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A Practical Implementation Smart Farming Using Recommendation Routing in WSN

S. Siva Rama Krishnan*, T. Arun Kumar

Abstract--- The objective of this paper is to automate crop supervision using Wireless Sensor Network (WSN). The main importance of the work is to help the agriculturalists improve the yield of the crop by trying to eliminate the human errors and the consequences which follow them. This is done by trying to maintain the optimum crop requirements in the Green house. The automated system also enhances measures for burst nature of data being transmitted the amount of traffic exceeds the speed of a link. At this point vulnerabilities of a network, causes failure at a moment, delay in delivery, reduced throughput and loss of packets in network. The framework takes intelligent decisions in order to help maintain the required conditions by proposing routing mechanism called recommendation routing. The Wireless mode of data transfer establishes a Wireless Sensor Network (WSN) which nullifies the problems that arise due to wired mode of data transmission. The main aim of this work is to automate the crop management using wireless sensor networks and proposing a dynamic routing mechanism to address the efficient data transfer in node.

I. INTRODUCTION

In today's world, Agriculture is one of the most important areas of human activity worldwide. Due to the surge in population there is a need to rise the agricultural production. Agriculture is becoming a very data rigorous industry where farmers need to gather and assess a huge amount of information from a varied number of devices (e.g., sensors, farming machinery, meteorological sensors, etc.) in order to become more well-organized in creation and connecting appropriate information [5]. The farmers find it extremely difficult to keep track of all data. Hence, in order to decrease the complexity of farmers, the concept of precision farming is introduced.

Precision farming denotes to detecting, gathering and distribution of data to a control station for decision making and trigger according to the decision [7]. Climatic conditions, soil fertility determine the scope of each crop. Since they are not deterministic, agriculture becomes challenging. Hence, the authors have integrated wireless sensor networks (WSN) with modern agro ideas with a proposed routing mechanism to address node failure.

Smart Farming help farmers and agriculturist manage details related to crop cultivation, soil education and to match efficient land use with their needs. Site specific databases must be built so that the crops are managed. Decision support systems with a strong knowledge base built from sensed parameters. The sensed data [7] are the environmental circumstances like weather, temperature, wind speed, wind direction, soil humidity, physical and chemical properties of the soil like pH level, crop identification, leaf moisture content, leaf area index, weed-disease discovery.

Farmers are facing water scarcity and soil infertility as major problems. All these problems are addressed in this method thus making farming smarter. In this paper, sensors are used to estimate temperature and moisture which can help in providing at most care to each plant in a farm. Monitoring agricultural features such as temperature and humidity along with other aspects performed for a remote monitoring system using Wi-Fi. These nodes direct data wirelessly to a central server [9], which gathers the data, stores it, allows it to be examined and exhibited as needed. The knowledge base here is an IOT (Internet of Things) platform that trails all the result. Based on these values, the soil moisture sensor node activates the water sprinkler during the period of water scarcity. Once the field is spread with adequate water [10], the water sprinkler is switched off. This way water is preserved and the crops grown are in good health.

The practice of Internet is attainment more and more importance. Under the concern of cost and redundancy, multiple link arrangements are necessary to decrease the network traffic congestion for a network to connect to the Internet. Congestion may occur due to buffer surplus, channel conflict, packet crash. This leads to packet damage which causes a reduction in throughput and lifespan. Maximum throughput, energy efficiency and least error rate can be attained by curtailing the congestion. A number of quality of service (QoS) techniques has been established to mend the quality of the network. This work deals with network improvement framework to abridge the difficulties related with studying customer network problems and making scalable solutions which can provide ideas to improve effectiveness of network. This framework may also act as a network analyzer to suggest various steps to be implemented to improve the performance of the current network.

The objective of this paper is to build a dashboard that controls all the devices inside the greenhouse and another dashboard that remotely receives the values of the sensors. For Example, Sprinklers are automated from the readings taken from the soil moisture sensor. Manual effort is reduced and performance efficiency is high in our system. The main importance of the work is to help the agriculturalists improve the yield of the crop by trying to eliminate the human errors and the consequences which follow them. This is done by trying to maintain the optimum crop requirements in the Green house.

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The automated system also enhances measures for burst nature of data being transmitted the amount of traffic exceeds the speed of a link. At this point vulnerabilities of a network, causes failure at a moment, delay in delivery, reduced throughput and loss of packets in network. The framework takes intelligent decisions in order to help maintain the required conditions by proposing routing mechanism called recommendation routing. The Wireless mode of data transfer establishes a Wireless Sensor Network (WSN) which nullifies the problems that arise due to wired mode of data transmission. The main aim of this work is to automate the crop management using wireless sensor networks and proposing a dynamic routing mechanism to address the efficient data transfer in node. This is executed by classifying the node which are actively participating in routing process. By implementing this mechanism, the packet delivery ratio and node failure rate can be calculated. This routing framework also make the WSN network more efficient.

Section 2 discusses about the literature review. Section 3 and 4 discusses about the proposed system overview and design. Section 5 converses about the real-time system implementation of the proposed system.

II. LITERATURE REVIEW

There arediverse applications of zigbee based wireless sensor network in agriculture such as checking of environmental conditions [7] like weather, soil moisture content, soil temperature, soil fertility, weed-disease detection, monitoring leaf temperature/moisture content and nursing growth of the crop, precision agriculture, robotic irrigation facility, storage of agricultural products. The limitation with the aforementioned work is it focuses on the aggregated routing mechanism used. Context aware mechanism has to be implemented for resource constraint network.

In [8] the authors proposed a model consists of a wireless conjunction node, sensor nodes and the server. A sensor node comprises a data sampling module which finalizes the real-time dimension of temperature and humidity, and a wireless transceiver module which obtains the data sampled by the data sampling module and directs the data to the conjunction node. Node failure is a major challenge. The limitation of this work is that single point of disaster may occur and data loss also may happen due to blocks at server.

The soil pH value [10]gained from the sensor is poised by the base station node and reported to the PC attached to it. The proposed WSN system will be able to connect data poised to the farmer's mobile via GSM technology and to activate the water sprinklers during the period of water scarcity. The limitation of this work is that congestion of data from node is not addressed. Queuing technique may be used to avoid data clogging. This scenario may be a failure if there is no mobile network

The wireless connection [11] is implemented to acquire data from the various sensors. The limitation of this work is that Data clogging may occur. Queuing technique might be used and priority can be assigned for packets.

The switch tool of microclimate [12] into greenhouses through the employment of an infrastructure of Wireless Sensors Network to switch environmental parameters. Sensor data accumulation efficiency is a challenge and producing a dynamic routing scheme in case of link failure is also a challenge.

Checking soil moisture undercurrents in the top soil to a detail, in both space and time, apt to analyze the interaction between soil moisture dynamics and plant physiology [13]. The arrangement consists of 27 locations (verticals) linked by a multi hop WSN. Dynamic routing is a major challenge and accurateness of data collected from sensor and delay arose in aggregating data is also a challenge.

A WSN system was deployed that consists of an array with a centrally situated receiver connected to a laptop computer and multiple sensor nodes in a field [14]. The system has shown results with cotton as crop. Node failure / single point of failure may occur. Aggregated data analysis should be done in the receiver for better decision making process.

A WSN system was developed that determines the water holding capacity for the soil [15]. Properties of soil like organic matter, organic carbon, clay content, bulk density and plasticity index are estimated. Uses simple device like wheel gauge to find depth thus system is not very expensive Natural fertilizers are used for the crops making it healthier. Burstiness of data may occur at the sink / aggregator node. Aggregated data analysis should be done in the receiver for better decision making process.

An integrated sensing system was developed [16] that can assess the soil moisture and provide decisions related to crop growth. Open GIS standards are used to provide long term access to construct sensor data and corresponding metadata. Reliability is questionable. Data cleansing has to be done to remove duplicate values measured from sensors in different location.

A hybrid wireless sensor network is deployed and tested in soil thus making it applicable to several moistures and frequencies of soil. The system [17] is a breakthrough to the traditional sensor networks. It communicates in the soil thus determining all the characteristics of the soil to help in irrigation and fertilizer management. Queuing management is a challenge and data fusion wouldn't be optimized due to burst traffic.

An ad-hoc based platform was established a like to the ones used to obtain environmental and meteorological data [18], where the manufacturing cost of the sensor node is curtailed, by an efficient selection of the system components. Node failure not addressed and dynamic routing scheme needs to be adapted as all the node in ad-hoc may be mobile.

There are many problems faced by the Indian farming community in order to maximize crop productivity. The proposed framework [19] for cost active agriculture information dissemination system (AgrIDS), to distribute expert agricultural knowledge to the farming community in order to recover crop productivity. The success of a crop rest on on the degree of avoiding the effect of the factors that disturb the crop.

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Some factors, such as bad weather and rainfall patterns are hard to foresee fairly in advance even with the current improvements in science and technology. However, the effect of several other factors on crop growth can be implicit and the possible corrective steps can be taken using the current advances in agricultural technology. Routing in such dynamic scenario is major challenge.

Precision farming uses various wireless technologies to provide better results in smart farming [20]. Global Positioning System Receivers(GPS) is one of the technologies of precision farming in which the satellite transmists signals that allow GPS receivers to calculate their location. Second technology used is yield nursing and planning in which the grain yield monitors incessantly measure and record the flow of grain in a clean grain elevator of a combine. Precision and consistency is major task. Queuing management needs to be altered while data aggregation process occurs at sink. Some machine learning scheme may be proposed for the betterment of data accuracy. The signal strength should be good for GPS accuracy.

Precision farming creates numerous operations [21], such as the best tillage, application of fertilizer, sowing, irrigation, and harvesting and turns traditional extensive production to intensive production according to space variable data. The authors have abeled the scenario of agriculture in the year 2004. The paper discourses the need for precision farming and the major mechanisms of precision farming which include (the enabling technologies) Remote Sensing (RS), Geographical Information System (GIS), Global Positioning System (GPS), Soil Testing, Yield Monitors and Variable Rate Technology. Direction-finding of sensor node is major challenge in precision farming. An intelligence method needs to be reformed while performing the data analytics so that best information can be given to farmer.

There is a dire need of dropping sensor's energy consumption. The author proposes [22] a new packet forecast algorithm integrated with wireless sensor networks to improve energy consumption. Scheduling algorithms are ordered as preemptive and non-preemptive. They developed a new scheduling algorithm for WSNs which can deliver a better QoS and decide the disadvantages of the current algorithms. The proposed Dynamic Multi Threshold Priority packet scheduling algorithm tries to exploit the level of QoS provided to dissimilar priority packets by reducing the loss ratio and waiting times. Also, the proposed scheduling algorithm is non-preemptive due to structure of reduced system load of WSNs. Algorithm developed for this work is Dynamic Multi Threshold Priority Packet Scheduling (DMTPS). In DTMPS algorithm, packets are located into the waiting queue according to their significances and each priority level has its own threshold value. The main objective of the DMTPS algorithm is to order different importance level packets according to their threshold. The most important operation of the DMTPS algorithm is to find lower priority and replace with higher priority arrival packets at appropriate own threshold value.

Examining various QoS metric requirements in WSNs from a wide range of applications classified by data delivery models is much need for precision in smart farming [23]. Two approaches based on traffic engineering are subjugated to achieve QoS, i.e., reservation-based and reservation-less approaches. In the reservation-based approach, network resources are allocated according to an application's QoS request and left to bandwidth management policy. In the reservation-less approach, no reservation is required. QoS is achieved via some policies such as admission control, policy managers, traffic classes, and queuing mechanisms.

There are various routing methods in wireless sensor networks which may be applied to upsurge the efficacy of farm network [24]. Arigorous research in the past years talks the potential of link among sensors in data assembly and dispensation and in the coordination and management of the sensing activity. However, sensor nodes are inhibited in energy supply and bandwidth. Thus, advanced methods that eradicate energy inefficiencies that would cut the lifetime of the network are highly required. Such constraints combined with a typical deployment of large number of sensor nodes pose many challenges to the design and management of WSNs. Some of the routing challenges are node disposition, energy ingestion without losing accuracy, Data Reporting model, Node/Link heterogeneity, Fault tolerance, Scalability, Network Dynamics, Transmission Media, Connectivity, Coverage, Data aggregation and Quality of service.

An intelligent system can be established which can monitor the agricultural environments of crops and provide services to farmers named as Precision Agriculture Monitor System (PAMS) [25]. The Precision Agriculture Monitor System consists of WSN, gateways, and communications sever. They deployed nodes in the farmland, which could read the related environmental information of crops. When the data is collected, nodes will packet the data using the specific protocol and along the multi-hop routing send the package to the Root node. And then, the Root node communicates the data to gateway. When receiving the data, the gateway excerpts the effective information that saved in local flash, at the same time, the gateway send the data to communications server by GPRS. The communications server levers the data and then stores it into the agriculture database. The NPU Mote is an Agriculture sensor node developed to be arranged in a PAMS and to sense the environment of the monitored areas.

The "5S" technology is the acronym of GIS (geographic information system), GPS (global positioning system), RS (remote sensing), SDDS (spatial decisions support system) and ES (expert system) [26].The "5S" technology establishes the main part of modern geography and technology. The system design contains system architecture which is a three-layer design: data layer, function layer and service layer. The data layer is used for storage of spatial data, attribute data, knowledge base, model base and other relevant data. The function layer is the basis and core of the system, which contains agricultural information collection, agricultural information management, agricultural data editing, agricultural decision support and other functions.

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The service layer: offers different levels of roles. According to this paper, the precision agriculture data is divided into three parts: basic geographic data, filed environmental data and agricultural production management data. The basic geographic data mainly comprise topographic map data, cadastral map data, and remote sensing image data. The field environmental data mainly comprise temperature data, humidity data, precipitation data, sunshine data, and soil fertilizer data. The agriculture production management data mainly comprise filed data (filed number, location, area, shape, grade, soil texture), farming mode, fertilizer input, pesticide prescription, crop yield, etc. This paper concludes that key element of 5S is building on concatenating data sets. Accuracy and dynamic routing techniques is much needed in this scenario. Queuing management needs to be adapted while data aggregation process happens at sink. Some machine learning scheme may be proposed for the betterment of data accuracy. The signal strength should be good for GPS accuracy. A GIS topographical method can be used for more accuracy.

The concept of precision farming is made clear and the study of key elements of precision farming is done. The Concept of GIS is discussed in detail [27] i.e. the geographic information system which is a distinct information system. The system utilizes GIS technique, assimilate agro technique, scientific research result, expert experience and computer technique in creating a comprehensive precision farming expert system which is of great intelligence.

The open source feature of Tiny OS is discussed in detail [28]. The detailed design and implementation of Wireless Sensor Network both hardware and software is discoursed. An experiment was passed out to validate the performance of *MDA300CA* driver. Single Node experiment and Multiple Node experiment were shown and the readings were analyzed. The readings helped in knowing the soil type i.e. whether it is dry, moist or water –saturated soil.

An agricultural environment monitoring server system is established [29] for nursing information concerning an outdoors agricultural production environment using Wireless Sensor Network (WSN) technology. The proposed agricultural environment nursing server system gathers environmental and soil information on the outdoors through WSN-based environmental and soil sensors, gathers image information through CCTVs, and gathers location information using GPS modules. This composed information is converted into a database through the agricultural environment monitoring server consisting of a sensor manager, which achieves information collected from the WSN sensors, an image information manager, which manages image information collected from CCTVs, and a GPS manager, which processes location information of the agricultural environment monitoring server system, and provides it to producers.

A context aware system was established [30] for the vertical farm with the use of Internet of things (IOT). In this paper, the authors propose a vertical farm ontology (VFO), an OWL based ontology model which aids in more understanding of the relationship between the domain factors. With the proposed model, the information from the Internet of things is recreated as context information and made available for the other systems.

A smart mobile farming service system is established based on WSN (Wireless Sensors Network), GPS and GIS technologies [31]. The hardware system includes WSNs based on Zigbee technology, tailored farming PDAs and a host PC. The software system includes the protocol between the Zigbee coordinator and the farming PDA, the embedded GIS system running on the PDA and the remote farming management system running on the host PC. The Farming PDA assimilates the Zigbee coordinator module, GPS module and GPRS module. It can screen and switch the WSN via the Zigbee coordinator, gather the farming information from the WSN nodes, obtain GPS information of each sampling site and interchange data with the host PC via GPRS.

A model and prototype was urbanized called the Farm Information Management System (FMIS) [32] which meets the changing requirements was developed. The aim of the work presented in this paper is to describe and examine the system boundaries and applicable decision processes for such a novel FMIS as a requirement for a devoted information modelling. The boundaries and scope of the system are described in terms of actors and functionalities, where actors are objects interfacing with the system (e.g. managers, software, databases). In order to analyze the complex and soft systems situations of how to develop an effective FMIS, which effectively meets farmers’ changing needs a conceptual model was developed based on soft systems methodology (SSM)and based on information derived from four pilot farms demonstrating diverse conditions across the EU that are partners of the Future Farmwork.

The NAV (Network Avanzato per ilVigneto – Advanced Vineyard Network) [33] system was established which is a wireless sensor network designed and developed with the aim of isolated real-time monitoring and collecting of micrometeorological parameters in a vineyard. The system includes a base agro meteorological station (MasterUnit) and a series of peripheral wireless nodes (Slave Units) located in the vineyard. The Master Unit is a typical single point monitoring station placed outside the vineyard in a typical site to collect agrometeorological data. It uses a wireless technology for data communication and transmission with the Slave Units and remote central server. The Slave Units are multiple stations placed in the vineyard and equipped with agrometeorological sensors for site-specific environmental monitoring, which stock and communicate data to the Master Unit. Software was developed for setup and configuration functionality. A graphical user interface operating on the remote central server was implemented to collect and process data and provide real-time control. The devices were tested in a three-step process: hardware functionality and data acquisition, energy consumption and communication. The NAV system is a complete monitoring system that gave elasticity for preparation and connection, which fully responded to the objectives of the work in terms of energy efficiency and performance.

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III. SYSTEM OVERVIEW

Agriculturists are the stakeholders for the work. The agriculturists need all the basic crop requirements to be maintained in the right quantity which every time cannot be obtained because of human negligence and error. This precision of requirements for agriculture can be catered by an intelligent computer based system, which is the sole purpose of this work. The computer based system that intends to solve the above problem is based on an IoT (Internet of Things) Framework. The system will consist of various sensors deployed at the site of farming, say a greenhouse. The sensors will collect the data from the agricultural environment such as humidity, soil pH value, temperature inside the greenhouse and will send this data wirelessly to a station where the data will be processed according to the crop being cultivated and take intelligent decisions to provide the most optimum conditions for the crop growth. The authors in this paperintend a framework to abridge the complexities associated with analyzing customer network problems and producing scalable solutions which can provide suggestions to the network designer to use frameworks for a particular network design. This framework may also act as a network analyzer to suggest various steps to be implemented to improve the performance of the current network and addressing the problem areas of latency, congestion and traffic management of packets to increase the throughput. The intelligent decisions might include switching on the temperature moderators automatically to meet the desired temperature requirement for the crop being cultivated or activating the sprinklers in case of low moisture content in the soil. The reason for choosing the wireless mode of communication is to curb the limitations of the geographical conditions which are faced in the wired mode of communication.

3.1 Challenges and Assumptions considered

3.1.1 Proper Design of the circuitry

The backbone of the entire system is building the right circuit design so that all the sensors and the devices like the sprinklers, the temperature moderators, the irrigation control equipment work in a proper manner.

3.1.2 Establishing a robust client server connection

All the intelligent decisions will be processed at the server by taking input from the Arduino client. Hence, we need to assure a robust client server connection either by using a WiFi shield or a GSM shield.

3.1.3 Writing an efficient server script

The server needs to process the input data from the client and log the same for future uses. This requires writing an efficient server side script to cater to this need.

3.1.4 Manage excess flow of data

keeping count of number of packets in a link and mange excessive flow of data. Calculation of latency & analyzing nodes causing reduced network efficiency

3.1.5 Intelligent decision making for better performance

When the network faces any loss, latency, or congestions, an intelligent decision module to re-route data.

3.1.6 Assumptions

1. The customer (Agriculturalist) buying the system knows about the crop requirements of the crop that is being cultivated.
2. The system will be deployed in a closed environment like a green house.
3. The place where the system will be deployed has an internet connection.
4. Each agriculturalist grows only one particular crop.
5. Every node has a weight value variable assigned to it in the network.

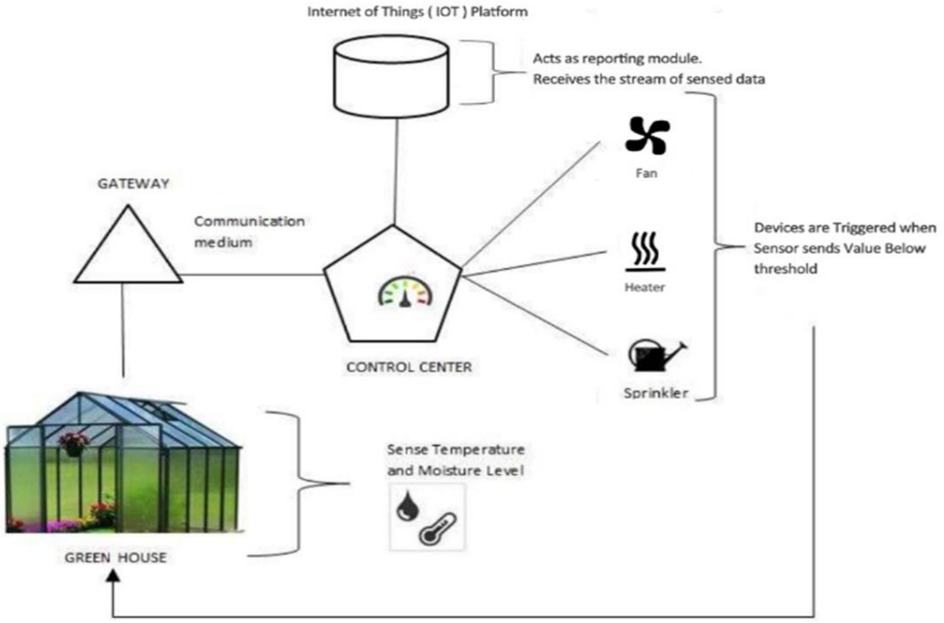

Fig.1: Greenhouse Architecture- Smart Greenhouse with devices installed

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Soil Water Holding Capacity (WHC) and available water are the key parameters in water management and irrigation scheduling [8]. In this paper, Coco-peat is used as a substitute for soil since the WHC of coco peat is greater than the WHC of soil. Grow bags and coco peat help us to provide an easier way to locate a particular crop inside greenhouse.

Greenhouse is an indoor covered place where plants are grown and cultivated.

The framework is outlined with Arduino Uno board as microcontroller. In the proposed method, agribusiness parameters for example, natural temperature and Coco peat moisture is detected and sent to the server. These qualities are then broke down and sprinklers are robotized taking into account of them.

Devices are attached to the greenhouse to provide a controlled environment as shown in Fig.1. These include Fan/Cooler, Heater and Sprinkler/Drip irrigator. All these devices are triggered based on the values sensed from the greenhouse environment. Temperature and humidity values are used in actuating the fan and the heater. Low temperature (below threshold) turns the heater on. High Temperature (above threshold) needs ventilation so auto-vents are provided using fan or a cooler.

3.2 Architecture Specifications

3.2.1 Temperature and Humidity Sensor Module

Model - DHT11

The sensor measures the atmospheric temperature and humidity. It sends the value through the Arduino board to the server. The server can compare values between two temperature sensors. First temperature sensor estimates value inside the greenhouse and other estimates the value external to it. Based on the values, the greenhouse is adjusted. The readings also play a vital role in determining the moisture content of the crop.

3.2.2 Moisture Sensor Module

Moisture sensor is used for estimating moisture content of the coco peat. In general, coco peat has five times water holding capacity to soil. So sensing the moisture from time to time can help in making the greenhouse a smart one. This value is again combined with temperature readings so that the crops are grown with sufficient water.

3.2.3 Irrigation controller Module

Irrigation controller consists of water level sensors to determine the water present in the tank. Moisture and temperature sensed outputs act as an input to the controller. The controller decides when to irrigate the crops with those readings.

3.2.4 Wi-Fi Weather Station

WSN are used in agriculture to enhance the efficiency and growth in crop yield. Numerous accuracy frameworks for agriculture are promptly accessible in the business. Sensors are made wireless by connecting them to the Wi-Fi shield. The sensor values are automatically evaluated by the controller and a decision is made. The values are taken for every second interval. All these decisions are recorded by the database so as to generate reports on the weather.

3.2.5 Reporting Module

This module summarizes all the decisions taken by the controller. Frequency of the report is set by the user of the system. Frequency can be daily, weekly, monthly, yearly. With these reports, amount of water spent for the week or month can be analyzed.

3.2.6 RF Module

An RF module (radio frequency module) is a small electronic device used to transmit and receive radio signals between the sink and the node. It helps in transfer of data wirelessly.

3.2.7 Ethernet Shield Module

The Arduino board is connected to the server via the W5100 Ethernet Shield. The data is sent to the server via the Ethernet shield and also the response generated after the data is processed is received via the Ethernet Shield.

3.2.8 Application Server Module

Key functionalities of application server is to send a TCP request to web server to establish a secure, reliable and dedicated connection between application and wireless sensor network. It provides a link through which packet analyzer could capture packets.

3.2.9 Intelligent Network Enhancer

The amount of Transmissions made by the node classifies itself as an Interested node or an Uninterested node. Weight value is inferred by number of transmissions made by the particular node.

Key functionalities of this module is to analyze information provided by packet analyzer and generate results based on the condition to enhance network performance.

Result produced should be reliable and can be applied practically. Another functionality is to provide a secure connection to data base to retrieve data which is used as input to generate result.

3.2.10 Packet Analyzer Module

Major functionalities of packet analyzer is to capture a packet and produce information through analysis. Produced results such as throughput chart, delay graph, packet loss, etc. can be determined through packet analyzer. Produced information is passed to network enhancer.

3.2.11 Database Server

Its functionality is to provide connection between intelligent network enhance and database and to retrieve or store reliable data as queried.

IV. PROPOSED SYSTEM DESIGN

4.1 High Level Design

4.1.1 Architecture Diagram

The architectural flow diagram is shown in Fig. 2.

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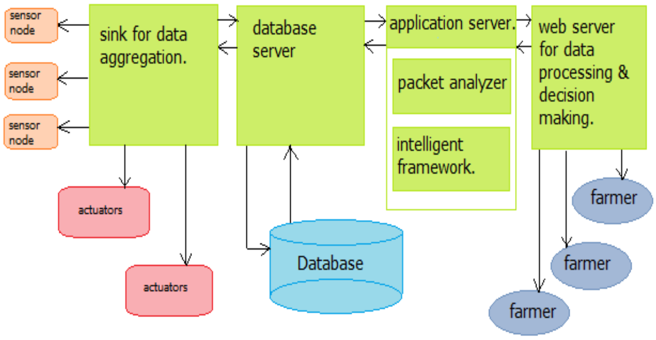
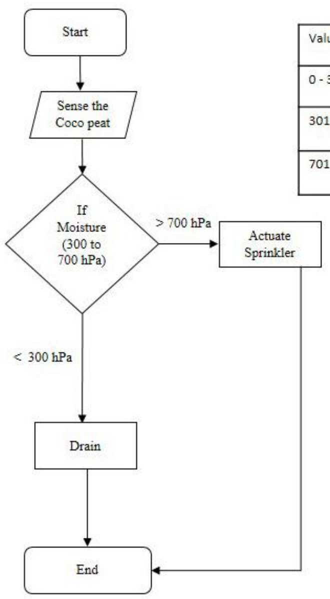


Fig. 2: Architechtural Flow Diagram

Moisture sensor senses the dampness present in the coco peat. This sensed value is shown in serial monitor. With this value, the sprinklers are actuated when required. The decision control flowchart is shown in Fig. 3. The table in Fig. 3 explains the range of moisture level and necessary action taken by the controller.



hPa – Hecto pascals

Value (hPa)	Comment	Action
0 - 300	Wet	Drain
301-700	Humid	Check after some time
701-1024	Dry	Trigger Sprinkler

Fig. 3: Moisture Sensor to actuate sprinklers dry level is attained

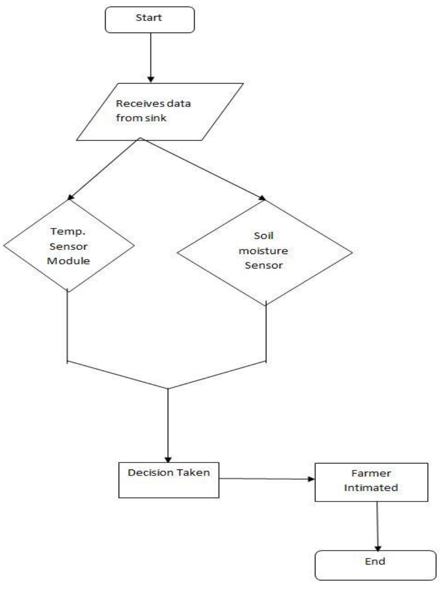


Fig. 4: Web Server Process

The web server process is shown in Fig. 4. The low-level design is shown in Fig. 5.

4.2 Low Level Design

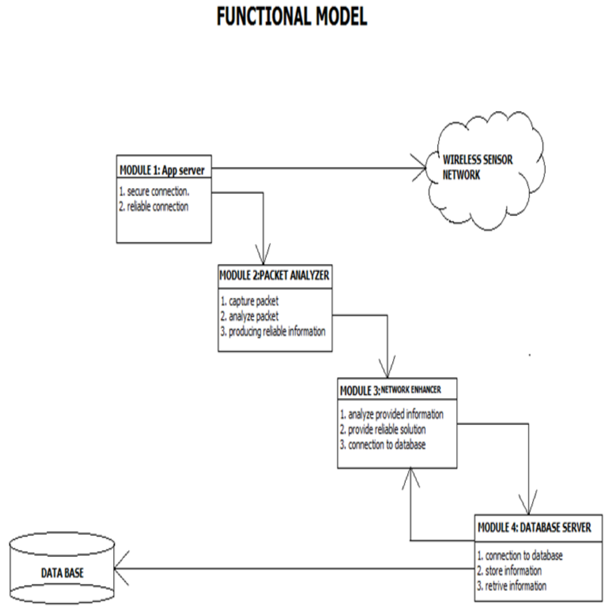


Fig. 5: Low Level Design

4.3 Constraints and Tradeoffs

Realistic Constraints:

Computational Complexity: Using artificial intelligence for network design requires spawning of numerous machines which has a resource constraint.

4.3.1 Network Design Constraint

- A network designer can use many archetypes in order to determine the exact network architecture. Yet, not all networks are created equal: Differences in topology (host, router, and link location and dependencies), software and hardware configuration, and protocol deployment makes every network unique. As a first step in Network Resource Planning (NRP), the network designer must consider both the functional and nonfunctional requirements.
- Development of a code to keep track of packet overflow control, keeping in regard the various capacity of links in a network.

4.3.2 Other Constraints

1) Internet Breakdown

In case of an internet breakdown, there would not be any client server communication which will result in failure of sending the sensor data to the server as well as inability to communicate the decision taken by the server to the client, thus hampering the functionality of the system.

2) Sensor malfunctioning

Due to malfunctioning of the sensors, like reading faulty values or not reading the values at all, erroneous messages will be sent to the server which will result in taking wrong

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decisions by the server and can affect the crop growth.

3) Hardware Availability

In case of unavailability of proper and robust hardware components, the system's efficiency can be affected to a large scale as the replacement of a high quality component with a low quality component may not provide the same accuracy or efficiency as the former one.

V. REAL TIME TESTING OF THE PROPOSED SYSTEM

To test the effectiveness of the proposed system, the systems is tested by using different modules namely: DHT11 Module, Ethernet Shield Module, RF Module and Soil moisture module. The results are illustrated from Fig. 6.1 to Fig. 6.4. Test cases are shown in Table 2.

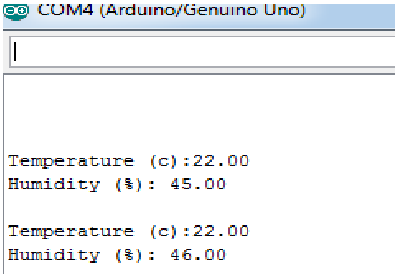

Fig. 6.1. Unit Testing of DHT11 Module

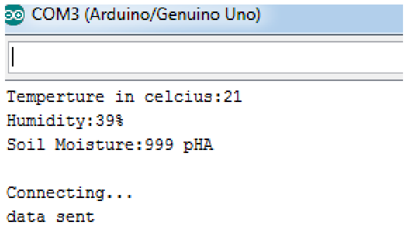

Fig. 6.2. Unit Testing of Ethernet Shield Module

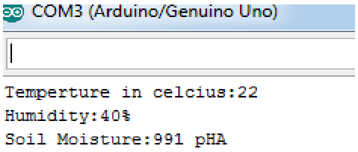

Fig.6.3. Unit Testing of RF Module

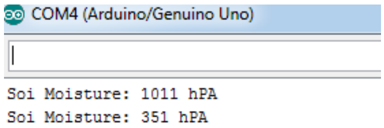

Fig. 6.4. Unit Testing of Soil Moisture Module

Table 1: Test Case Table

Test Case no.	Crop Grown	Standard Crop requirements	Sensed Data	Expected Result	Observed Result	Status
1.	cotton	Min.Temp:17°C Max Temp:28°C Min Moisture:700 hPA Max Moisture:300 hPA	Temp: 24°C Humidity: 39% Soil Moisture: 400hPA	Heater: Off Cooler: Off Sprinkler: Off Drainer: Off	Heater: Off Cooler: Off Sprinkler: Off Drainer: Off	Pass
2.	cotton	Min.Temp:17°C Max Temp:28°C Min Moisture:700 hPA Max Moisture:300 hPA	Temp: 31°C Humidity: 60% Soil Moisture: 999 hPA	Heater: Off Cooler: On Sprinkler: On Drainer: Off	Heater: Off Cooler: On Sprinkler: On Drainer: Off	Pass
3.	cotton	Min.Temp:17°C Max Temp:28°C Min Moisture:700 hPA Max Moisture:300 hPA	Temp: 31°C Humidity: 60% Soil Moisture: 999 hPA	Heater: Off Cooler: On Sprinkler: On Drainer: Off	Connection Failed	Fail
4.	Coffee	Min.Temp:21°C Max Temp:25°C Min Moisture:600 hPA Max Moisture:300 hPA	Temp: 22°C Humidity: 60% Soil Moisture: 999 hPA	Heater: Off Cooler: Off Sprinkler: On Drainer: Off	Heater: Off Cooler: Off Sprinkler: On Drainer: Off	Pass
5.	coffee	Min.Temp:21°C Max Temp:25°C Min Moisture:600 hPA Max Moisture:300 hPA	Temp: 20°C Humidity: 60% Soil Moisture: 999 hPA	Heater: On Cooler: Off Sprinkler: On Drainer: Off	Heater: On Cooler: Off Sprinkler: On Drainer: Off	Pass

5.3 Output/ Results

```
COM3 (Arduino/Genuino Uno)

Temperture in celcius:21
Humidity:37%
Soil Moisture:991 pHA

Connecting...
data sent
H:0 C:0 D:0 S:1


Heater:0Cooler:
0Drainer:
0Sprinkler:
1
```

Fig.7: Displays temperature, humidity and soil moisture readings respectively at the sink.

```
Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0
    Interface id: 0 (\Device\NPF_{651AE461-A93E-4A69-A22E-D3EF7574CBBE})
    Encapsulation type: Ethernet (1)
    Arrival Time: Apr 28, 2016 09:01:30.853645000 India Standard Time
    [Time shift for this packet: 0.000000000 seconds]
    Epoch Time: 1461814290.853645000 seconds
    [Time delta from previous captured frame: 0.000000000 seconds]
    [Time delta from previous displayed frame: 0.000000000 seconds]
    [Time since reference or first frame: 0.000000000 seconds]
    Frame Number: 1
    Frame Length: 60 bytes (480 bits)
    Capture Length: 60 bytes (480 bits)
    [Frame is marked: False]
    [Frame is ignored: False]
    [Protocols in frame: eth:ethertype:arp]
Ethernet II, Src: de:ad:be:ef:6f:ed (de:ad:be:ef:6f:ed), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
    Destination: Broadcast (ff:ff:ff:ff:ff:ff)
        Address: Broadcast (ff:ff:ff:ff:ff:ff)
        .... ..1. .... .... .... .... = LG bit: Locally administered address (this is NOT t
        .... ...1 .... .... .... .... = IG bit: Group address (multicast/broadcast)
    Source: de:ad:be:ef:6f:ed (de:ad:be:ef:6f:ed)
        Address: de:ad:be:ef:6f:ed (de:ad:be:ef:6f:ed)
        .... ..1. .... .... .... .... = LG bit: Locally administered address (this is NOT t
```

Fig. 8: A preview of captured file and analyzer results

```
COM3 (Arduino/Genuino Uno)

Temperture in celcius:21
Humidity:37%
Soil Moisture:991 pHA

Connecting...
data sent
H:0 C:0 D:0 S:1


Heater:0Cooler:
0Drainer:
0Sprinkler:
1
```

Fig. 9: Result Analysis for Coffee Crop

Result analysis for coffee crop was carried out. The standard crop requirements of coffee are Min.Temp:21°C, Max Temp:25°C, Min Moisture:600 pHA, Max Moisture:300 pHA. Temperature, Humidity and soil moisture recorded at the node are displayed above. On Comparing the standard values and the recorded values, an intelligent decision of switching on of the sprinklers was taken thus the value of Sprinkler displayed is 1.

When the captured file is analyzed by packet analyzer, if the results show no loss of packets this infers that all the nodes between sender & receiver are functioning smoothly.If there is any packet loss i.e. the number of packets transmitted are not infers that there is an erroneous or faulty node. When Delay is calculated using delta time, all nodes who transmit packets with a time delta more than the calculated threshold are those which cause delay in transmission due to reasons like congestion or node failure.

When a solution is provided is provided from database, a decision call is made on the basis of delay in transmission caused in the network. When we take up a case which causes latency & delay the authors allow the framework to take up recommendation routing. In a network when every node is transmitting data we assign a unique identity variable to node. This variable increments itself depending upon the number of transmission it made. Thus assigning a weight value to each node and hence classifying the nodes as interested or uninterested node. As a result, this will segregate the busy and free nodes in network. With the help of pedagogy, we can re-route packets who are on congested paths thus increasing the efficiency & throughput of network and causing less latency & transmission delay.

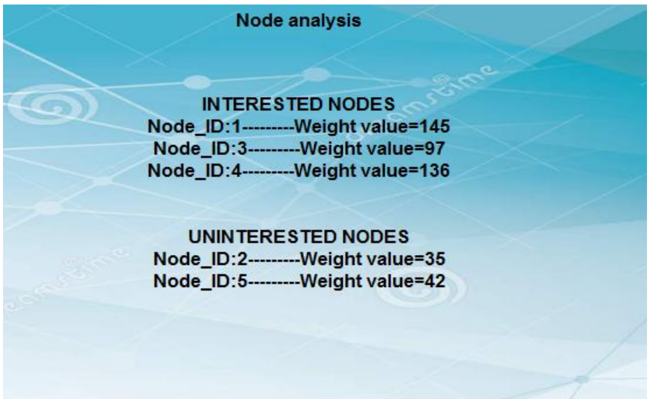

Fig. 10.1: Node Analysis

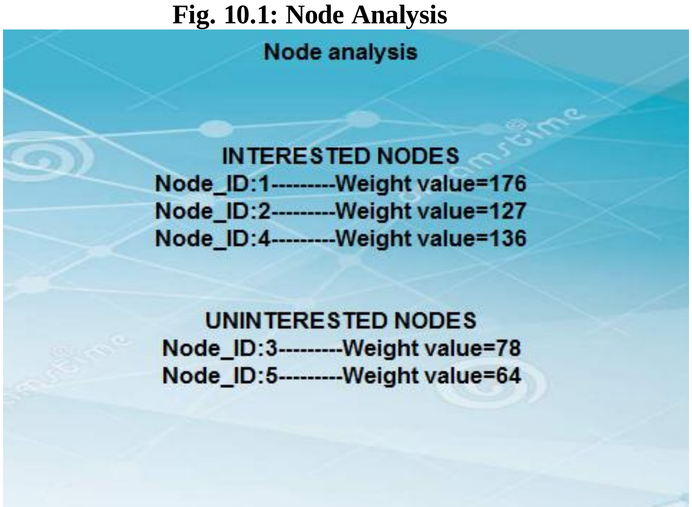

Fig. 10.2: Node Analysis

Every module is tested successfully. The efficiency of the network is improved by identifying, minimizing unnecessary delay and efficient usage off network nodes by balancing the network traffic. This framework works for wired as well as wireless networks both. And this is the reason why this system is scalable when deployed in real time environment resulting in high efficiency when

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all the realistic design constraints are properly maintained.

From the above tests which were carried out in order to test the functionality of the system, we conclude that the results of these tests meet the requirements of the proposed system. The system works efficiently for any crop provided the standard crop requirements are well known and available in the database. Node analysis is shown in Fig. 10.1 and Fig.10.2

Table 2: Test Cases – These Scenarios are taken with respect to threshold values

Scenarios	Condition	Expected Action	Status
Moisture: less than 300 Temperature: less than 18^{0}C to 24^{0}C	WET, Low Temp	Turn heater on	Pass
Moisture: 301 to 700 Temperature: less than 18^{0}C to 24^{0}C	HUMID, Low Temp	Check after a specific Interval	Fail
Moisture: Above 700 Temperature: less than 18^{0}C to 24^{0}C	DRY, Low Temp	Automate the water sprinkler	Pass
Moisture: less than 300 Temperature: 24^{0}C to 30^{0}C	WET, Normal Temp	No need to trigger	Pass

Fig. 11 shows the decisions taken inside the greenhouses. Dashboard is which acts as a control unit of all the devices inside the greenhouse. Proper ventilation is to be built to adjust temperature. Once the decision made by server to turn a particular device on. It can be done with the help of Device Dashboard.

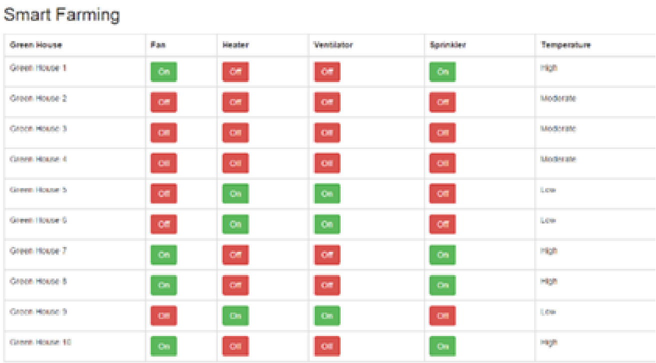

Fig. 11: Dashboard to trigger devices

VI. CONCLUSION

The authors have successfully been able to collect the environmental conditions through the various sensors and send that data wirelessly via the RF transmitter to the sink which receives the data via the RF receiver. Connection is established from the sink to the web server and then the data is sent to the server from the sink using an Ethernet Shield and eventually decision is made by the server after processing the received data. This is a platform independent framework as it is a web based framework. This framework is also scalable when deployed in real time environment resulting in high efficiency when all the realistic design constraints are properly maintained. Based on the decision, the respective actuators get powered up to meet the crop requirements. User Interface for this system has been built which allows the customer to register themselves and the crop they wish to grow in their field along with all the necessary crop details. A successful implementation of message transmission is done in which the agriculturist timely receives a message regarding the action taken in his field. The message includes the environmental conditions at that point of time in the field and thus explains the action of activation of any of the actuators in the field. The system prescribed is helpful for farmers and agro specialists in managing agro resources. Agriculture mainly depends on nature which is uncontrollable. Thus controlling some parameters paves way of real time management and efficient utilization of available resources.

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