Developing an Energy Efficient Ubiquitous Agriculture Mobile Sensor Network Based Threshold Built-In Mac Routing Protocol (TBMP)

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Abstract

Smart agriculture has been a promising model with the intention of supervising farms by means of contemporary wireless technologies to enhance the quantity and quality of yield at the same time as minimizing the individual labor requirement. In addition the effective utilization of the Sensors as communication components that is the key one to monitor and manage soil, water, light, humidity, temperature. A Mobile Ad-hoc sensor node comprises sensors to gather real time environment from the agricultural land with the wireless communication technology and process the data before sharing information with other nodes in the network. On the other hand, the challenges have been enormously high path loss and lack of communication range under the environment when passing through soil, sand, water and other climatic conditions. As Wireless Sensor Networks (WSNs) has self-organized and adhoc wireless capability to monitor physical or environmental conditions, it can be used effectively in smart agriculture. As sensor nodes have been limited itself by means of power to be in active mode always, the design of such energy efficient Agriculture WSN is a paramount issue. Hence it has been planned to utilize the WSN as well as Ubiquitous technology for the smart agriculture with energy efficiency. With the purpose of build up a model, a Ubiquitous agriculture Mobile Sensor Network based Threshold built-in MAC Routing protocol (TBMP) has been proposed to make it fit for minimal resource utilization by comparing with the existing protocols IMR and PTSR. In addition, the testing will be done to monitor changes in environmental surroundings in the agricultural land smartly in order to obtain maximum usage of Ubiquitous concept by applying existing and proposed protocols.

1. Introduction

Agriculture, all in all, has gone through a comparable development and innovation has become an essential piece of working together for each rancher and agronomist. The expanding selection pace of innovation in agriculture shouldn't be amazing to anybody. Cultivating is exceptionally land and work concentrated. Ranchers are headed to utilize innovation to build effectiveness and oversee costs [1]. The horticultural advantages of climate conditions observing sensors offer more exact observing of climate conditions for better forecasts of yield needs. Further Climate checking can help cut expenses, produce higher harvest yields, and forestall over or under watering.

Sensors permit ranchers to settle on better choices about pesticides, watering, and forestalling sickness. Then again, in agriculture Ranch mechanization practices can make agribusiness more productive while likewise diminishing the biological impression of cultivating simultaneously. Site-explicit application programming can lessen the quantity of pesticides and compost utilized while additionally diminishing ozone depleting substance discharges. Points of interest regularly endorsed to computerization integrate higher formation rates and prolonged profitability, more proficient utilization of materials, better equipment quality, improved security, more limited work filled weeks for work, and diminished processing plant lead times.

WSN used for noticing, assessing temperature, water framework systems, assessing water supply, and so forth WSN advocates the farmer to make the reap with a high computation and decrease the cost of yield. A far off sensor association (WSN) suggests a social event of spatially dissipated and submitted sensors for noticing and recording the conditions of being of the environment and assembling the accumulated data at a central area[3,4].

There have been several existing agriculture protocols to look after the land remotely as the lack of field workers, deficiency in natural resources needed for cultivation and growth of the crops or paddy which have been normally chosen as a beneficial and profitable one but by compromising energy efficiency and smartness in decision making.

2. Preliminary Studies

This section illustrates the various researches so far conducted on Wireless sensor networks used in smart agriculture, different models using Ubiquitous technologies and communication models with the purpose of energy conservations.

Junghoon Lee et al (2011) designed and applied a smart pervasive sensor system design for agricultural farms which comprised a range of sensors and generate abundant capacity of sensor records. Francisco Javier Ferrández-Pastor (2016) established and verified a cost-effective sensor network platform, established in Internet of Things, incorporating protocols with the use of human machine interaction. For that greenhouse with hydroponic crop invention was established and experienced by applying IoT and Ubiquitous Sensor Network to monitor and control with the experimental outcomes of the improvement of Precision Agriculture. Saraswathi Sivamani et al (2013) projected an intelligent agricultural services based on ontology based model to help in thoughtful the association amongst the domain factors by the statistics data from the IoT. Zhao Liqian et al (2011) proposed an agricultural application of wireless sensor network to instrument two types of nodes with the objective of delivering a portion of mechanism and synchronization guidelines to each node in the network constantly in the form of feasible agriculture monitoring system precisely.

Tamoghna Ojhay et al (2015) reviewed the impending WSN applications, and the explicit subjects and tests related with positioning WSNs for better-quality agriculture in order to emphasis on the requirements. They offered numerous circumstance trainings to systematically discover the existing clarifications by means of design and implementation connected factors. Andres Villa-Henriksen et al (2020) addressed a logical review of the present and possible application of IoTs in agriculture, by overcoming extremely changing surroundings, job variety and portable strategies associated to further agricultural schemes. The evaluation donated an indication by providing applications, encounters and probable results and operations. Abhijit Pathaka et al (xxxx) projected a Cuckoo Search Algorithm to the distribution of water for agriculture in every situation with the numerous factors namely temperature, turbidity, moisture have been composed by applying IoTs and wireless communication methods.

Muhammad Shoaib Farooq et al (2019) offered various features of tools difficult in the IoT domain in agriculture by intelligent farming that includes network architecture and protocols through cloud computing, big data storage and analytics without compromising security issues. Partha Pratim Ray et al (2017) studied many possible IoT applications, issues and challenges related with IoT placement for better farming by means of analyzing requirements of the devices, wireless technologies. Xiaojie Shi et al (2019) reviewed to gain insight IoT applications in confined agriculture to recognize the structure of the challenges along with the exploration.

Himanshu Agrawal et al (2019) offered the energy proficient model and algorithms to sustain energy necessity at the base position in order to improve average energy consumption, residual energy and throughput. Vippon Preet Kour et al (2020) offered the IoT tools in the farming region, by means of developing the hardware and software systems in order to offer elegant and sustainable clarification agriculture effectively based on the perception of IoT precision farming. William Ruiz-Martínez et al (2019) presented the Internet of things (IoT), as a technological tool for the use of a wireless sensor network to monitor and manage a sequence of ecological variables. Ziang Zhou et al (2016) intended a smart agricultural WSN for managing and calculating the issues such as humidity, water level, temperature and human machination using ZigBee as the communication medium in order to control the complete system. Olakunle Elijah et al (2018) recognized a number of advantages and challenges of IoT by means of presenting the IoT ecosystem for the smart agriculture.

Kazy Noor E Alam Siddique et al (2017) deliberated the efficiency of proactive and reactive routing protocols using sensors for agriculture and it was proven that that the AODV routing protocol executed intended for a system with more nodes comparatively with DSR routing protocol. Georgios A. Kakamoukas studied the performance and evaluation of Flying Adhoc network routing protocols that can be used effectively for agriculture monitoring. Haider Mahmood Jawad et al (2017) studied the current applications of WSNs in agriculture research by comparing numerous wireless protocols, energy-efficiently in order to meet the challenges and for handling Internet of IoT). Mohamed Amine Ferrag et al (2020) examined the privacy-oriented blockchain-based algorithms using IoTs to apply in agriculture by means of highlighting challenges in the security and privacy. Redmond Ramin Shamshiri et al (2018) studied an effort to focus certain progresses in greenhouse technology to increase the alertness for technology transmission for an effective move to urban agriculture. The investigation stressed urban agriculture challenges as well as vertical farming, rooftop heat resisting homes and plant factory. Jun Lin et al (2018) recommended a reliable and ecological food traceability system established with the combination of blockchain and IoT technologies by replacing physical recording and corroboration in order to decrease the human interference to the system excellently. Jesús Martín Talavera et al (2017) appraised agro-industrial and conservational applications that use IoTs to classify application regions, leanings, architectures and tasks in representing a extensive variety of present explanations.

From the preliminary studies, it is well understood that though previously many techniques were used to develop agriculture WSN, but compromising the node movement and energy conservation while

communication towards the central node. Hence there is a need to develop a smart Ubiquitous WSN mainly focusing on energy efficiency.

3. Present Scenario On Precision Agronomics

Precision agronomics is another significant term identified with the consolidating of the procedure with innovation [5]. At its center, it's tied in with giving more exact cultivating methods to planting and developing harvests. Precision agronomics can include any of the accompanying components: The figure 1 shows the accompanying components used in precision agriculture

3.1 Variable-rate innovation (VRT) : It allows experts to manage the quantity of data resources they concern in a specific region. The essential parts of this innovation incorporate a PC, programming, a regulator, and a differential worldwide situating framework (DGPS)[6].

3.2 GPS soil examining: Testing a field's dirt uncovers accessible supplements, PH level, and a scope of other information that is significant for settling on educated and beneficial choices. Fundamentally, soil inspecting permits cultivators to consider efficiency contrasts inside a field and detail an arrangement that considers these distinctions. Assortment and examining administrations that merit the exertion will permit the information to be utilized for contribution for variable rate applications for upgrading cultivating and compost [7].

3.3 Distant detecting innovation : Remote detecting innovation has been being used in agriculture since the last part of the 1960s. It very well may be an important device with regards to checking and overseeing the area, water, and different assets. It can help decide everything from what components might be focusing on a harvest at a particular point so as to assess the measure of dampness in the dirt[9]. This information improves dynamic on the cultivation and can emerge out of a few sources including robots and satellites. At its most fundamental level, precision agronomics plays the part of an agronomist and helps make the strategies they utilize more exact and versatile [10,11]. While precision agriculture standards have been around for over 25 years, it's just been over the previous decade that they have become standard because of innovative progressions and the selection of other, more extensive advances. The selection of cell phones, admittance to the rapid web, ease, and solid satellites for situating and symbolism and farm hardware that is enhanced for precision agriculture by the producer is a portion of the key innovations portraying the pattern for precision agriculture. A few specialists have recommended that over half of the present ranchers use at any rate one precision cultivating practice.

3.4 Supporting for greatness: Precision agriculture advancement proceeds and an ever-increasing number of homesteads are receiving accessible innovation and practices. Like some other industry, we need more supporters to drive more prominent appropriation and thus more noteworthy productivity. Producers need backing to effectively actualize new advancements to guarantee achievement. At Decisive Farming, we uphold our cultivators with preparing and mastery [12].

4. What Are Agriculture Sensors?

Agriculture Sensors: Agriculture sensors make orientation to a rundown of agriculture Sensors with their deployments which are shown in figure 2.

- Sensors utilized in keen cultivating regions known as agriculture sensors.
- These sensors provide data to the farmers about the climatic condition of the area where their agriculture lands are located. In addition, forest experts also can collect information about location identification in the forest, agriculture farms in order to prevent the dangers during emergency times. The sensors also create a platform to reduce the workers to go on to field daily instead that presence of sensors holds the responsibility to respond any deceases happen if the crops or other field [13] [15].

Agriculture Sensors Functional description

Uses of Agriculture Sensors: The main applications of Agriculture Sensors are given below:

- They can be used in agricultural weather stations by equipping sensors which gives information like soil heat, atmosphere temperature, rain, leaf moisture, chlorophyll, airstream track, solar emission, dryness and pressure.
- They can be made using in agriculture drones with the aim of spraying insect killer and fertilizers.
- As a part of green energy, by using solar energy, automatic electrical pumps can be operated remotely [16].

Advantages of Agriculture Sensors: The advantages of Agriculture Sensors are illustrated as follows:

- Due to the rising demand of highest capitulate by means of smallest resources to conserving capital and mapping fields.
- Sensors are easy to use, cheap and set up [17].
- Remote monitoring is done with wireless chip.

Drawbacks or disadvantages of Agriculture Sensors: The shortcomings of Agriculture Sensors are illustrated as follows:

- Smart farming and IoT technology require uninterrupted internet connectivity is highly needed for the smart agriculture and Ubiquitous WSN [19].
- There has been an assumption in the promotion that consumers are underestimated that they are not aware to pickup modern technologies.
- The availability of essential communications necessities is not accessible all over the place [18].

5. Proposed Threshold Built-in Mac Routing Protocol For Smart Agriculture

This section presents the proposed Threshold built-in MAC Routing protocol for smart agriculture. This protocol has been designed by amalgamating the advantages of the agriculture land which is in Square as well as circle shape for occupying-up the entire land area. The inspiration behind the creation of the proposed protocol has come from the existing Periodic Threshold Sensitive Routing Protocol (PTSR) and Integrated MAC as well as Routing protocol(IMR) and routing methodology that uses integration played a vital role in the transferring the information between nodes. The figure 3 illustrates the deployment of WSN nodes in the agriculture land where 8 regions have been marked. All nodes in the network have been connected with each other nodes logical and physical address and hence the connectivity does not miss out from the network at any cost. These regions can cover the entire agriculture area irrespective of its shape either which is in square or circle or rectangle. Important representations in the architecture are given as follows.

- R1-R8 (Regions): It represents the eight regions from R1 to R8, which comprises the parts of segmented agriculture area in square and circle.
- C1 – C4 (Circle IMR nodes): It represents the nodes with the characteristics of Integrated MAC and Routing protocol mechanisms. These nodes are responsible to forward the information to its immediate head as the nodes are arranged here in the hierarchical way.
- S1 - S4 (Square PTSR Nodes): It denotes PTSR nodes which is responsible for gathering and transmission of ecological factors and which are then forwarded to their cluster head.
- H (Header node): It heads the network for collecting the information from all the nodes in the agriculture land. The Header node is also directly connected with Control Node for information sharing.
- CN(Control node): It manages the WSN through the Header node and take the decision making to respond as per the ecological factors.

The communication flow for the proposed TBMP is explained in the figure 4. The flow starts from the Region initialization as R1 to R8, which includes Circle IMR Nodes (C1-C4) and Square PSTR Nodes (S1-S4) in which Circle IMR nodes are responsible for collecting the threshold values in terms of ecological factors and Square PSTR Nodes has the responsibility to calculate the energy efficiency of the nodes so as to ensure the reliability of the network. These thresholds cum energy efficient estimation values are then to be communicated to the control nodes through header node for further processing. Based on the collected information, ubiquitous decision making takes place for further commands which is to be shared to the regions in the form of course of actions to be taken in the agriculture region. In such a way, the environmental factors like pressure, moisture level, humidity and temperature are monitored and controlled via the commands as per the ubiquitous decision making.

6. Proposed Model Of Ubiquitous Wireless Sensor Network

The proposed agriculture environment model is explored in Figure 5, which comprises IoT module. The platform is explained as follows

Analysis: The experts can set the essential objectives as a part of accomplishing agriculture venture by means of environmental factors.

Ubiquitous sensor organization: sensors/actuators (things) and their correspondence/preparing abilities ought to be obviously characterized. Additionally, the mediator (network access hubs) gathering data from a gathering of things should be proposed. These hubs encourage the USN network access, speaking with a control place or with outside elements. In this stage, the design of the correspondence layer is proposed.

Control Processes: agrarian exercises by means of essential and progressed policy amid possessions are indicated through agronomists. An innovation stage is on the way to empower the successful utilization of a USN in specific application specialists.

Edge figuring: empowers insightful as well as information age by the side of the wellspring in the information. Then the Edge between information basis and cloud server farms wherever M2M convention, direct, information preparing, and net administrations are coordinated. Edge figuring pushes applications, information, and cycles from installed hubs that control USN to the coherent boundaries of a cloud organization.

Cloud administrations: checking, preparing as well as logical administrations, along with others, could be planned at this stage utilizing web innovations. Inquiry and scientific layers have been additionally characterized. Things and administrations are straightforward in light of the fact that both cloud and independent cloud utilize similar ideal models, advancements, and conventions.

Examination and approval: possessions, manage measures, net correspondence in Cloud users are tried and approved in genuine situations.

7. Experimental Results And Outcome

The following constraints have been taken in to account for experimental platform of TMBP agriculture design is as follows:

- **Cost effective sending:** Node (heat, humidity, PH, brightness, drain off, illumination) innovation utilized isn't costly. Regulators and sink hubs (switches) are implanted gadgets with equipment of broad use.
- Standard correspondence conventions and non-exclusive equipment programming. TMBP- USN system makes use of short range wireless communication techniques and sequential transport conventions as help to create correspondence administrations.

- **Effortless Use and support:** Nodes and gadgets are not difficult to distinguish, associate, and keep up.
- **Administer cycles and edge figuring stage improvement:** fundamental management measures effort in the nearby organizations. A number of logical, stockpiling, and UIs are dispersed in independent service providers by internet through cloud.
- **Maintain the coordination of a novel brilliant management element and interoperability:** Network administration conventions like HTTP and open-source equipment programming standards permit to a program of innovative component that could be effectively incorporated. Interoperability among possessions is guaranteed to utilize IoT appliances.
- Present uphold for the upkeep, set up as well as fundamental augmentations.
- Analyze agronomist input.

System Representation: The Threshold built-in MAC Routing method to calculate the threshold values and energy efficient calculation required for the agriculture land. According to the threshold values and energy efficient calculation, a decision can be taken as to when the environmental factors like pressure, moisture level, humidity and temperature. Earlier than going away into the details of TBMR, a few hypotheses regarding the system are ready:

- All the deployed nodes are motionless.
- Header node is moreover motionless.
- Header node is positioned at the middle location of the agriculture area
- Circle IMR nodes are surrounded within the range.
- Square PSTN Nodes are deployed within the range
- Control node uses the Ubiquitous Decision Making

Threshold Levels: The proposed TMPR is threshold susceptible for the reason that organized the nodes constantly intellect the ecological constraints, however a nodes information is sent to header node, when the detected boundary's worth surpasses the ideal edge limit (for example Unbending Threshold and Serene Threshold). When a header node is chosen in a round it communicates two edges, alongside different boundaries, to its individuals. These two thresholds (UT and ST) are mostly utilized for information transmission and it is mostly dependent on the climate conditions and the necessity of water for a specific farming area. These edges are:

- **Serene Threshold (ST):** A threshold assessment for miniature transform in the conveyed characteristic which activates the node to broadcast information to header node.
-
- **Unbending Threshold (UT):** A threshold assessment for intelligence characteristic afar which the nodes collecting this assessment have to convey the information to header node.

Energy Efficient Calculation: The process starts by the occurrence of a node with changes in the ecological parameters which is to be forwarded in the direction of the header. All nodes of region is being monitored by means of energy based on the continuous access towards the header node through which the energy level will be monitored as a non stoppable process. Hence the selection of node to have information exchange among nodes is fixed by the ubiquitous mode of operation and the follow up commands. The Energy level of Square and circle region can be calculated as follows.

$$E_{SC} = E_{\text{send out}} * K * d^P + E_{\text{get in}} * K * N + E_{\text{Receive Head}} * K$$

Where

- E - Energy
- SC -Square and Circle Land
- K- Data Size(bit/byte)
- D-distance
- P-Path loss
- N—Nodes
- $E_{\text{send out}}$ – Energy disbursement to the S/C
- $E_{\text{get in}}$ – Energy receiving from the S/C
- $E_{\text{receive Head}}$ – Energy expenditure of the header node

The proposed simulation model using Network Simulator 2 for square and circle region for agriculture land has been fixed with the following parameters: The simulation also makes the comparison between PSTR, IMR and proposed TBMP.

- Number of nodes taken are 24,48,72,96 as four iterations
- Data Size K is 124 byte
- Energy factor - 1
- Temperature- Serene Threshold (ST) – 8 °C
- Temperature- Unbending Threshold (UT): 55 °C
- Moisture - Serene Threshold (ST) – 10 %
- Moisture - Unbending Threshold (UT): 50 %
- Minimum threshold for S- H /C-H Distance: 50 m
- Maximum threshold for C- H /S-H Distance: 80 m
- Lowest threshold for Residual Energy as 0.3 joule
- Highest threshold for Residual Energy as 7 joule

The simulation statics from figure 6 represents the Network life of PSTR, IMR and Proposed BMP for agriculture purpose. From the figure 6, the proposed TBMP has got an edge over the existing methods PSTR and IMR in terms of network life time comparatively.

The simulation statics from figure 7, 8 represents the Serene Threshold (ST) Calculation and Unbending threshold calculation with temperature of PSTR, IMR and Proposed BMP for agriculture purpose. From the figures, the proposed TBMP is better Threshold (ST) Calculation and Unbending threshold calculation with temperature when compared to the PSTR and IMR nodes.

Residual energy is the vital constraint of the nodes to enhance the lifetime of the network nodes. Figure 9 and 10 shows the Minimum threshold and Maximum threshold for "Residual Energy. It is observed that the figures demonstrate that the average energy of the node is better in proposed TBMP while compared to the PSTR and IMR.

Propagation speed is the measure of time it takes for one specific sign to get starting with one point onto the next. Transmission Rate is the aggregate sum of information that can be sent from one spot onto the next in a given timeframe. While getting to the any nodes in the network area, small units of information called packets which are transmitted and received. At the point when at least one of these packets neglects to arrive at its expected end point or target place, then the sequence is called packet loss. Transmission time and packet loss senorio are the important terms shown in Figure 11 and Figure 12 despite the transmission time and packet loss of the network. The figure 11 shows that the proposed TBMP is having better transmission time while comparing to the PSTR and IMR. From Figure 12, it is also observed that the proposed TBMP has less packet loss than the existing PSTR and IMR.

The paramount reason for the efficient TBMP is the better deployment of sensor nodes in the agriculture network, where it occupies all terrain in the cultivation land irrespective its shape and size as well as the iniquitous decision making in response to environmental changes.

8. Novelty And Contribution

The following are the significant contributions:

- Since, the proposed TBMP for smart agriculture has the properties of both IMR and PTSR, the network has been inbuilt with reliability and smart decision making capability.
- The proposed architecture covers the most of the shapes of the agriculture land that includes square, circle and rectangle through which sharing of information and covering the entire agriculture land reliably.
- The nodes deployed have got connected with other nodes in the network in the hierarchal way and hence information gathering and forwarding is not at all a problem at any cost.

- The novelty of the proposed TBMP for agriculture is the utilization of ubiquitous decision making in one end and keep updating the energy efficiency and reliability on the other end.

8. Conclusion

This paper presented a mechanism to utilize the WSN as well as Ubiquitous technology for the smart agriculture with energy efficiency. The main objective of developing a model Ubiquitous agriculture Mobile Sensor Network to make it fit for minimal resource utilization has been done. Further, the testing has been completed to check the changes in environmental surroundings in the agricultural land smartly in order to obtain maximum usage of Ubiquitous concept by comparing with the existing agriculture protocols namely IMR and PTSR with ecological parameters as wells as transmission time, energy efficiency and temperature. From the implemented model, it is concluded that the concept of ubiquitous could be used for the smart agricultural domain energy efficiently. The proposed Threshold built-in MAC Routing protocol TBMP for smart agriculture has proven that it is more suitable and easy to use in any agriculture land which is not reachable easily by the farmers in terms of energy efficiency as well as ubiquitous smart decision making against the environmental changes reliably. In the future work, large scale agricultural parameters will be applied on the various environmental situations with different use case studies.

Declarations

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Figures

Figure 1
 Accompanying components used in precision agriculture

Figure 2

Types of Agriculture Sensors

Figure 3

Architectural view of the proposed Threshold built-in MAC Routing protocol (TBMP) for Smart Agriculture

Figure 4

Communication Flow diagram

Figure 5

Proposed agriculture environment model

Figure 6

Comparative analysis for life time of Network

Figure 7

Temperature- Serene Threshold (ST) Calculation

Figure 8

Temperature- Unbending Threshold (UT) Calculation

Figure 9

Residual Energy on Minimum threshold

Figure 10

Residual Energy on Highest threshold

Figure 11

Transmission time comparison

Figure 12

Packet Loss comparison