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A Survey of Energy Efficient Approaches of Wireless Sensor Network for Precision Agriculture

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***Abstract*— Due to unpredictable weather conditions agriculture and farming facing various critical problems now a day. There is a need to improve agricultural practices so as to increase the agriculture standards. New technological advancement is going on in this field. Precision agriculture is a scientific approach to improve the agricultural products by the use of various technologies like Global positioning system, remote sensing to monitor and control variations in the environmental parameters and by analyzing conditions suggest effective utilization of resources like water, soil, nutrients to improve product quality. Wireless Sensor Network (WSN) is one of the suitable technology for precision Agriculture in terms of low cost, energy-efficient, real time monitoring of environmental parameters.**

The objective of this paper is to review the various Wireless sensor network technologies used for precision Agriculture. Wireless sensor network is used for monitoring the environmental conditions like soil temperature, soil moisture, soil fertility, humidity, luminosity and weed detection. Energy efficiency is one of the most important design factors for the WSN as the typical sensor nodes are equipped with limited power supply. Minimizing energy consumption and maximizing the lifetime of the networks are key requirements in the design of sensor network applications

Keywords— *Wireless sensor network, Precision Agriculture, Energy Efficiency.*

I INTRODUCTION

The recent advances in Wireless sensor network (WSN) techniques have spread rapidly into various application fields. Agriculture and farming is one of the application areas which is now using Wireless Sensor Network technologies for precision agriculture due to cost effectiveness to improve its production and enhance agriculture yield standards [1]. Wireless sensor network consist of spatially distributed nodes, also called as motes, each of which is equipped with sensors, memory for storage , microprocessor for computing their decisions, batteries for energy supply and able to communicate wirelessly with other nodes in a short range[2]. WSN monitors the different environmental parameters like soil temperature, soil moisture, soil fertility, humidity etc. The aim is to monitor and maintain the farm remotely and derive the predictions and solutions of diseases that may occur due to adverse environmental conditions. The action of monitoring and providing solutions to the farmers for appropriate use of water, fertilizer and pesticides significantly helps to increase productivity and crop quality[3].

Each sensor in WSN has capability to sense and collect data. It sends that data to other node or sink node depending on single hop or multi-hop topology. Each sensor node communicates either to other node or sink node wirelessly. In sensor node power is required for data sensing, communication and data processing [4].As sensor node is having low-power batteries, sensor networks must be energy-efficient as well as of long life with data accuracy for real time monitoring applications. In Wireless Sensor networks , various MAC and routing protocols are available to minimize the energy consumption of WSN, thereby prolonging the sensor lifetime.

II WIRELESS SENSOR NETWORK IN PRECISION AGRICULTURE

Sensing is a technique used to gather information about a physical object or process, including the occurrence of events (i.e., changes in state such as a drop in temperature). An object performing such a sensing task is called a *sensor*. A sensor is a type of transducer that converts energy in the physical world into electrical energy that can be passed to a computing system or controller.

An example of the steps performed in a sensing (or *data acquisition*) task is shown in Figure 1.1. Phenomena in the physical world (often referred to as *process*, *system*, or *plant*) are observed by a sensor device. The resulting electrical signals are often not ready for immediate processing; therefore they pass through a *signal conditioning* stage. Here, a variety of operations can be applied to the sensor signal to prepare it for further use. For example, signals often require amplification (or attenuation) to change the signal magnitude to better match the range of the following analog-to-digital conversion. Further, signal conditioning often applies *filters* to the signal to remove unwanted noise within certain frequency ranges. After conditioning, the analog signal is transformed into a digital signal using an *analog-to-digital converter*. The signal is ow available in a digital form and ready for further processing, storing, or visualization [5].

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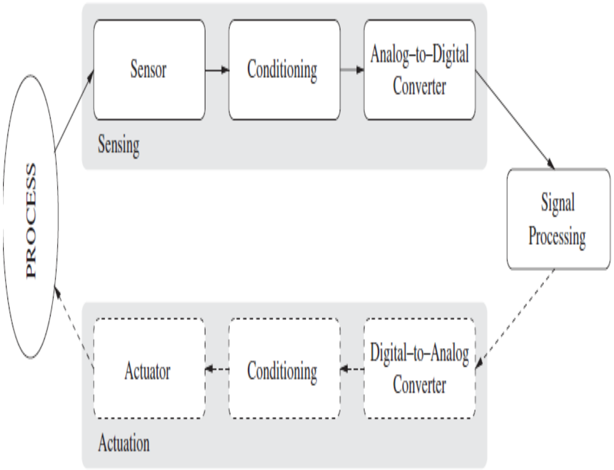

Figure1 Data acquisition and actuation

When many sensors cooperatively monitor large physical environments, they form a *wireless sensor network* (WSN). Sensor nodes communicate not only with each other but also with a *base station* (BS) using their wireless radios, allowing them to disseminate their sensor data to remote processing, visualization, analysis, and storage systems[5].

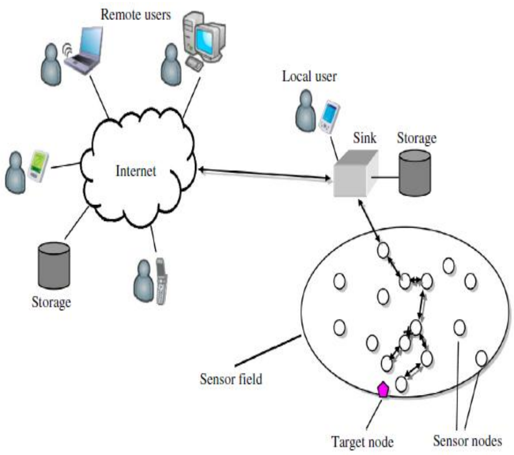

Figure 2. Sensor nodes on WSN

In precision Agriculture, WSN system has the capability to sense different environmental factors like temperature, soil moisture, humidity and ph value of soil. Sensors in WSN can be arranged in one of the suitable topological structures available for WSN. Once the nodes are distributed in the environment and need to self-configure the network and adapt themselves to it.

These sensors can be programmed to record the different environmental parameters. All the data which are collected from the sensors, using a wireless multi-hop routing technology, end up in a sink node which transfers them to the end user through wireless network, internet or LAN as shown in Figure 2.

Because sensor nodes are low power devices and power is required for data sensing, communication and data processing, energy efficiency is a major issue in designing of WSN. The main sources of energy loss are

- Idle listening occurs when a node is waiting to receive data from its neighbour nodes. A radio keeps their receiver open all the time as it does not know when a message will arrive from its neighbours. So it is seen that nodes are keeps in ideal for most of the time.
- Collision occurs when two nodes wants to send data at the same time and interfere each other.
- Overhearing takes place when a node receives packets that are destined to other nodes.
- Over-emitting happens when a node sends packet to its destination but its destination is not ready to receive that packet.
- Control packet overhead is the energy required to send, receive and transmit control packet [6].

Optimal design of MAC and routing protocol ensures power-efficient WSN application that minimizes power consumption and hence, maximize battery lifetime of the network. The medium access control (MAC) layer is responsible for providing sensor nodes with access to the wireless channel. Some MAC strategies for communication networks are *Contention-based*, that is, nodes may attempt to access the medium at any time, potentially leading to collisions among multiple nodes, which must be addressed by the MAC layer to ensure that transmissions will eventually succeed. Downsides of these approaches include the energy overheads and delays incurred by the collisions and recovery mechanisms and that sensor nodes may have to listen to the medium at all times to ensure that no transmissions will be missed. Therefore, some MAC protocols for sensor networks are *contention-free*, that is, access to the medium is strictly regulated, eliminating collisions and allowing sensor nodes to shut down their radios when no communications are expected. The network layer is responsible for finding routes from a sensor node to the base station and route characteristics such as length (e.g., in terms of number of hops), required transmission power, and available energy on relay nodes determines the energy overheads of multi-hop communication [5].

III RELATED WORK

Kavi Kumar et al.,[3] has implemented precision agriculture application Potatosense for monitoring a potato plantation field in Mauritius . With this additional monitoring application has also developed to process the data obtained from the simulated WSN. The monitoring application senses various environmental parameters like temperature, soil moisture, soil PH value, Wind Speed etc. in the potato field and is able to indicate the need of irrigation, Pesticides or fertilizers for the potato crop. Furthermore, administrator can also able to view historical data of specific region in the potato field. The sensor nodes are placed in the grid structure to provide better coverage for large plantation due to its simplicity & scalability. In this work, they have used HEED (Hybrid Energy Efficiency Distributed) protocol which is a clustering protocol with hybrid approach to reduce energy consumption thereby prolonging the network lifetime.

In HEED, nodes do not need to have knowledge about their geographical location. Thus no GPS needed in sensors and no energy is consumed by GPS sensors. So clusters are formed based on the information about local neighbors. In HEED, rotation of Cluster Head (CH) and rebuilding of clusters puts extra overhead. The Recursive Converging Quartiles method is used to aggregate all received data together with Cluster Head own data.

Thus this work shows the feasibility and potential of using WSN system to improve productivity, reduce the waste of natural resources and the use of fertilizing substances and decreases the adverse effect on the crop due to fluctuating environmental conditions. Ana Laura Diedrichs et al.,[2] has developed a WSN based on IEEE 802.15.4 for frost characterization in precision agriculture by measuring temperature. A main objective is to reduce the power consumption of the network to the minimum, allowing several measurement points per node and the remote monitoring of the sensors behavior. They have developed a serial protocol inspired in SDI-12 for the communication interface between a WSN node and the sensors. WSN allows better spatial and temporal resolution.

In case of network connectivity failure, the gateway also has capacity to store frames and try to reconnect with the server to send the data. An oversampling technique has been used to improve the noise tolerance. SDI-12 serial protocol provides following advantages. Low system cost, Probes can be interchanged without reprogramming the mote, Power and data are available through the same connector, Low power consumption, cost effective, precision measurement, battery status indication, and battery life estimation.

Some disadvantages like we can use only star or peer-to-peer topologies, motes does not have real time clock so additional module has to developed which require additional hardware & software specification and real time environmental factors were not considered for estimating battery life.

Anurag D. Et al., [9] has build a wireless sensor network AGRO-SENSE for precision agriculture where real time data of the climatologically and other environmental properties are sensed and send to a central server/repository.

The network architecture is divided into three distinct sections – (a) the sensor-nodes (b) the wireless mesh network and (c) the actuation components. The sensors are selected based on the properties suited for the most common crops. The sensor network is based on the IEEE-802.15.4 standard. They have developed a new static routing algorithm suited for the sensing application. The algorithm overrides the deficiency of the Hierarchical Routing scheme inherent in the ZigBee specification where the Cskip addressing algorithm limits the possible depth of the network topology due to address wastage. The new algorithm maintains the hierarchical network topology and thus ensures routing at its optimal best. The algorithms for both addressing and routing are provided. The actuation components are also a part of mesh network and are activated wirelessly for controlling irrigation and fertigation.

ZigBee based Wireless Sensor Network with Mesh topology

- Very low energy consumption for long battery life
- Dynamic, expandable network (up to more than thousands of nodes)
- Able to react on external influences (change measurement frequency)
-Different node configurations for adapted Measurement setups
- Measured data stored in a database (easy and variable access)
-WSN are self-forming as nodes are powered on, they automatically enter the network.
-They are self-healing. As a node leave the network, the remaining node automatically re-route their signals through other available paths.
- They support multi-hop routing.

N. Sakthipriya et al.,[7] has developed a WSN for crop monitoring which consists of sensor motes which have several external sensors to measure various environmental parameters like leaf wetness, soil moisture, soil PH, atmospheric pressure etc.

Based on value of soil moisture system switched on irrigation system and as soil moisture reaches required value, it automatically switched off irrigation system. Likewise, it sends soil PH value to base station if it is below threshold value and in turn base station sends SMS to the farmer to intimate for need of the fertilizer.

Thus WSN provides a helping hand to farmers in real-time monitoring, achieving precision agriculture and thus increasing the rice production. It also helps in distributed data collection, monitoring in adverse environment, precise irrigation & fertilizer supply to produce crop production. Reduced cost & assisting farmer in real time data gathering. PA could raise the crop yield, labor cost, saving & environmental protection against over pesticide or fertilizing.

The effective agriculture monitoring concern both the system level issues i.e. unattended operation, maximum network life time, adaptability or functionality & protocol self-reconfigurability & final user needs. i.e. communication reliability & robustness , user friendliness, versatile & powerful graphical user interfaces. In this system they have used XMesh routing algorithm, the cost metric is one that minimizes the total no of transmissions in delivering a packet over multiple hops to a destination. Sherine M. Abd El-kader et al.,[8] in 2013 has developed a WSN which is used in precision farming in cultivating the potato crop in Egypt. This system saves the resources like water, fertilizer etc. At the same time it improves quality of the crop and avoids excessive use of pesticides. This system uses APTEEN protocol for routing. Larger coverage area and high temporal and spatial resolution, improved accuracy, relatively inexpensive, easy to install are some of the advantages of this system.

APTEEN protocol sends data periodically as well as senses data continuously and responds immediately to drastic changes.

For low energy consumption, this system uses TDMA protocol for transmission which enables nodes to sleep and prevents collision among cluster members. Energy saving as the node senses the environment continuously and only transmits if hard threshold condition met. Energy consumption can be controlled by changing the count time as well as the threshold values.

This system gives small response delay, full coverage of the field, scalability of the fields. With respect to the performance of APTEEN network in terms of lifetime and energy dissipation, it is better than the two popular hierarchical routing protocols Low-Energy Adaptive Clustering Hierarchy (LEACH) and Low-Energy Adaptive Clustering Hierarchy-Centralized (LEACH-C) .

IV CONCLUSION

We have seen various energy efficient routing protocols of Wireless Sensor Network for precision agriculture. In HEED, cluster formation is based on local information, so no need of GPS sensors which saves the energy. But rotation of cluster head and rebuilding of clusters puts extra overheads. In other application they have used SDI-12 as a serial communication protocol which is low cost solution but with topology limitations. XMesh routing algorithm, the cost metric is one that minimizes the total no of transmissions in delivering a packet over multiple hops to a destination. APTEEN protocol for routing gives more coverage area and high temporal and spatial resolution, improved accuracy, relatively inexpensive, and it is easy to install. APTEEN protocol sends data periodically as well as senses data continuously and responds immediately to drastic changes.

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