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A Novel Intelligent Efficient and Dynamic Cluster Based Routing Protocol for IoT Assisted Precision Agriculture

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Abstract: Day by day population of world is increasing, so there is crucial task in front of farmers to fulfill the basic need of food of individuals. Internet of Things (IoT) plays a crucial role in current agricultural practices for well in time results. An efficient working of IoT network requires intelligent, dynamic and efficient routing protocols which minimizes latency, improves the energy efficiency and increases network lifetime. Such protocols give better contribution in IoT assisted Precision Agriculture (PA) for getting higher yields in stipulated time. There is scope for improvement in the current IoT protocols. Our experimentation and simulation study introduces Novel Intelligent Robust Optimized Dynamic and Efficient Cluster (NIRODEC) based routing protocol for IoT assisted PA. NIRODEC highlights on minimizing latency, improving the energy efficiency and increases network lifetime. The results show that the NIRODEC protocol offers better performance than the protocols mentioned in the state of art. For the experimentation we have considered the case of identifying soil fertility and soil health with consumption of soil nutrients such as nitrogen (N), phosphorus (P), and potassium (K) etc.

Keywords: Sensors, Precision Agriculture, Internet of Things, Routing protocols, Base Station, Cluster Head, Adaptive Immune Algorithm, Motes.

I. INTRODUCTION

Agriculture is a backbone of the Indian economy. India is the world's largest producer of rice, wheat, sugar cane and pomegranate etc. IoT is a network of smart gadgets, mechanical equipment, items, animals, or people that can send and receive data without requiring human contact. It is a network that connects physical devices and ordinary objects to the internet. Internet-connected IoT devices can communicate with one another [1]. It can be controlled and monitored from afar. Agriculture is the art and science of farming, agricultural production, and livestock management. It entails the processing of plant and animal items for human consumption. The majority of the world's food and ingredients come from agriculture. It also aids in the reduction of poverty, the increase of income, and the improvement of food security. Agriculture is the backbone of the Indian economy, as we all know. Due to the rise in population and major change in climatic conditions day by day, the maximum and required crop production is challenging task in front of farmers. It is requirement of today’s market that at every stage the farmer should get accurate information about which particular factor he has to deal with for getting the maximum yields. In this paper we have focused on the issues of prime agricultural aspects such as soil fertility, fertilizers planning, data transmission in IoT network, prolonging network life, enhance efficiency etc.

II. RELATED WORK

In [2], authors stated their research on recent IoT-based agriculture innovation. Generally, farmers allude to the rapiness of soil and how it has altered crop production adversely. They ignore soil humidity, water levels, nutrition levels and most importantly changing climatic circumstances. IoT provides energy to the agriculture industry, empowering farmers. IoT modernization aids in the collection of data or information on a variety of conditions, including climate, wetness, temperature, and soil fertility [2]. Sensors such as soil moisture sensors, temperature sensors, humidity sensors, water level sensors, NPK sensors, pH sensors, and others are used to gather data [3].

The issues that affect crop growth were examined by presenter [4]. Crop development is primarily influenced by soil nutrients and moisture levels. As the world's population grows, crop output must expand as well. Soil moisture, temperature, pH, nutrients, and minerals must all be controlled in order to grow more efficient crops [3]. As a result, nutrient levels must be evaluated on a regular basis for effective crop development. Various approaches for nutrient detection are available, according to the authors [4]. Various sensors, such as pH sensors, temperature sensors, soil moisture sensors, and microcontrollers, can be used to detect and monitor soil nutrient levels, pH, moisture level, and temperature. The gathered data is saved and transferred to a server for later use. The percentage of soil nutrients such as nitrogen (N), phosphorus (P), and potassium (K) is determined using an electrochemical sensor in this device. The technology will analyses the soil nutrient concentration in real time and make recommendations for changes. The essential aspect in the agriculture business is monitoring the land and delivering appropriate fertilizers based on the soil nutrients.

Farming development that incorporates IoT technology is extremely beneficial to crop production. Cultivation is difficult in precision farming without understanding or monitoring the soil properties. Farmers may suffer financial damages in this circumstance [5]. In this paper authors concentrated on a sensor-based soil monitoring system. Various soil monitoring sensors are employed in this system to measure soil parameters such as temperature, moisture, NPK, light, pH value, and so on. [2], [5]. The data from the soil sensors is sent to the MCP2304 A/D converter, which subsequently sends it to the cloud via the Raspberry Pi. Finally, on both the mobile and laptop, we can view the information that has been received and saved to the cloud. The farmer will be able to determine which crop is suited for the given soil parameters based on this information. [5] [6].

Besides soil parameters, IoT should be used to examine the mineral composition of the soil. The mineral content of the soil can't be measured using a particular sensor [7] [8]. In smart farming, IoT can play a critical role in addressing issues such as climate change, temperature, rainfall, and water level. IoT can be used to increase the efficiency of agricultural inputs such as fertilizers, soil nutrients, herbicides, and water. If the pH rate of the soil is lower than usual, the IoT can propose which pesticides should be employed to promote cultivation and increase productivity [3]. IoT has the potential to modernize agriculture and kick start exponential growth. It is all poised to revolutionize the way agriculture is carried out. Furthermore, it is projected to significantly reduce wastage and increase profit margins.

The key advantages of using IoT in agriculture include [9] [10]:

- The effective use of inputs helps in reducing wastage and thus decreases costs incurred.
- Losses due to diseases and infections can be reduced, by continuous and real-time crop monitoring.
- The use of IoT-based devices allows better management of farm activities.

Above mentioned state of art mainly analyzes the importance of parameters in the traditional agricultural practices and gives a direction for moving towards the precision agriculture. Now the below mentioned review of literature gives an idea about how IoT gives its contribution in precision agriculture and what sort of routing protocols are present for the smooth working of data flow among various nodes in the network. We know if the farmers get the required information well in time then there is more possibility of having better decisions for planning higher yields. An efficient and intelligent IoT routing protocols plays an important role data transmission in less time, increase the lifetime of sensor nodes, enhance the packet delivery which results into higher throughput.

In [11], the researchers created PSO-ECHS (Particle Swarm Optimization-Energy Efficient-based Cluster Head Selection) strategy which extends lifetime of network. Here the CH is picked by wellness works that contemplate the detachment from cluster node to BS. The node with least wellness work worth will be picked as CH. CH then, starts the gathering improvement by conveying the message to join. The joining weight worth will be controlled by the gathering nodes when they get the joining message. Group will be created by interfacing nodes to the CH which has the most raised joining weight regard. In [12], the makers imagined the Energy-Efficient Centroid-based Routing Protocol (EECRP). Here at first, BS enlists the energy centroid position among energy centroid area. The close by node to the energy centroid area is picked as CH. During opening of CH change, the head recalculates the energy centroid area and close by node is gotten as the going with CH.

In [13]**,** the makers developed Distributed Unequal Size Optimize Cluster (DUSOC) strategy to tackle the load adjusting component of CH. As demonstrated by the protocol, the BS picks the CH subject to the power level just with distance from BS. The closer CH to BS picks the most un-number of motes when appeared differently in relation CH which is afar from BS while cluster formation. Also, in intercluster multihop routing a few of the CH technique is embraced for facts transmission closer to the BS.

In [14], creators proposed a Clustering Centroid-based Energy Efficient Routing (CEER) protocol. CEER protocol resolved the issue of zone creation and effective information transmission to BS or sink. CEER protocol chooses the zone organizers and heads to get the effective way. CEER utilizes both one hop and two hop levels for data transmission. Assuming the transmission distance from zone head to BS is less, single hop correspondence happens and on the off chance that it is more, two hop information transmission inclines toward [14]. Agriculture advancement utilizing IoT innovation is a lot of supportive in development. In the precision cultivating, without knowing or checking the issues of Wireless Sensor Network like restricted energy, lifetime of the network, latency is troublesome. In this situation farmers might experience the ill effects of monetary misfortunes. In [15], makers focused to know the working rule, parts and limitations of Low Energy Adaptive Clustering Hierarchy (LEACH) protocol and endeavored to chip away at the drawbacks by updating the convenience of LEACH protocol. Filter is loosened up by recognizing a CH reliant upon the base partition from the BS which decreases the energy utilization in CH nodes and in the entire network [15]. The exhibition of improved LEACH protocol is better than LEACH protocol by additional fostering the network lifetime and in restricting the power consumption [15].

Precision Agriculture essentially includes IP-enabled sensor nodes passed on in an allocated farm. Exactly when the space of the farm fabricates, the amount of recognizing nodes increases. This outcome in expanding the information trade among nodes, because of that network blockage happens. In this exploration, investigators proposed an original coordinating estimation widening the prominent IPv6 Routing Protocol for Low Power and Lossy Networks (RPL). This protocol is known as Partition Aware RPL (PA-RPL) [16]. PA-RPL protocol is arranged by additional fostering of the RPL transmission calculation. PA-RPL limits network clog up to most extreme degree and give longer correspondence way, which might bring about higher delay.

In [17], makers presented the work on continuous progression into the agrarian field by the use of IoT. In this paper they have focused on routing protocol in precision farming especially the critical issues presented for restricting stack of CH and addition the lifetime. The Periodic Threshold Sensitive Routing (PTSR) Protocol gives favored execution over LEACH and other standard protocols [17]. A Mobile Sink-based Adaptive Immune Energy-Efficient Protocol (MSIEEP) endeavors to encounter the energy opening issue. The protocol uses Adaptive Immune Algorithm (AIA) for having visit to flexible sink. Additionally, the estimation moreover gives a data to redesign the CHs count subordinate concerning dispersed force. The central benefit of compact sink is to gather the data from CH with overhauled network accessibility. This protocol has the store changing issue on account of this it doesn't totally resolve the open issue [18].

In [19], the researchers presented the Mobile Energy-Aware Cluster-Based Multihop (MEACBM) routing protocol where network is partitioned into clusters, picking CH having most significant remaining power. Also, strategy stays aware of incorporation and accessibility inside network by developing a sub-cluster for nodes that passed on additional in multihop routing between inter-clustering groups and sub-clusters. Resulting to picking up CH, the estimation segments the network into regions containing Mobile Data Cluster (MDC) node which accumulates a data from CH. MDC node computes Expectational Maximization (EM). With this estimation, node measures the course by contemplating the CH waiting power and region. This moves to accumulate data from the CH, whose remaining energy is least. Furthermore, this node assembles data from other CH on a useful course and passed on to BS.

In [18], the researchers presented Gateway Energy-Efficient Centroid (GCEEC) routing protocol for smart farming. This protocol essentially centers for the improvement in the work changing over CHs which worries with network power utilization. Protocol is secluded into two modules network arrangement module and cycle module. The association course of action module indicates the energy utilization model, energy centroid position, entryway node weight, and CH joining weight used in this protocol. The getting ready module explains the network arrangement stage, transmission stage, and turn time of protocol. The technique selects and rotates the CH around the cluster's energy center. Similarly, each CH selects a gateway node for multihoping itself and other CH data to the BS, reducing CH burden. The outcome of this protocol assessed by thinking about lifetime, throughput, and energy usage, yet not pondered a latency.

In [20], authors proposed LEACH protocol. Protocol is a progressive directing protocol utilized in remote sensor network to expand the network lifetime. In this protocol, sensors include in a cluster, and a single node of these clusters plays out a CH. Simply the highest point of a gathering is allowed to propel the data to the BS; the CH data from outstanding nodes then, hoards and packs them to be delivered off the BS. This protocol is good for changing, organizing, and gathering information. Protocol has the hypothesis as demonstrated by the components of sensors and BS. Protocol consolidates two stages: network formation stage and a steady state. The first stage is segregated into promotion point and gathering course of action perspective, while the steady stage joins the creation of schedule and moving of data. Every sensor node is static, unequivocally undefined, and blamed for the unclear measure of starting force. Every node eats up power at a comparative degree and can perceive its abundance force and controls power moving estimations like energy usage, correspondence distance, bounce count and child node count. There is a deferral in data transmission, in light of control overheads and normalized overheads added to distinguished data move measure.

Position Responsive Routing Protocol [21] fundamentally planned to diminish energy usage of each node by restricting the time the sensor node is out of stuff listening state and by lessening ordinary correspondence distance over the association. Nodes uses Time Division Multiple Access (TDMA) to move the data from CH to BS. In this protocol transmission delay is not considered at all. The energy uses of heads arranged afar from BS will debilitate its power faster than common. So it prompts reselection of CHs sometimes. In such case multi-hop level routing requires for better execution and result.

Our audit has taken apart actually made IoT routing protocol in the field of precision agribusiness and resolves a couple of issues which impact the introduction of novel protocol. From the reviewed literature, obviously remaining open requests present extraordinary opportunities to lead further assessment. There is augmentation to focus on the things.

- Need to further develop the data way among CHs and BS by having multi-hop correspondence between them wherever required.
- Need to setup improved and dynamic IoT network protocol where at the edge of recognizing field base station is situated.
- When the BS is far reachable then CH needs to scatter most of the energy for data move. So there is need to overhaul the best approach to avoid pack disaster.

Sensor nodes sense the environmental factors in IoT enabled network and conveys the information to CH or sink. Relentless data transmission consumes more energy than taking care of and distinguishing. Among the various challenges in agriculture we are giving focus on one aspect as a case study i.e. soil health monitoring and control. Soil fertility and health is decreasing day by day with non-appropriate management of water, fertilizers, pesticides etc. Our Experimental and simulation results show that the NIRODEC protocol offers better performance in the case of identifying soil fertility and soil health with consumption of soil nutrients such as nitrogen (N), phosphorus (P), and potassium (K) etc. than the protocols mentioned in the prior art.

The remainder of this paper is as below:

Section-III includes the data collection methodology, data inclusion criteria and data analysis methods. Section-IV contains the design and working of NIRODEC protocol. Section-V includes the results and discussion with graphical representation which describes NPK consumptions by various crops per year. The raw data is collected from the web site of agriculture department of Solapur district, Maharashtra. Section-VI shows the IoT network simulation results for examining the health of soil. Section-VII concludes the paper with future directions.

III. MATERIALS AND METHODS

Data collection involves finding the research articles based on precision farming using IoT. Particularly peer-reviewed scientific publications on precision farming using IoT and the routing protocols in IoT assisted precision agriculture are referred. The raw data is collected region wise from 2014 to 2019 related to the article from the Solapur district agriculture department website [22].

The data for this experimentation and simulation is collected from IEEE database (2010-2020). All these publications have different applications in agriculture field that have been studied and analyzed. For the data inclusion different tables and graphs are drawn. The analytical and descriptive details of the study based on publication year were observed from 2010-2020. Also the experimentation and simulation results are taken for proving that how NIRODEC routing protocol is more suitable in precision agriculture than the existing protocols.

IV. DESIGN AND WORKING OF NIRODEC

NIRODEC routing protocol improves the capability and efficiency of IoT assisted precision agriculture as compared to other existing protocols. The number of sensor nodes deployed in the uniform random fashion. The IoT enabled precision agriculture network contains more than 100 nodes and a BS.

Fig. 1 shows the architecture of NIRODEC routing protocol for IoT assisted Precision Agriculture. This protocol works in different phases.

- Network set up
- ICH selection
- CH selection
- Neighbor discovery
- Data transmission

This protocol works in the following scenarios:

1. BS is situated at the middle of sensing field.

2. BS is far reachable or at the boundary of sensing field.

I. NETWORK SETUP

The IoT network contains 105 nodes and a BS. The motes deployed in the uniform random fashion in hostile environment. Each node senses the environmental parameters such as temperature, pressure, moisture, humidity, water level etc. and transmits to the CH and towards BS via single hop communication (direct communication) or two or multihop communication (indirect communication).

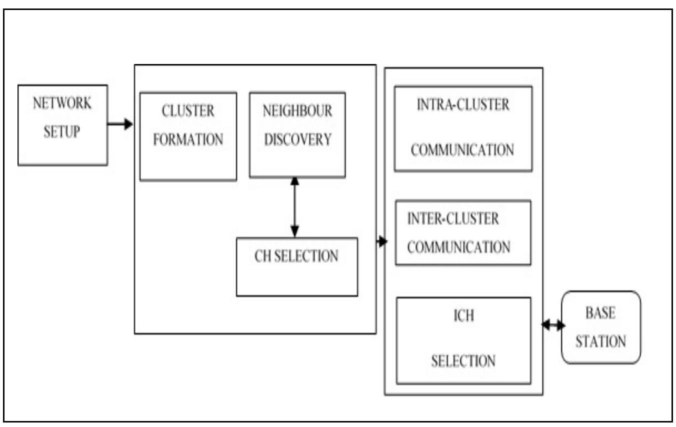

Fig. 1. Architecture of NIRODEC routing protocol for IoT assisted Precision Agriculture

This communication is based on the distance between CH and BS. The energy of sensor node is mostly consuming during the data exchange. The power model is presented in [21] as:

$E= l(e_r+e_t+€_{fs}*d^2)$ if$(d<=d_{th})$

$l(e_r+e_t+€_{mp}*d^4)$ if$(d>=d_{th})$ -----(1)

where l is a packet size, e_r and e_t are energy for receiving and transmission, $€_{fs}$ and $€_{mp}$ are required energy to transmit in free space and multipath respectively, the transmission energy consumption depends on distance d.

$d(x,y)=[(x1-x2)^2+(y1-y2)^2]^{1/2}$ ------(2) -----(2)

NOTATIONS:

N – Number of cluster nodes

CH – Cluster Head

ICH – Intermediate Cluster Head

BS – Base Station

II. ICH SELECTION

Sensor nodes deployed in the hostile environment senses the parameters and transfers towards BS via CH. CHs receives data from all the cluster nodes and transmits to the BS. Due to the heavy responsibilities CH depletes more energy. So there may be a chance to die CH earlier. When CH dies in between then there is a possibility to loss of sensed data. In this case ICH plays a crucial role of monitoring and controlling the status of all CHs in the network. Also ICH perform the task of balancing the load imposed on CHs. ICH observes the liveness of CH and N by sending random message to them.

ALGORITHM 1 ICH Selection

if the transmission distance from CH to BS > d

then

there is a need to find ICH nearby

ICH node will be elected with higher energy and minimum distance to BS.

FOR (ICH)

ICH gets the aggregated data from CH

if the transmission distance from ICH to BS <= d

then

ICH transmits the data to BS

else

ICH searches nearby CH for transmission

END FOR

In this protocol ICH node is having higher energy than all other cluster nodes. ICH node randomly checks the availability of all CHs and performs the load balancing among all CHs.

III. CH SELECTION

Basically, BS sends the CH selection message to all cluster nodes in the IoT network. In all the clusters every node responds to this message in terms of its location and residual energy.

Node_ID	X Coordinate	Y Coordinate	Direction	Residual Energy

After receiving the message from every sensor node BS calculates average energy of the network. The node with higher energy and minimum distance to the BS will be elected as CH in respective cluster. After selection of CH, CH sends a message to all cluster nodes about its selection as CH. Also it sends the joining message to the neighboring cluster nodes.

ALGORITHM 2 CH Selection

FOR EACH (CH)

CH gets the data from N

if

the transmission distance from CH to BS <= d

then

CH transmits the data to BS directly

else

CH searches nearby ICH and transmits data to BS via

ICH

END FOR

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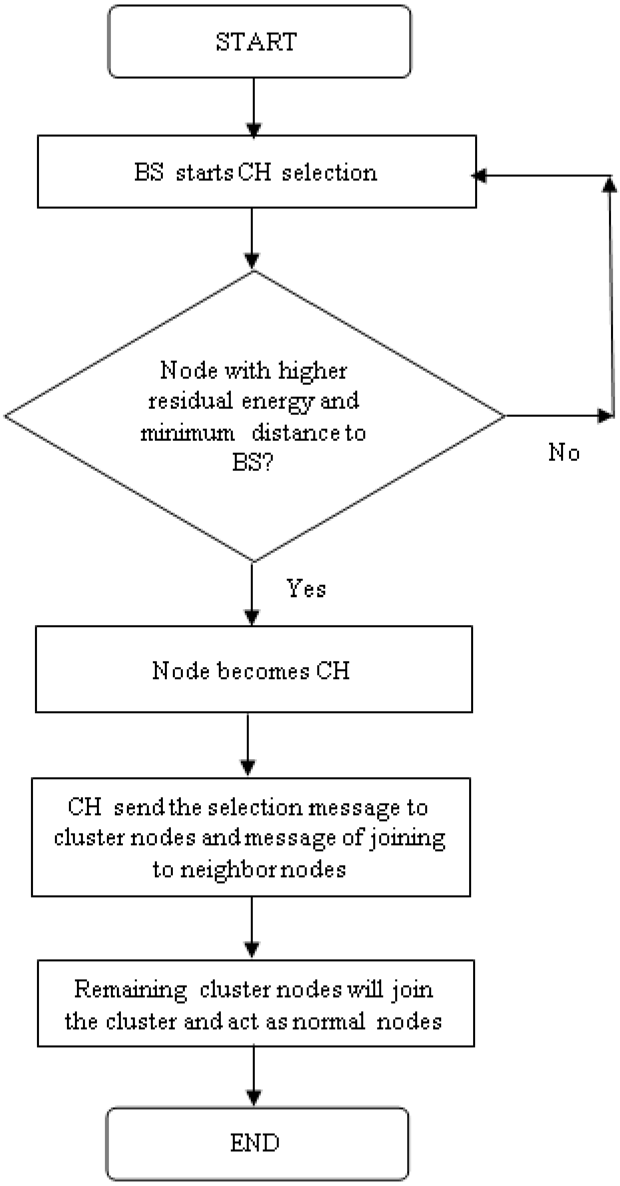

Flowchart: CH Selection

IV. DATA TRANSMISSION

All N percepts the information from environment and transfer to respective CH. ALGORITHM 3 describes how Sensing/Perception and transmission occurs among the nodes in clusters.

ALGORITHM 3 Sensing/Perception and transmission

FOR EACH (N)

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N senses the data

if

the distance from N to CH <= d

then

N transmits the sensed data to CH in respective time slot

END FOR

V. RESULTS AND DISCUSSION

The main aim of this research is to analyze the use of IoT in smart agriculture for increasing yields and maintaining the health of soil. The study focuses on collecting the issues and enlist the parameters which plays an important role in increasing the yield and maintaining the health of soil. In the field of agriculture, there are many environmental factors that need to be considered to enhance crops productivity [24]. Table 1 Shows the consumption of soil nutrients (NPK) by various crops in the Solapur district area per year. Fig. 2 shows its graphical representation.

Around fifteen essential nutrients which are supplied by soil to plants for proper growth. Out of these Nitrogen (N), Phosphorous (P), and Potassium (K) are referred as primary/micronutrients. Due to this, in the large amount they are required by the plants. These nutrients play an important in the development and proper growth of plants. Table 1 shows the consumption of NPK nutrients by various crops per year. On the other hand, Calcium (Ca), magnesium (Mg) and sulphur (S) are secondary nutrients. As compared to primary nutrients these are required in less amount. Other remaining minerals are very rarely required for the plants such as Zinc (Zn), Chlorine (Cl), Boron (B), Molybdenum (Mo), Copper (Cu), Iron (Fe), Manganese (Mn), Cobalt (Co) and Nickel.

Normally it is a thought process that more use of fertilizers increases the production. Majority of the farmers doesn’t check which particular fertilizer is required for both soil and plant for the proper growth of plant. Day by day the use of fertilizers is increasing, but on the other hand the health of soil is degrades. So there is need to check the requirement of fertilizer before its actual use for both soil and plant. By the use of IoT one can check soil health and its actual requirement. Current agriculture scenario shows that day by day use of fertilizers is increasing, which may effect on the soil fertility. This is one of the major reasons of decreasing yield now a day.

Crop	**N (Kg/ha)**	**P (Kg/ha)**	**K (Kg/ha)**	**Total**
Cotton	100	50	50	200
Jawar	50	25	0	75
Soyabean	50	75	0	125
Sunflower	50	25	25	100
Maize	50	40	40	130
Sugarcane	150	50	80	280
Vegetables	20	20	20	60
Banana	400	200	300	900

TABLE 1. THE CONSUMPTION OF SOIL NUTRIENTS (NPK) BY VARIOUS CROPS IN THE SOLAPUR DISTRICT AREA PER YEAR.

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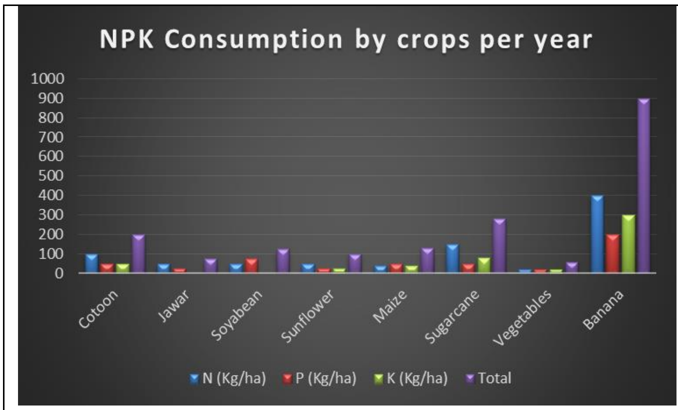

Fig. 2. Consumption of soil nutrients (NPK) per year by various crops in the Solapur district area.

VI. IOT SIMULATION RESULTS

CONTIKI is a cross-platform open-source operating system for IoT devices. It focuses on low-power communication that is dependable and reliable, as well as standard protocols like IPv6/6LoWPAN, RPL, and CoAP. CONTIKI focuses on low-power IoT devices. The CONTIKI network simulator is known as COOJA. COOJA can mimic both big and small networks of CONTIKI motes. COOJA simulator supports many standards like IEEE 802.15, CONTIKI-RPL etc. IoT works by creating and integrating smart objects that can be operated over a network from afar. COOJA is the tool used to simulate the NIRODEC protocol. The goal of this study is to examine and demonstrate the performance of the NIRODEC protocol.

The assumptions before the actual simulation are:

- Channel is error-less
- BS is placed on the boundary of the field (100,100).
- Individual mote within sensing field of its next-door neighbor. The simulation setup, which includes a 100X100 m area with more than 100 sensor nodes, is used to assess the performance of the suggested protocol architecture. All of the sensor nodes are stationary and aware of their surroundings.

We conducted the experimentation on field by using various sensors such as humidity, water level, soil moisture, light, air temperature, CO2, solar energy sensor, airflow sensor pH sensor, NPK sensor, electrochemical sensor etc. along with Raspberry Pi. Also performed the simulation 30 times to examine the overall performance of the protocol with the aid of using adjusting the wide variety of CH in network nodes. The common of those times of information is applied to depict the outcome. Latency, network lifetime and energy consumption are the simulation characteristics used to compare the NIRODEC protocol to existing protocols.

Performance Metrics:

- Latency: The protocol can be said as efficient and fruitful if it considers an important factor i.e. communication latency. The protocols like PA-RPL and other considered in the state of art have not concentrated on latency. If the data sending and receiving time is as less as possible then the remaining parameters also improves network lifetime, energy efficiency, throughput etc. Fig. 3 highlights the latency of different routing protocols. Simulation conducted provides the values of latency as less as compare to other state of art protocols. NIRODEC protocol improvement in latency for different sizes of clusters namely clusters with 50 nodes, 100 nodes, 150 nodes, 200 nodes, 250 and more than that nodes. The transmission of packets in different sized network measures in bytes and latency is measured in milliseconds.

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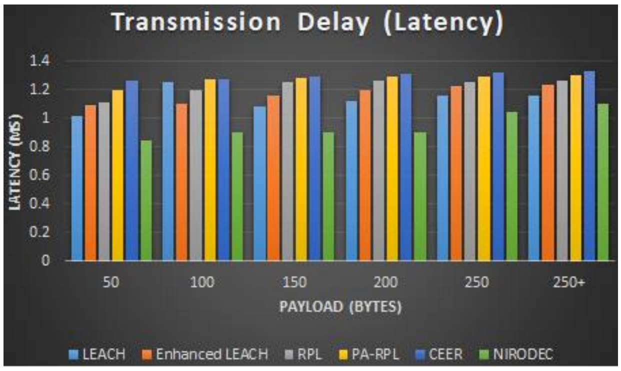

Fig. 3. Latency of simulated IoT network in milliseconds

- Energy consumption: A vital parameter for a IoT network is energy consumption, because motes use their power for exchanging data packets.

The energy consumed per round in this simulation time is in clustering, sensing, and transferring data from cluster nodes to the BS via the involvement of CHs and ICH. In this case, ICH is responsible for monitoring and random verifying the liveness of CH as well as obtaining and transmitting data to the BS. Fig. 4 shows energy consumed by sensor nodes in the simulation of NIRODEC protocol. Initially all nodes have 2J energy. Once the CH and ICH gets selected, all the motes senses the environmental parameters such as soil moisture, temperature, humidity, CO2, air flow, water level etc. and send it to the CH. The role of ICH is to check randomly the availability of CH and provide intermediate path whenever distance from CH to BS is more. Due to this energy consumption gets minimized. As compared to the IoT network with other protocols, the network with NIRODEC protocol gives 19% better performance.

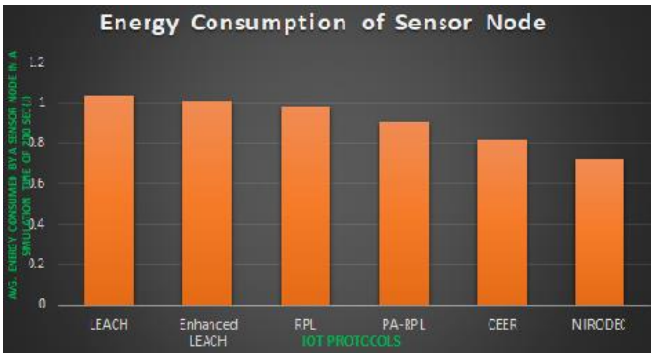

Fig. 4. Energy consumed by sensor nodes in the simulation of NIRODEC protocol

- Network lifetime: The network lifetime expands as the number of nodes depletes their energy with fewer amounts. The beginning power of the mote in this simulation is 2J, which decreases as nodes transmits and receives the data and control messages. In any IoT network if the data transmission latency is as minimum as possible, if the throughput of the network is better then the energy depletion of nodes will be less, so the lifespan of sensor nodes will increase, ultimately the overall lifetime of the network improves. The NIRODEC routing protocol works intelligently and efficiently, due to that the performance of the IoT network enhances. Fig. 5 shows the network lifetime comparison after number of mentioned simulation rounds.

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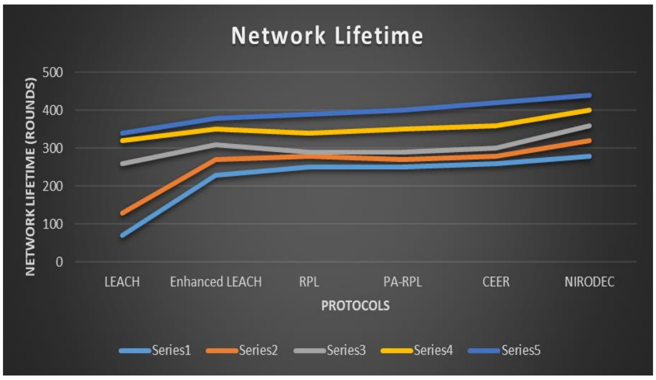
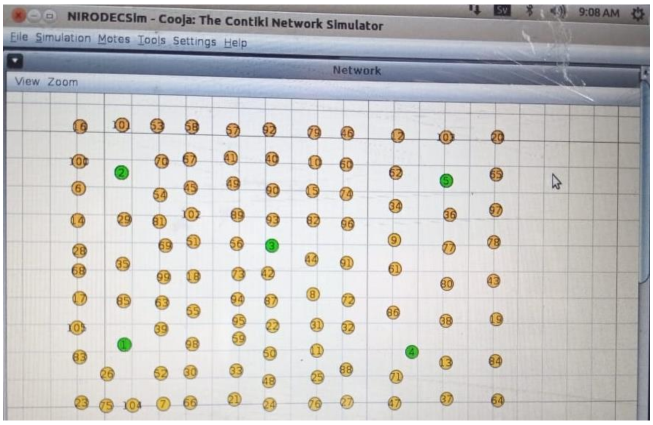


Fig. 5 Network lifetime comparison chart after number of simulation rounds



Screen Shot 1. Layout of simulation where the sensor nodes are deployed in uniform random fashion

Screen Shot 1 shows the simulation structure of IoT assisted precision agriculture network. In this simulation more than 100 sensor nodes are deployed in uniform random fashion and a base station which is situated at the boundary edge of network. The simulation is carried out in different rounds and the values of different parameters are taken for the performance consideration. The graphs shown above gives a clear idea about the better performance of NIRODEC routing protocol as compared to the protocols mentioned in the state of art such as conventional LEACH, enhanced LEACH, RPL, PA-RPL and CEER routing protocols. In the IoT enabled Precision Agriculture using NIRODEC routing protocol, the COOJA simulation is used for simulation of activities in the network.

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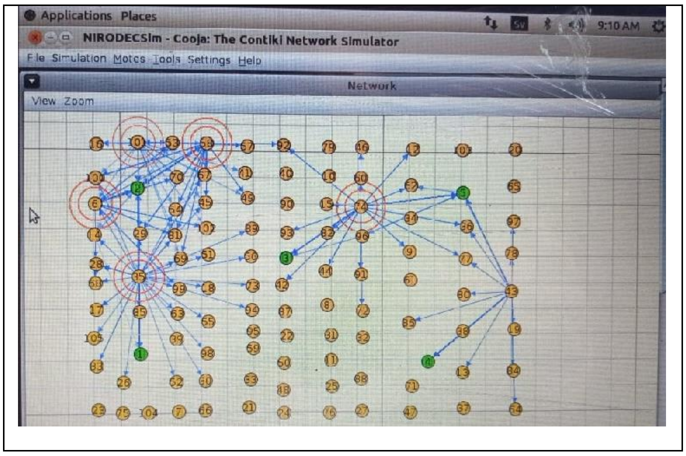

Screen Shot 2. Data transmission during simulation of NIRODEC protocol

Screen Shot 2 shows a sample snap shot which contains the structure of IoT network in which the sensor nodes are deployed in a required style. Also it demonstrates the data communication between the cluster nodes and highlights the catchmate area in the sensing field where the data transmission occurs. All the cluster nodes senses the environmental parameters and send it to the BS via CHs and if necessary through the ICH node. The simulation is performed in the number of rounds with specific time period t=200 sec. The values collected from experimentation and simulation shows that the NIRODEC protocol gives better performance than the existing protocols.

VII. CONCLUSION AND FUTURE SCOPE

For getting higher yields in precision agriculture there is a need to measure the mineral contents of the soil along with other parameters such as soil moisture, humidity, temperature, pH, water level etc. Getting the nature of soil by extracting the contents is beneficial to the farmers for finding the right crop for right field. In the IoT assisted precision farming, monitoring environmental factors/conditions is major issue for improving yield. There is need to design intelligent routing protocol which determine the percentage of soil nutrients in less time before the actual plantation. Also there is need to predict the diseases of plant using IoT enabled precision agriculture in earlier stage so that it will not affect on overall production efficiency. The literature shows that there are lot of work ongoing in the development of precision farming using IoT. However still there are number of issues need to find and address for increasing the yields. The key issues are identifying and maintaining the soil health frequently in less time, checking the nutrients in the soil, improving soil fertility, prediction of frost etc.

The motivation behind this research is to audit and examine the cluster based routing protocols in the IoT assisted Precision Agriculture. The NIRODEC routing protocol for IoT assisted Precision Agriculture centers essentially around the boundaries like latency, network lifetime and energy efficiency. To examine the performance of this protocol we have considered the data required for examining the soil fertility and health. The protocol advises that after sensing the environmental parameters, when the data transmission distance from cluster node to CH and CH to BS is least then the latency of information transmission is less which straightforwardly consequences for expanding the network lifetime. At the point when the distance between cluster node to CH and CH to BS is all the more then, at that point, the energy dissemination will be more, henceforth the network life will be decreased. So there is need to present multi-hop correspondence any place vital for the better performance. Multi-hop model can be presented by having a middle of ICH for less dispersal of energy. In future we are trying to optimize the NIRODEC protocol.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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