Decision based Precision Farming using Wireless Sensor Network

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Abstract: Agriculture played important role in the growth of the Indian economy. Quality growth in agriculture can be achieved by the use of new technologies. One such ever-growing area is Precision Farming (PF) with the advancement in WSN technology. The routing technique Delay-Constrained Energy-Efficient Cluster-based Multi-Hop Routing in Wireless Sensor Networks (DECM) resulted in energy conservation and minimized delay in non critical data transmission. The Precision Farming without Cluster-Based wireless sensor network (PFwoCB) provide transmission of emergency data with maximum delay. Precision farming using APTEEN (PFAPTEEN) incur more delay in response time for one-time and persistent queries while Decision based Precision Farming in Wireless Sensor Network (DPF) support transmission of data without delay in critical events such as soil moisture or microclimate conditions exceeding beyond the set threshold.

Keywords: Clustering, Delay, Precision Farming, WSN, Routing

1. Introduction

A large population of India majorly depends on the growth of agriculture production. [1]. The smaller producers cannot achieve large benefits as monitoring cost is more than what the farmer has invested. The technology control and monitoring of the growth of crops by farm automation increases the production of the quality crop. One important advantage gained is the reduction of dangerous agricultural products through Precision Farming (PF).

PF identifies variation in production of the crop in the field to increase financial returns, minimizes environmental impact and waste [2]. PF uses new technologies for remote sensing [3]. WSN, as depicted in figure 1, is a collection of low power sensing devices to sense environmental phenomena like temperature, climate, humidity, wind, and soil moisture useful for Precision Farming.

The inadequate energy of the wireless sensor nodes and unattended operation demand an energy preserving routing scheme to minimize energy consumptions of the node for data transmission from the source node to the sink [4]. Even though clustering optimizes data gathering, minimizes consumption of energy, and improves the lifetime of the network, there is a need for a proper cluster head (CH) selection [5].

Energy conservation achieved by scheduling of nodes based on predicted sensing error [6]. The routing protocol Delay-Constrained Energy-Efficient Cluster-based Multi-Hop Routing in Wireless Sensor Networks (DECM) performs cluster head (CH) selection considering node energy and delay [7]. There exits trade-off in achieving all QoS parameters and need a careful design of WSN architecture for efficient implementation of Precision Farming. The proposed framework highlights the WSN support for Precision Farming using latest technologies for different soil types, temperature, and humidity.

The remaining part of the paper includes section 2 that gives information about related work done. Section 3 specifies WSN supported PF. Section 4 discusses cluster-based approach for PF. Section 5 discusses about

Decision based precision framing. Section 6 depicts the results with discussion. The paper is concluded with section 7 conclusion of the work.

2. Related Work

The decision support system (DSS) to monitor the real-time soil condition through dashboard software in the form of a graph and to get an alert message in case of a critical level of water for achieving a good quality of the crop discussed in [8] , [9]. In [10] author discussed remotely environment monitoring with low power consumption and high precision.

The routing strategies i.e. hierarchical and flat for Precision Farming in a watermelon field [1] faced the scalability issue. Also the location-based routing protocol has been modified with a clustering technique to resolve scalability issue. In [11] the author proposed WSN based decision support system (DSS) for agriculture to avoid water wastage. Wireless sensor networks (WSNs) consist of sensor nodes that can interact directly with the physical environment to provide access to real-time data to indicate the regions in need, particularly in the farm. Different issues in technology-assisted irrigation management and their solutions are also addressed.

A good survey of routing protocols [12] cluster-based [13] are proposed in the literature for achieving energy efficiency, throughput, reliability, and minimized the delay.

3. WSN supported PF

To identify variation in production of the crop in the field and to increase financial returns, minimizes environmental impact and waste, PF can be automated [14, 15] considering agricultural parameters to be sensed and the technology needed as discussed next.

3.1. Wireless Sensor nodes Support for PF

The agriculture parameters sensed using different wireless technologies and different types of sensors have been listed in table 1.

Table 1: Requirements of Precision Farming

Sensing agricultural parameters	Wireless technology used	Sensor nodes used
• Temperature, • Nutrient, • Moisture content, • Soil moisture, • Irrigation, • Humidity	• Bluetooth, • Wi-Fi, • Zigbee, • RF	• SHT11 temperature / humidity intelligent sensor • Telos B • MICAz • MICA2 • IRIS 2.4GHz • IRIS OEM Edition • IMote 2.0 • SunSPOT • CRICKET MCS410 • ST01 or TMP36 temperature sensor • DHT11 humidity sensor • Soil moisture sensor

These technologies assist in predicting the soil, temperature, and humidity conditions of the soil for better yield from precision farming.

3.2. Wireless Technology Support for PA

Choosing the right communication technology for efficient data transfer is essential. The Zigbee [16,17] has its broad application due to its small power consumption, cost, coverage range between 50m – 200m and operating frequency band of 2.4 GHz and a lifetime of not less than one year. Comparatively, Bluetooth [18] has a lifetime of a week with a coverage range of only 10m and operates at 2.4GHz [19, 20]. WiFi, on the other hand, has a lifetime of 2 to 3 hours, incurring high energy consumption with 100m coverage operating at 2.4 GHz. [21] RF used for the measurement of temperature and moisture has useful features compared to WiFi and Bluetooth but less than Zigbee, providing coverage range of 100m with low cost, less coverage, energy consumption and life of a battery up to 6-12 months. These technologies assist in predicting the soil, temperature, and humidity.

3.2. The technological approach toward Precision Farming

PA uses information of sensor node and technologies to implement a decision based system using the following algorithm.

Algorithm 1: Algorithm for PF

Step1: Specify the sensing area

Step2: Specify the sensing parameter according to application requirement

Step3: Apply energy-efficient data collection and reliable routing

Step4: Perform required action based on a decision made on sensed data

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The first step is to specify the area to be monitored. Step 2, specify the sensing parameter based on which alert message can be sent using reliable routing in step 3. And finally required action requested based on a decision in step 4. Each step makes use of WSN technology. The cluster-based routing is applied for energy-efficient data transmission with minimal delay as depicted in figure 1.

4. Cluster based approach for PF

The detailed studies related to PF allege to specify the number of the nodes to be deployed with optimal routing techniques for energy conservation while data transmission. The proposed framework for PA using the clustering technique has been depicted in figure 1. Since cluster-based routing protocol is the best routing protocol for an energy-constrained network. The nodes are organized in clusters. The number of clusters can be specified based on the application requirements. Each CH monitors respective cluster. The CH in each cluster collects data from its respective cluster member (CM) and then sends collected data to the sink. The routing protocol based on clustering helps to minimize energy consumption with reliable load-balanced data transmission.

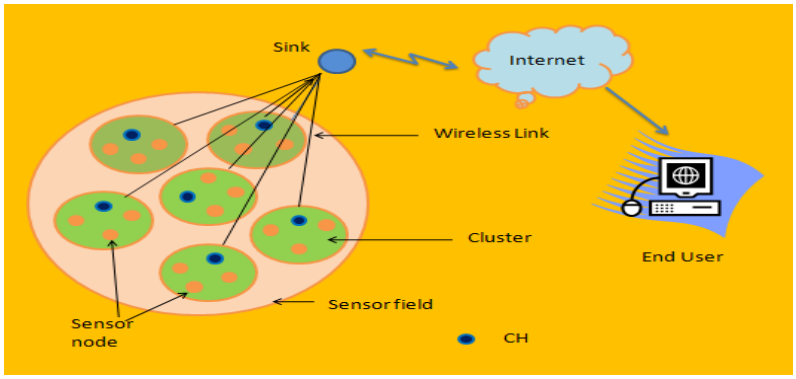

Fig.1. Cluster-Based WSN architecture

5. Decision based Precision Framing

Decision based precision farming can trigger a sudden change in temperature, humidity, moisture, and light for the plant's proper growth. DPF checks if the temperature during daytime takes the necessary action as per table 1. In case of high temperature, notify to use shade net. It also checks that if humidity is greater than set threshold and less than set threshold, it notifies to operate the curtains. If the humidity is high, curtains rolled up while if humidity is low, curtains rolled down. DSS also checks the moisture level and notify to operate sprinkler as specified in table 1.

Table 1: Sensed Parameters and respective action

Sr. No.	Parameter	Comparison with threshold value	Action to be taken
1.	Temperature (T)	T > set threshold in day time	Close top shade net
		T < set threshold in day time	Open top shade net
		T > set threshold in night time	Roll up curtains
		T < set threshold in night time	Close curtains
2.	Humidity (H)	H > set threshold	Roll up curtains
		H < set threshold	Roll down curtains
3.	Moisture (M)	M < set threshold	Supply water through sprinkler

6. Results

Fig 2: Interval versus Delay

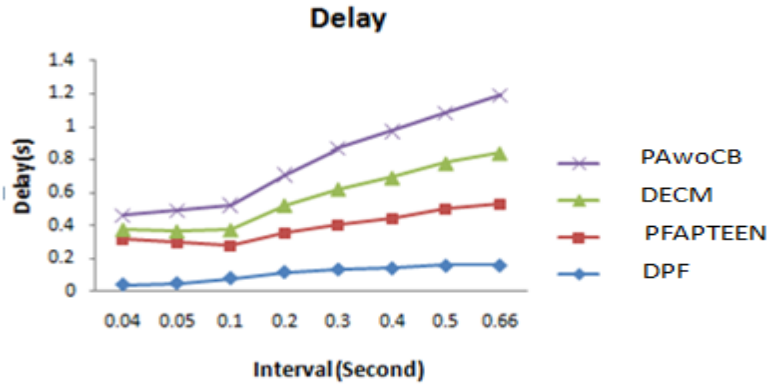

Figure 2 depicts that in the case of DECM and PFAPTEEN, as the number of data packets increase, the delay also increases compared to DPF. PAwCOR chooses in advance delay constraint and the congestion-free paths resulting in minimal delay even with an increase in packets per second but more than DPF.

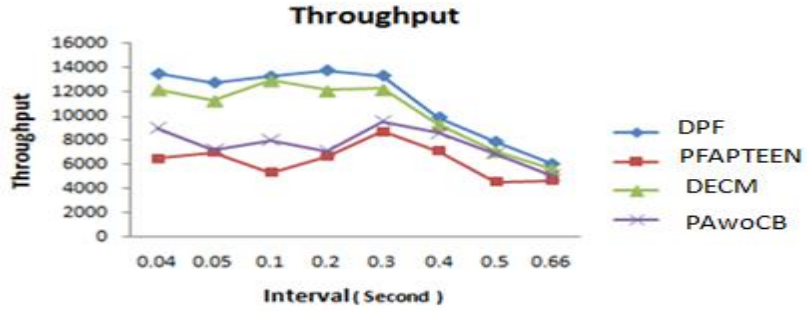

Fig 3: Interval versus Throughput

Figure 3 depicts that in the case of DECM, PAwocR, and PFAPTEEN, an increase in the packets per second leads to collusion and packet retransmission resulting in a decrease in throughput compared to DPF. Also PAwocR attain high throughput compared to DECM and PFAPTEEN

7. Conclusion

The proposed DPF uses a distributed approach for CH selection. It supports periodic data application with minimal delay using cluster based routing. It also satisfies the non-delay tolerant application requirement by prioritizing time-critical data transfer. The DPF provides improved performance compared to existing protocols DECM, PAwoCB, and PFAPTEEN. DPF has minimal delay for data transfer compared to DECM, PAwoCB, and PFAPTEEN. DPF is optimal method for reliable transmission of precision framing data. The DPF with an decision based system achieves improved performance.

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