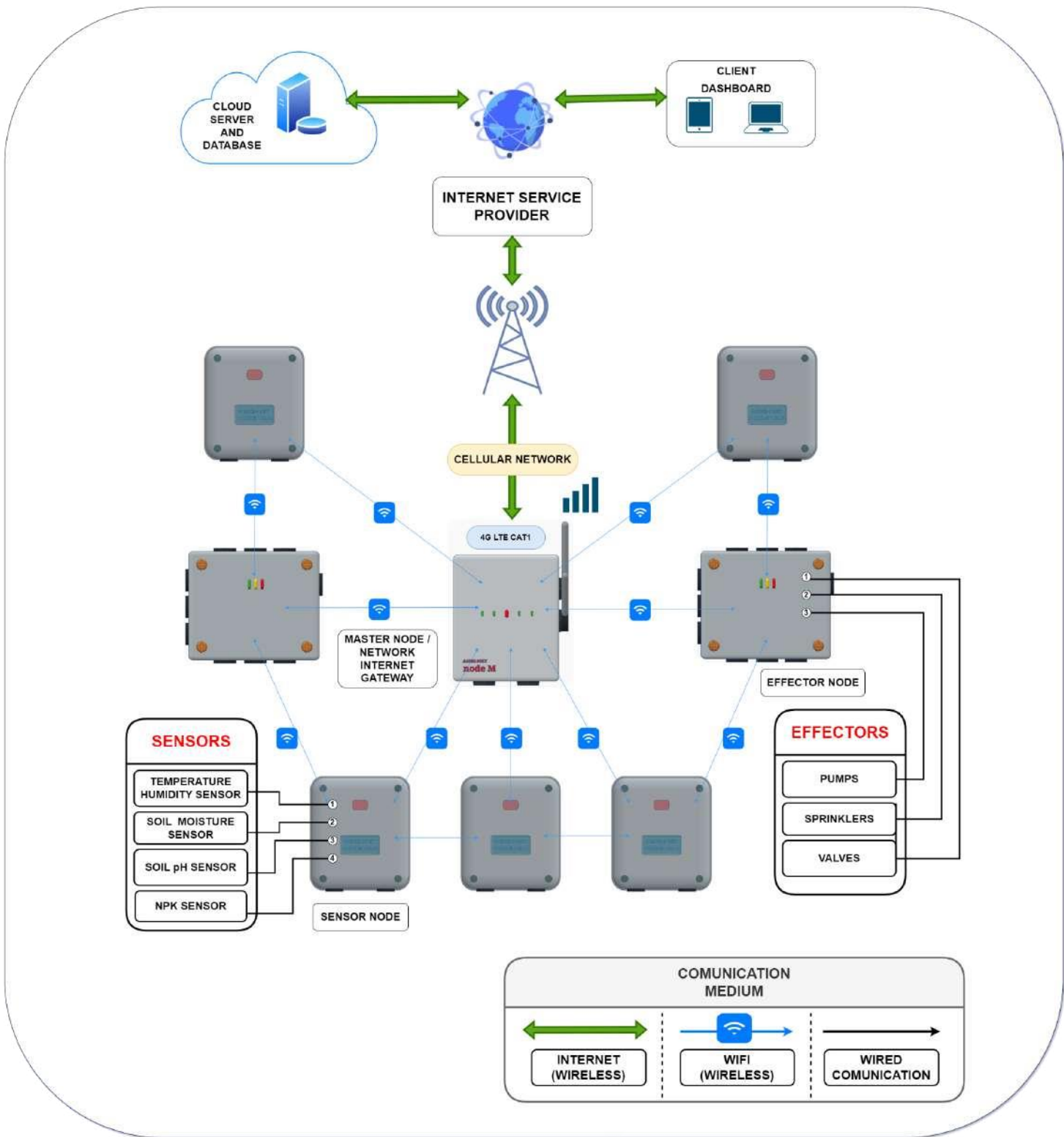


Fig 12: Comprehensive System Architecture of our project, which shows the arrangement of Sensor and Effector Nodes along with a Master Node in a P2P network. The Master Serves as a Network-Internet-Gateway to forward data packets to the cloud.

IV. Technologies utilized in our project.

(A) Peer-to-Peer (P2P) Network:

Peer-to-peer (P2P) is characterized as a decentralized organized engineering in which members, called peers, are associated straightforwardly with each other without the requirement for a central specialist or server. In a P2P organization, each member acts as both a client and a server, empowering them to share assets and administrations straightforwardly with other peers. The biggest advantage of this organization is that it is dependable, reliable, proficient, profoundly adaptable and blame tolerant. P2P systems encourage coordinated communication between peers. Peers can connect with each other without mediators, permitting for productive and real-time communication. In case one Peer goes down it would not influence others in any way.

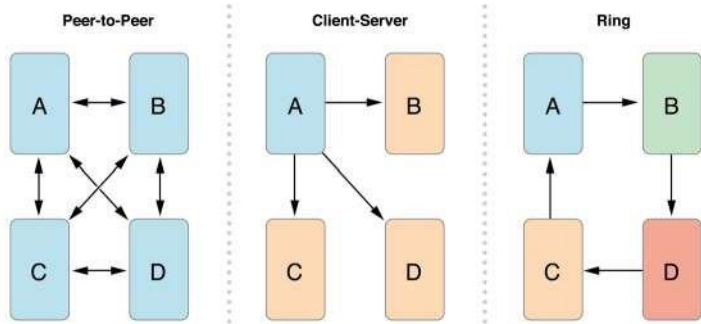


Fig 13: Some commonly used Network Topologies.

In our application we are ready to include or remove any sum of sensor or effector hubs sent within the foundation and will communicate with the existing ace hub without any issues.

(B) Cellular Network (4G LTE CAT 1):

LTE Cat-1 is a variety of 4G LTE innovations planned particularly for the Web of Things. LTE has more than 20 particular Client Hardware (UE) categories that characterize particular uplink and downlink capabilities. The lower the category number, the slower its information speeds are. This implies LTE Cat-1 devours less control and is less complex than higher LTE UE categories, making it superior suited for battery-powered gadgets. Separated from its competitors like LTE-M and NB-IoT, LTE Cat-1 has a more extensive scope since LTE CAT-1 is displayed all over so that 4G/LTE is accessible, and wandering is not restricted. This implies that gadgets can effortlessly switch to a distinctive arrangement in case there is no scope in the particular area, giving way better association and unwavering quality.

| | LTE (Cat 3-12) | LTE Cat-1 | LTE Cat-M1 |
|--------------------|----------------|-----------|---------------|
| Worldwide Coverage | Excellent | Excellent | Poor / Medium |
| Bandwidth | 20 MHz | 20 MHz | 1.4 MHz |
| Downlink rate | 100-600 Mbps | 10 Mbps | 1 Mbps |
| Uplink rate | 50-150 Mbps | 5 Mbps | 1 Mbps |
| Power consumption | High | Medium | Very low |
| Cost | High | Medium | Low |

Fig 14: This table shows the variants of LTE UE and compares them with each other.

(C) LoRa WAN:

LoRaWAN is a low-power, wide zone organizing convention built on the best of the LoRa(Long Extend) which is a remote tweak strategy determined from Chirp Spread Range (CSS) innovation. It encodes data on radio waves utilizing chirp pulses. LoRaWAN is a Media Get to Control (MAC) layer convention built on the best of LoRa balance. It is a computer program layer that characterizes how gadgets utilize the LoRa equipment. It wirelessly interfaces gadgets to the web, reviewing communication between end-node gadgets and organizes portals.

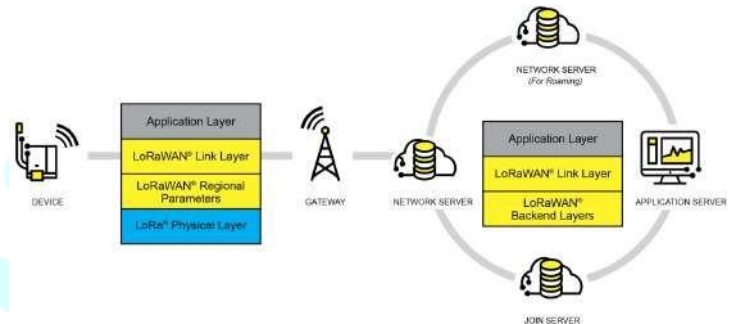


Fig 15. LoRaWAN Architecture.

LoRaWAN can be utilized in places where the accessibility of cellular systems is restricted. Input of a 4G LTE cat-1 modem we can utilize a LoRa radio module and send and get information from far-off information capacity centers.

(D) MQTT (Message Queuing Telemetry Transport):

MQTT is a lightweight, publish-subscribe, machine-to-machine organize convention for message queue/message lining benefit. It is planned for associations with inaccessible areas that have gadgets with asset imperatives or constrained arrange transfer speed, such as in the Internet of Things (IoT).

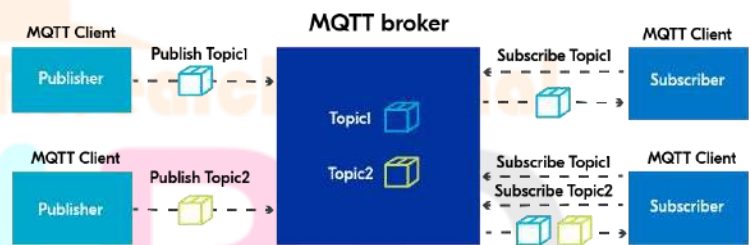


Fig 16: Working of MQTT mechanism

After getting Information Bundles from the Sensor Hubs, the Ace hub distributes the information to a Cloud MQTT Broker utilizing a special Theme title and the Application Server brings the information from the broker by subscribing to the Subject title.

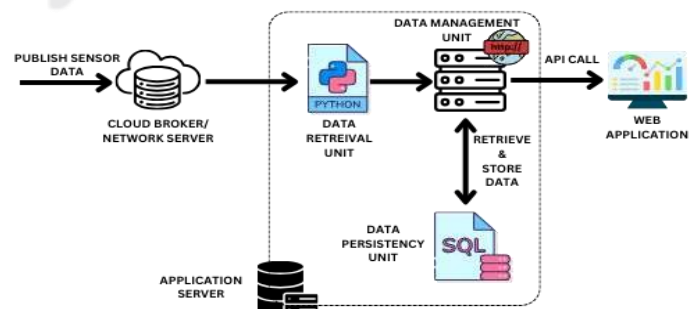


Fig 17: Representation of server side data flow.

V. Implementation of the project.

Starting with the Keen Horticulture Framework and Water system Framework, numerous off-the-shelf equipment components and Open-Source software are utilized to minimize the toll and empower bother-free integration.

(A) Hardware Selection and Configuration:

Microcontroller Unit (MCU): The chosen ESP32s3 MCUs coordinate with the entirety of hub gadgets because of their energy-saving, built-in WiFi, and solid information processing.

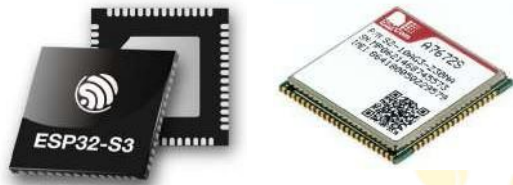


Fig 18 and 19: The Microcontroller and the modem

4G Modem: On the lower side of the optimization, the ace hub would utilize as it was one SIM M3316G A7672s 4G Modem that interfaces to the web. This comes to an extraordinary lesson in the toll of panhandles done through the establishment of one modem to cover arranged gadgets as differentiated with the situation of conveying a modem to each hub gadget.

(A) Network Configuration:

Peer-to-Peer(P2P)Network: The hubs are made accessible and associated into a P2P ad-hoc WiFi arranged in this manner permitting them to build a mesh-like environment without requiring the clusters to go through any middle person to get to point. The foundation implies an improvement of versatility and adaptiveness which is basic to guarantee compatibility with diverse field sizes and plans in cultivating environments.

This way, the information is not transmitted through the arrange layer, the transport layer, the session layer, the introduction layer, and the application layer. Moreover, there is no requirement for bundle headers or unpackers on each layer, which leads to a speedy reaction diminishing the delay caused by parcel misfortune in congested networks.

Internet Connectivity: On being served with information from the sensor hubs by an ace hub, the coordinates modem that capacities on 4G LTE Cat-1 stage are utilized to make a web association. In this regard, this association licenses the going before information bundles into the coordinated servers which might be either in the cloud or nearby capacity for encouraging handling and analysis.

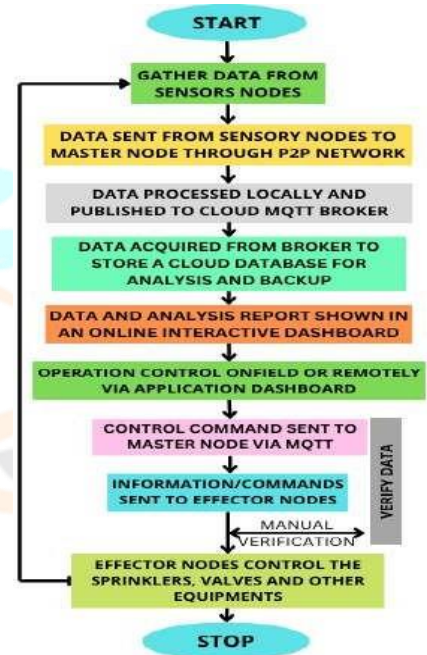


Fig 21: Flow Chart of the entire process.



Fig 20: This shows how the ESP-Now works. The one which sends data(Sensor Node) is called the initiator and the one which receives is called the responder, the connection is full duplex.

ESP-NOW Protocol: To transmit information parcels from the sensor hubs to the ace hub without the issue of tall control utilization, the ESP-NOW convention instep has been utilized. Between the gadgets, this convention passes on information in the data-link layer level in this way minimizing communication and misconduct rate as it is absent with the need for higher OSI demonstration levels

(B) Data Transmission Mechanisms:

Structured Data Packets: The little remote hubs collect organized information groups that join parameters such as temperature, stickiness, soil dampness levels, etc that are important for agrarian purposes.

ESP-NOW Protocol: Hence, these information bundles are conveyed to the mother/master hub by the ESP-Now convention that employs the coordinate communication properties of WiFi. ESP-NOW is a remote communication convention based on the data-link layer, which decreases the five layers of the OSI to as if it were one.

(C) Integration and Interoperability:

Interoperability: The carefully compiled equipment, counting ESP32s3 Hub MCU and SIM A7672s 4G LTE Cat-1 Modem, would be superbly synchronized to give compatibility that slips smooth and productive operation. The design of the framework is planned to be adaptable, giving the plausibility to extend the case number of the agrarian sensor hubs, by putting them in distinctive areas, this together being associated with the central ace node.

Cost Optimization Strategies: Minimizing the number of equipment components stresses on occasion i.e. at the slightest 4G modem interfacing $n > 1$ hubs, gets to be a vital calculate for a steady and productive framework foundation, which implies for numerous hubs we are utilizing one 4G modem, cutting the fetched of the foundation significantly.

Reduced Hardware Components: Less utilization of a modem and in this manner, lower costs both for the arranged operation and for the memberships to the cellular network are provided.

Elimination of Local Servers: The rancher ranchers with a small-scale cultivate, utilizing a versatile application, require no foundation of expensive neighborhood servers or information centers which compares to higher operational costs. **Integration with Existing Foundation:** The design is implied to work inside the existing water system framework in a simple way diminishing costs of execution.

VI. Applications of the project.

This project will change and make agriculture even more revolutionary. This in turn will contribute in minimising the loss of crops and the method will be of benefit to all the farmers. Besides the farmers load reducing will this project have. This project is used not only by farmers but also by all other people throughout the county. As it can be done on any type of farm, this project is a good fit for those who grow food. Besides that the grid system, although in gardens of large size, nurseries and greenhouses, can be used in agricultural fields of large areas since the existing network can be developed to a wide range. Agriculture has a list of various real-time applications as well. We know that there are various problems in current agriculture due to unpredictable weather, frequent droughts, erratic rainfall which leads to soil erosion leading to improper growth of crops and crop failure as well. Our system will help in detecting the abrupt weather conditions thus preventing crop failure. They will do this by using soil, humidity, temperature sensors to estimate the parameters and check properly. These techniques are also used to efficiently detect crop failure.



Fig 22 Detection of soil moisture and humidity using sensors

Other than this, our project will have many other applications as well. We know that irrigation is very expensive for small-scale farmers. Through our Smart Agricultural Infrastructure, we can easily automate irrigation with ease and help the farmers to get better produce at a lower cost and less time. This will act as a boon to the farmers especially those from drier parts where rainfall is irregular and irrigation is the only source of cultivation. Another aspect where our project will have great application is the use of fertilizers. Fertilizers are usually composed of NPK and various chemicals which can often damage crops. So our agricultural infrastructure aims to provide ways and algorithms to help farmers use environment friendly yet useful composts to get better results. This system also provides real-time monitoring and control to farmers. Along with all these applications our project has several other utilities as well. Our project plans to grow in the field of Precision Agriculture. Our project already involves GPS, sensors etc.. which will help in taking the data with precision. This is an advanced approach which can help farmers in the long run. This structure will also help largely in livestock management which can ultimately create great benefits for the farmers as cattle is still an integral part of cultivation. This project will also help in Soil Health Monitoring and will check the soil moisture, soil content etc. This project will also play a great role in predicting weather and market trends for better agricultural practices.

The project will also have applications in crop rotation, crop monitoring etc.. This project has great applications in the industrial scale as well. As our project is aimed at reducing the cost yet using the better technologies, we should use this project to get the best results. Smart Agriculture helps to give optimised results in less time.



Fig 23: Automated irrigation system



Fig 24: Crop failure detection images

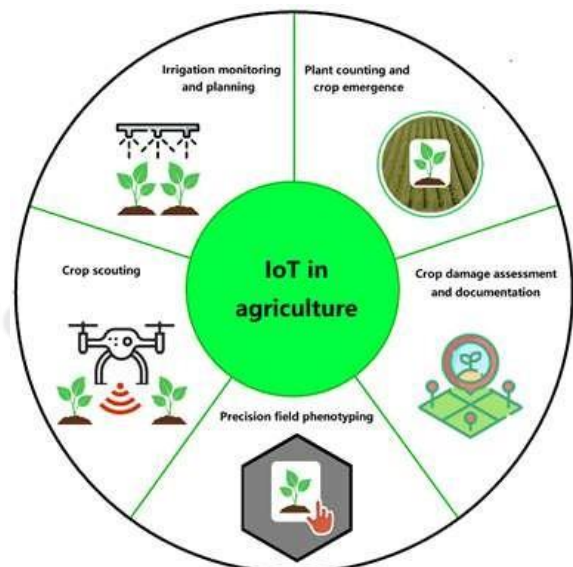


Fig 25: Various applications of Project combined

VII. Conclusion.

This paper proposed the use of technology, mechanized ways to customize and automate the agricultural monitoring process. We had learnt a lot while doing this practical project. We have aimed at reducing cost as well as using efficient technologies for helping farmers at grass-root levels. We have learned to create an optimised system architecture so that the devices can be efficiently used. We have a lot of future plans to grow on this project as well. For now we have implemented the Internet of Things and some new emerging technologies in this project. We plan to create a software system that will integrate the concepts of machine learning and artificial intelligence. For the long term we plan to create a fully automated agriculture infrastructure that will give the most desired plans. This project will help reduce the wastage of crops and reduce the workload of farmers. Our product will definitely help revolutionise the conventional techniques of agriculture. This will boost the production of crops, thereby helping to attain the Sustainable Development Goal of "No Hunger". We'll be able to eradicate hunger through our project. This project will not only eradicate hunger but will also provide easier yet efficient technologies to farmers specially for irrigation and crop cultivation.

A developing country like India where agriculture is the major occupation we need advanced agriculture techniques to boost the GDP and overall economy of the country. For these reasons, we have targeted this project on Smart Agriculture that too at a lower cost and better effective to give the best results. The technological improvements of the recent decades offer us new possibilities in everything we do. Our lives are an open book of benefits and risks connected with these newly emerging technologies. This one is believed to be the factor behind making our life convenient by the possibility to use whatever resources anytime from any place. Arguably, M2M, is recognized as IoT, and by the fact that it has created a community (mainly, where sensor data is collected continuously and transmitted to either the internet or to sensors for the appropriate action) which is large. The study demonstrated that small-scale farmers were vulnerable, which is linked to high degree of risk exposure and hence reducing existing and future risks is very crucial. Seeing all the benefits, challenges through this paper, our project will provide a futuristic approach to develop this project. Lastly at the end of the project, we would like to acknowledge and specially mention our mentor **Bijoyini Bagchi, Assistant professor, Department of Computer Science and Engineering, Institute of Engineering and Management, Kolkata**. We would also extend our heartfelt and warm greetings to our friends and family who encouraged us in the entire process. We are determined to inculcate our learnings for future projects and estimate the results effectively.

We are determined to inculcate our learnings for future projects and estimate the results effectively. We really hope that our research through this project will help the small-scale farmers at the grass-root levels.

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