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Scrutinise the Energy Efficiency in WSN for Precision Agriculture

P. Jasmine Lizy¹, Dr. N. Chenthalir Indra²

Research Scholar, S.T. Hindu College, Nagercoil, Affiliated by Manonmanium Sundaranar University,
Tamilnadu, India ¹

Assistant Professor, S. T Hindu College, Nagercoil, Tiruvelveli, Tamilnadu, India ²

ABSTRACT: Wireless sensor networks comprises of networks of tiny sensor nodes connected through a wireless communication protocol. This WSN helps to monitor the agricultural activities such as plant disease detection, water irrigation, soil fertility, etc. Precision agriculture is one of the modern farming practices that help to increase the production. Precision agriculture help to monitor the environmental factors such as temperature, humidity, etc. The uniformly distributed sensors nodes have only a limited energy. These sensor nodes process the data. To increase the energy various algorithms are used. The main focus of this paper is to assess the energy efficiency of the wireless sensor networks in precision agriculture.

KEYWORDS: WSN, VSI-PA, Energy- Harvesting, ZIGBEE

I. INTRODUCTION

Wireless Sensor Networks consists of three main components such as sensors, microcontrollers and RF transceivers. Sensors are the tiny device that help to monitor the environment. WSN are the cost-effective equipment used for agriculture automation [1]. The motes or the sensors are the sensing layer in WSN. Sensors monitor the environment in a real-time manner. The monitored signals are processed and transmitted through wireless networks to the base station or sink node. The base station act as a central processing and controlling unit [3]. Some of the sensors used for agriculture applications are air temperature and humidity sensors, soil moisture, leaf wetness, atmospheric pressure, solar radiation, dendrometers, the soil temperature etc. WSNs are used in wide range of applications, such as healthcare, target tracking, environmental monitoring, weather monitoring, decision support systems, inventory control, wildlife habitat monitoring, smart homes, bio-chemical material detection, disaster management, surveillance, and agriculture.

Precision agriculture helps to improve the growth of food crops. PA management tactic that practices information technology to improve agricultural quality and production. Sensor nodes are deployed in the agricultural land to monitor the temperature, humidity, moisture content of the soil. These sensor networks help to improve the irrigation system of an agricultural land. The sensor network is used for data collection. But the energy of the sensor nodes is based on the battery life. The main problem behind this WSN is the energy efficiency, communication range, optimum deployment schemes, scalability, routing protocols and fault tolerance. Deploying a WSN network is cost effective which is difficult to recharge the battery very often.

In this paper, we provide a detailed description of energy efficient algorithms for wireless sensor network. This helps the researchers to know the major challenges and the potential options in search of energy efficiency improvement. In this paper, section 2 describe about Precision agriculture and the sensors, microcontrollers and wireless technologies used for PA. Section 3 provides the deployment of WSN, its challenges and limitations of WSN and section 4 provide the energy efficient protocols used for PA. This phase use various method that help to enhance the efficiency of wireless sensor networks. Finally, the conclusion phrase.



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II. PRECISION AGRICULTURE

Precision Agriculture (PA) is an information-based and technology-driven agricultural system, designed to improve the agricultural processes by precisely monitoring each step to ensure maximum agricultural production with minimized environmental impact technology [4]. Precision agriculture is an forming method that is monitored and recorded. This method help to satisfy the global needs. This technology driven forming method help to increase the production rate of food items.Precision agriculture help to monitor the agricultural activities such as plant disease detection, water irrigation process, etc. PA has five stages such as data collection, diagnosis, data analysis, Precision field operation and evaluation. The three major requirements for PA are sensors, micro controllers and wireless technologies [1].

| Sensors used for PA | Micro controllers | Wireless Technologies |
|---|--|---|
| <ul style="list-style-type: none"> • Leaf Wetness Sensors • LW-100 Leaf Wetness Sensors • 237-L Leaf Wetness Sensors • TPS-2 Portable photosynthesis • LT-2M Leaf Temperature • PTM-48A photosynthesis monitor • YSI 6025 chlorophyll sensors • WET-2 Soil Sensors • Hydra Probe II Soil Sensors • EC-250 Soil Sensor • BetaTherm 100K6A1B • CM-100 compact weather station • LI-200 Pyranometer • Met One Series 380 Rain Gauge • All -In-One(AIO) Weather Sensor • Waspnote • CI-340 • RM Young(model 5103) • HMP45C | <ul style="list-style-type: none"> • Arduino UNO • TIMSP430 • ARM920T • MSP430 • MSP430G2553 • MSP430F149 • PIC24FJ64GB004 • PIC18F452 • ATmega128L • ATmega2560 • AT86RF230 • ATMega64L • Marvell PXA271 • 8051 • JN5148 • STM 32/F4 • Cortex 3LPC17xx | <ul style="list-style-type: none"> • WiFi (IEEE802.11) • GPRS/3G/4G • ZigBee/IEEE 802.15.4 • Bluetooth (IEEE 802.15.1) • Bluetooth low energy (BLE) (IEEE802.15.1) • LoRa (IEEE 802.15.4g) • SigFox(IEEE802.15.4g) |

WSN consists of large number of sensor nodes. These sensor nodes are extremely smaller devices. These nodes or sensor devices survive with the help of battery power but it is limited. WSN affords simple and cost-effective solution to monitor and control the modern agriculture

The major role of WSN is to sense the remote data from the desired location and transmit the same through the wireless network which can be received in the receiver end. WSN is a collection of sensor nodes deployed in a network where the parameters are sensed, monitored and controlled. In WSN, the accurate data can be sensed and transmitted to the receiving station. If the measured value is above the threshold value an alarm can be generated. Previously RF technology is used in WSN, then Bluetooth and Bluetooth is replaced by ZIGBEE technology. If the Signal-Noise Ratio increases the bit error rate decrease. This help to decrease the error rate and increase the signal strength [11].

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III. DEPLOYMENT OF WSN IN PA

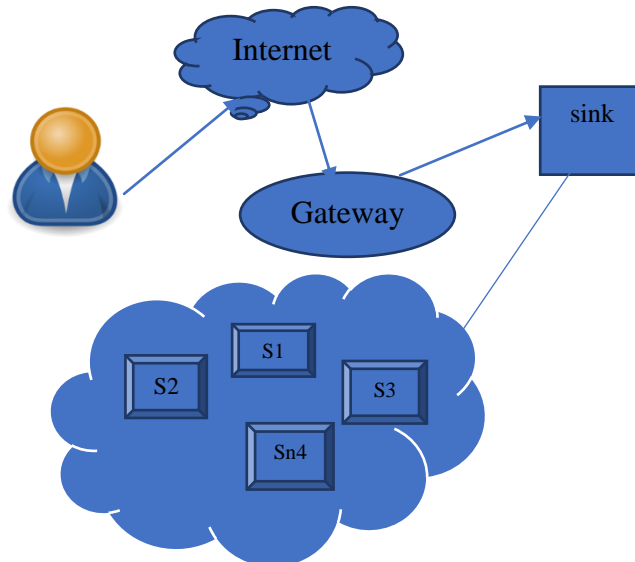


Fig1. Deployment of WSN

The major challenges in WSN are

- Power consumption and battery life
- Communication Range
- Propagation Losses
- Routing
- Data Management
- Fault Tolerance
- Security
- Storage and recording of data
- Delay Tolerance
- Cost
- Scalability
- Reliability
- Localization and tracking

Since wireless sensor networks consists of large number of smaller sensor nodes having a limited battery life. Once they are deployed in a network it is difficult to recharge the batteries. Many algorithms which help to enhance the lifetime of a sensor networks. The WSN also consists of RF transceivers and microcontrollers. The RF transceivers consumes more power in the sensor nodes. This problem is addressed by two steps. The first step proposes an intelligent energy efficient algorithm and the second step is utilizing available energy-harvesting techniques, such as solar cells, vibration, and WPT [1]. Energy-harvesting methods can be implemented with batteries for the sensor nodes. Solar cell energy has been used to provide long-term energy to sensor nodes in agriculture applications.

WSN is operated on a wide range of open agricultural areas to monitor the environmental conditions such as humidity, temperature, pressure, soil fertility, etc. In precision agriculture, most wireless sensor technologies support a relatively short communication range. Therefore, many sensor and router nodes need to be diffused in a WSN. In the point-to-point Zigbee network, the communication distance can reach 100 m in outdoor environments. The ZigBee communication range can be extended by adopting multi-tire, ad-hoc, decentralized, and mesh network topologies.

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IV. ENERGY EFFICIENT ROUTING PROTOCOLS

Wireless sensor network is highly depending on the battery of the sensor nodes. It is difficult to change once it is deployed. To improve the lifetime of the network we must concern the necessary constraints such as routing protocol and clustering. Routing protocols are classified as hierarchical routing and flat routing. In Flat routing, nodes are deployed in same level and hierarchical routing has various level of nodes called clusters. The energy efficient routing protocols defines is how exactly to route a packet from source to destination. The major requirement for routing protocol is

- Energy efficiency
- Flexibility

Routing protocols depend on network structure and protocol operation [7]. Routing depends on MAC layer and Link layer protocols [6]. The routing protocols must be cope with the nodes entering from one network or exiting from another network. The routing models were organised for increased robustness, strong scalability and flexibility. Various algorithms are proposed to enhance the lifetime of the network system. The MAC layer used to transpire periodic collection of sensor data and improve energy efficiency. This energy efficient method is based on adjusting the receiver sensitivity level and sender transmission power during the wake-up phase to exchange the energy consumed at the receiver for that at the transmitter of the wake-up signal [8]. Energy efficiency during radio communication is attained by lessening idle-listening, over-emitting, collisions and overhearing. Protocols used as a periodic listen-sleep schedule to minimize idle-listening are S-MAC, T-MAC, B-MAC and WISE-MAC. The PHY/MAC layer receive the wake-up synchronization. This keep the internode communication per round is minimum. Round refers to period of time where the sensed data from all the nodes in a field are forwarded to the particular satellite node acting as the sink [8].

4.1. Variable Sampling Interval Precision Agriculture (VSI-PA)

This VSI-PA system is proposed to monitor and measure the agricultural parameters for agricultural activities such as water irrigation, etc. This system provides significant energy consumption in sensor nodes. The agricultural form contains heterogenous plants planted in the farm. They are monitored using the sensor nodes. Here the sensor nodes are classified as master sensor nodes (MSN), Normal Sensor nodes (NSN) and Sink sensor nodes (SSN). NSN has limited resource whereas MSN and SSN has full resource with high processing and energy capabilities. MSN and SSN are used for data exchange and communication and NSN is used for sensing the temperature and moisture of the soil. The sensor node helps to sense the soil moisture and temperature and the communication mode transmit. The communication and processing modes are the active modes whereas the sleeping mode is a low-energy communication channel in which sensor node listens to channel status for transmission initialization, or waits for traffic from other sensor nodes [4]. The sleeping mode is triggered into a 'wake-up' mode. The 'wake-up' mode convert itself as active mode which helps in communication and processing.

In an agriculture form, NSN sense the agricultural parameters, MSN receive the information from NSN and SSN forward information to the server via a cellular network. The server performs processing and storage requirements for VSI-PA. the server sends triggers for actuators and pumps for irrigation. It calculates the next sampling interval and sends commands to the farm

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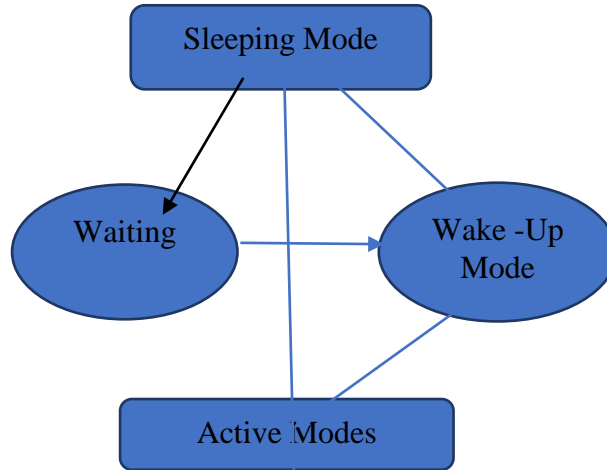


Fig2. Data transmission in VSI-PA

Variable sampling algorithm calculates the sampling interval to maintain the soil moisture of the plants and improve the energy efficiency. All plants in the form has the same water consumption. According to soil temperature the sampling level may vary. The sampling interval is reduced when the temperature is high. When the temperature is low, that is the soil moisture is high the sampling interval is increased. The overall energy consumption is reduced by the network and the network lifetime is improved. Algorithm

- Input the area of width W and length L.
- Select the sensor nodes depending on the Euclidean Distance
- Initialize time to zero and measure the soil temperature
- Calculate the sampling interval
- NSN send beacon message to MSN
- Record the states of MSN and synchronize with NSN
- Receiving the message , SSN turn on energy communication channel.

4.2 Cross-Site Leaping Algorithm for Efficient Data Transmission

Internet enable us to an end-to-end data transmission. The source sends the data as a packet to the destination. In contrast, WSN data are distributed spatially to the sensors. They are collected and processed via a sink node. Instead of sending the data to a single node, simply it broadcast the message to the neighbouring node. This leads to fault-tolerant. Clustering is the technique which helps to form a structure to the data set. Many algorithms such as K-Means, PAM are used for clustering the data set.

In WSN, group of nearby and similar sensors form a cluster. Each cluster has a cluster head and cluster member. The cluster head transfer the information to its member nodes. The base station gathers the information from the source node. The energy-based clustering protocol is responsible for selecting the suitable path for data transmission. There will be no loss in the data transmission. The cluster head generates the energy beam which helps to generate random virtual cross site nodes. This algorithm gives best result for groundwater calibration model. It helps to solve optimization problem. Linear discriminant Packet flow algorithm helps to enhance the lifetime of the cluster node, scalability of the network and detect the attack.

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Algorithm

- Randomly generate the energy ($F=m \times s$) for each group and its nodes.
- Find the fitness value and global best individual value.
- Sort the fitness value in descending order and divide the subgroup into nodes.
- Identify the best individual in each group.
- Repeat the process until to get the optimum output.

4.3 Adaptive Sleep Scheduling for Cluster Based Algorithm

This algorithm is used in energy consumption for Wireless Sensor Networks. Consider 50 sensor nodes are distributed to monitor the environmental factors such as Humidity, temperature, soil PH, soil moisture, etc. The sensor nodes which are distributed uniformly will collect the real time data. The sensor network is divided into a number of clusters. Each cluster has a Cluster Head (CH) which has the maximum energy. The remaining nodes sense the data and send to the CH. When the cluster head energy is reduced then there will be selection of new CH with maximum energy. This uses wireless tree topology design ie, all the node are kept at a specific distance. All the nodes are physically interconnected. The cluster head used to collect all the data from the source node.

Algorithm:

- Initialize the sensors with its internal energy.
- When it is active it senses the data or enter into sleep mode.
- Calculate the CH using threshold node
ie, total consumed energy= total energy (data receiving+ data transmitting)
- If any error occurs, data packets get retransmitted

Packet Delivery Ratio: It expresses the quality of the network. There will be no loss of data packets between the transmission.

Packet delivery ratio= $\frac{\text{Packet received at the destination end}}{\text{Packet transmitted at the source end}}$

4.4 Modified Zonal Stable Election Protocol

Zonal Stable Election protocol is a hybrid network protocol which is proactive in nature. SEP is also a two-layered network protocol. Z-SEP protocol is designed for heterogeneous networks. To increase the efficiency, it uses normal nodes as well as advanced nodes(α). It uses both direct and indirect communication. Here the normal nodes having less energy and advanced nodes having greater energy. In modified Z-SEP, the agricultural form is categorized into different zones such as zone 0, Head zone 1, Head zone 2. Let n be the total number of nodes deployed, m be the advanced node, then normal nodes be $(1-m) \times n$.

In direct communication, Zone 0 are normal nodes and data transmission take place between nodes and base station (BS). In Indirect communication the data transmission carried out by cluster heads takes paces in the two Head Zones where advanced nodes are deployed. It transmits data with the help of clustering algorithm to the base station. The selection of cluster head is chosen between the advanced nodes such as Head Zone 1, Head Zone 2. The optimum probability of becoming cluster head would be (P_{opt})

$$P_{opt} = (K_{opt} / n)$$

Where K_{opt} is the optimal number of clusters. Throughput in modified Z-SEP protocol is significantly better than other protocols.



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V. CONCLUSION

Wireless Sensor networks uses a large number of sensor nodes to monitor the agricultural activity in PA. To enhance the efficiency of sensor nodes various protocols are discussed in this paper. This paper helps the researcher to get a detailed knowledge about the limitations in wireless sensor networks. We have presented the deployment of sensor nodes in wireless sensor networks. This paper also discussed about the clustering technique in wireless sensor networks. This helps the upcoming researcher to gain knowledge in precision agriculture.

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