ZigBee Based Wireless Sensor Network in Precision Agriculture - The Survey

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ABSTRACT

A WSN is a collection of micro-electro-mechanical devices. These devices have wireless receiver and transmitter technology, computational processing ability, and a power supply [12]. In a WSN large number of sensor nodes usually span a physical geographic area. The main purpose of sensor node is to monitor and control the environmental parameters as per the crop requirements. Wireless sensor networking is gaining popularity for managing precision agriculture through real-time monitoring of agricultural parameters and climatic conditions. Using Clustering and data routing algorithms in Wireless Sensor Networks nodes can be deployed and managed in ubiquitous applications like precision agriculture and many more. This paper investigates a remote monitoring system using ZigBee. Data is sent wirelessly by sensor nodes to a central server, which in turn stores it and will allow it to be analyzed [9].
Keywords: Clustering, Sensors, Ubiquitous Computing, Wireless Sensor Network, ZigBee.

1.INTRODUCTION

A huge loss is incurred every year due to damage of crops because of improper crop maintenance. Ubiquitous computing is used to monitor environmental parameters so that a farmer can irrigate the crop based on parameters like temperature, soil moisture, humidity at any time from any were, [7]. WSN facilitates the aggregation of microclimate information from agricultural fields by installing sensors within the crop canopy at various locations in the field [3] [8]. Sensor nodes senses the environmental parameters using clustering technique, and sends the result to base station through WIFI or internet and in turn base station sends the message to end user's mobile, with this end user can take a proper decision whether to irrigate the crop or not to irrigate [11].

2.PRECISION AGRICULTURE AND ARCHITECTURE

Precision agriculture is defined as the art of using advanced technologies to enhance crop production. Wireless Sensor Network (WSN) is one of the major technologies that derive the development of precision agriculture. Sensor node deployment in an agricultural field is highly reliable, gives high- performance and is cost- effective. The type of data to be sensed are temperature, humidity, etc. [1]. Precision Farming (PF) relies on intensive sensing of environmental condition and ability to handle variations in productivity within a field and maximize financial return, various technologies were used in PF such as Remote sensing (RS) , Global Positioning System(GPS) which helps to identify problems related to crop density [4]. Each node of a sensor network consist of three basic subsystem; a sensor subsystem to monitor local environmental parameters, a processing subsystem which provides computational support to node, and communication subsystem provides exchange of information wirelessly among neighboring nodes, since each individual sensor node covers limited area and they need to be connected to one another in a coordinated manner to form Wireless Sensor Network, Which provides large amount of detailed information about a geographic area.
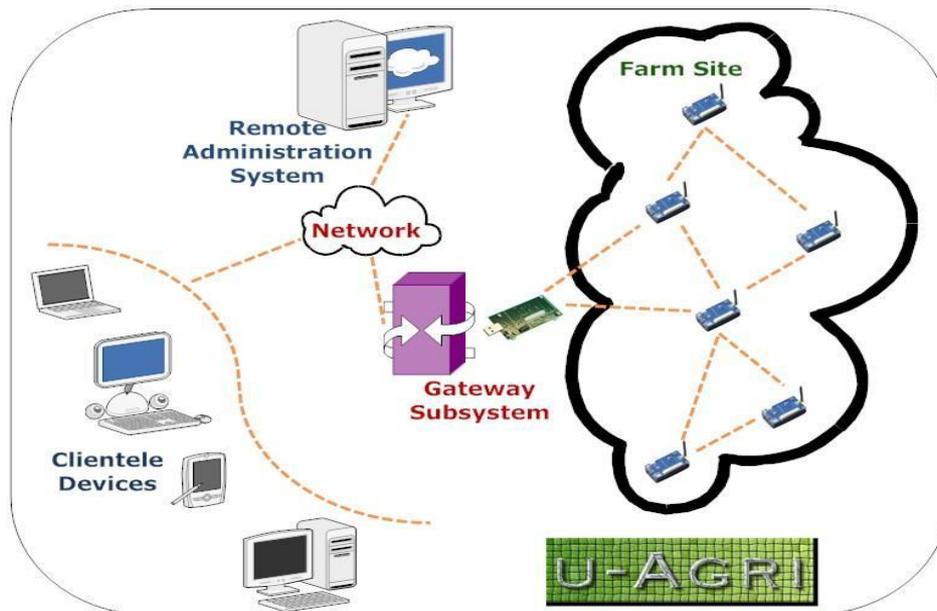
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Figure 1: u-Agri System Architecture [12]

The system architecture (Fig. 1) consist of three components Farm Site (FS): It consists of WSN motes deployed in the field. Remote Administration System (RAS) utilizes WSN weather data for data analysis. Gateway Subsystem (GS): Which aggregates sensed weather data from FS and stores it on the Remote Administration System (RAS) [12]. In precision agriculture, monitoring of sensor data at any minute may not be needed. The data may be monitored on hourly basis or at different times of day, e.g., morning, afternoon and evening. This, in turn, helps in conserving the battery power of sensor nodes; it may be good idea to aggregate the sensor data captured over a period of time at each node before sending the aggregated data the monitoring system [2].

Table 1: Parameters set for precision agriculture using ZigBee Technology for a soil type

Name of Crop	Soil	Water	Temperature
Paddy cultivation	Clay or clay loams are more suitable	1200-1400mm	20^0-27^0 C
Wheat cultivation	Clay loams are best suited	400-430mm	21^0-24^0 C
Toor Dal Cultivation	Sandy loam is more suitable	600-650mm	30^0-55^0 C
Bajra cultivation	Sandy soils, black and red soils	70-80mm	25^0-35^0 C

3. ZIGBEE PAN COORDINATOR

The ZigBee standard is built on top of the IEEE 802.15.4 standard. The top layer is called application layer which is responsible for converting input into digital data and/or converts digital data into output. Network layer provides ZigBee functionality like message routing and security and act as a buffer between application and data link layer, IEEE 802.15.4 standard defines the physical and MAC (Medium Access Control) layers for low-rate wireless personal

area networks. The physical layer supports three frequency bands with different gross data rates: 2,450 MHz (250 kbs-1), 915 MHz (40 kbs-1) and 868 MHz (20 kbs-1) [10] as shown in Table1. Power consumed by the ZigBee network is relatively less; batteries must be changed when the power gets exhausted [23].

Table 1: ZigBee protocol Layer

Application Layer
Network Layer
IEEE 802.15.4 MAC sub-layer
IEEE 802.15.4 Physical Layer

4.CLUSTERING ALGORITHMS
Clustering technique increases scalability, energy consumption and network lifetime.
4.1 Location Routing Algorithm with Cluster-Based Flooding (LORA_CBF)
LORA-CBF routing algorithm includes a metric to monitor residual battery energy. LORA-CBF is formed with one cluster-head, one or more members and gateways to communicate with other cluster-heads. "Cluster Table" is maintained by each cluster. A "Cluster Table" is defined as a table that contains the addresses and status of neighbor nodes [5]. A node in LORE-CBF can be in any of the following four states:
1. Undecided: a node is in this transactional state when it is in search of cluster-head. Nodes are initially undecided when they enter the network.
2. Member: a node that is a member of any cluster assigned to cluster-head. A member in LORA-CBF cannot re-transmit a search packet.
3. Cluster-head: a node that is responsible for all the nodes in its client. The cluster-head is responsible for periodically transmitting Hello Message. The cluster-head also maintains the cluster table of member and gateway nodes in its cluster.
4. Gateway: A node that is member of at least two cluster-heads that can be used for communication between clusters [8].

4.2 IC-SVD-Based Sensor MEB Clustering Algorithm
Immuno-Computing and SVD (Singular Value Decomposition) based Minimum Energy Binding (MEB) algorithm is another algorithm for sensor clustering in WSN. The MEB algorithms address communication and energy constraints in networks made up of a large number of sensors that require effective mechanisms for the multi-hop data transmission. The most prominent feature of the MEB algorithms is their ability to allow individual sensors as well as the entire WSN fields to monitor events by configuring nodes according to their affinity to events that occur in environment. The configuration of the sensor field has an opportunistic character as the WSN resources that are organized according to the MEB model, The MEB class of algorithms can be applied to generate resource utilization and quality of clustering/routing maps to support decision making in WSN. The MEB clustering and routing algorithms for WSN include: Minimum Energy Binding Clustering and Minimum Energy Binding Re-nomination of Cluster Heads [6].

4.3 Comparison study between LORA-CBF and IC-SVD sensor MEB clustering algorithm
LORA_CBF is suitable for both flat and hierarchical algorithms and is suitable for small-scale agricultural use. Immuno-Computing and SVD (Singular Value Decomposition) based Minimum Energy Binding (MEB) algorithm address communication and energy constraints in networks made up of a large number of sensors for the multi-hop data transmission.

E. RESULTS
The following monitoring results are obtained for temperature, humidity. This real time monitoring results are recorded on server. The graphs are plotted for monitoring of temperature, humidity for the month of Feburary 2014 [14] designed using ZigBee WSN as shown in figure 2 for monitoring crop by deploying moister sensor in the land to detect where the water level is low.
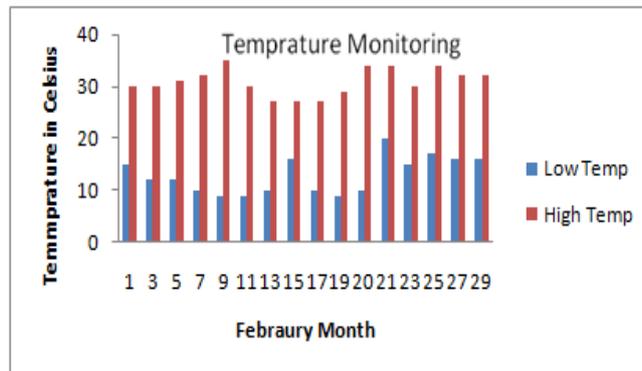
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Figure 2: Temperature monitoring on 10th Feb 2014

Humidity sensor is used to sense the weather. So, that farmer gets the idea of climate. If there is any chance of rainfall, the farmer needs not to irrigate the crop. Due to this we preserve water and also power since we do not turn on motors [15] (figure 3). If humidity is kept below 50 percent for extended periods, growth can suffer as loss of water from leaves [14].
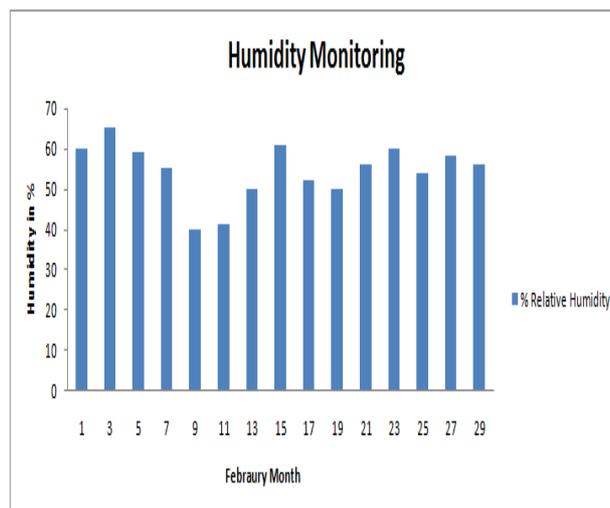

Figure 3: Humidity monitoring on 10th Feb 2014

Based on the agricultural product being grown the temperature can affect growth, germination, and sprouting and fruit development. Measurements acquired by the system and logged for temperature within an enclosed Hydroponics greenhouse can be seen over an approximately 12 hour period as shown in Table 3 [13].

Table 3: Temperature monitoring on 14th march 2014

Time	Temperature in Celsius
12.01AM	20
1.01 AM	20
2.04 AM	20
3.06 AM	19
4.08 AM	19
5.10 AM	20
6.12 AM	18
7.14 AM	18
8.16 AM	20
9.18 AM	22
10.00 AM	22
11.22 AM	25

Humidity is of importance, as when levels are too low or too high agricultural products can suffer. If humidity is above 80 percent for extended period risk of disease can increase as shown in Table 4 [21].

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Table 4: Humidity monitoring on 14th March 2014

Time	Humidity in %
12.01AM	28
1.01 AM	28
2.04 AM	28
3.06 AM	28
4.08 AM	28
5.10 AM	28
6.12 AM	28
7.14 AM	29
8.16 AM	30
9.18 AM	31
10.00 AM	31
11.22 AM	33

5.CONCLUSION

ZigBee based agriculture monitoring system serves as a reliable and efficient system to efficiently monitor the environmental parameters like temperature, humidity, etc from anywhere at any time by sensing the data using clustering algorithms in wireless sensor network. Wireless monitoring of crop allows user to reduce the human power. It is much cheaper in cost, consumes less power.

6.FUTURE WORK

The power of sensor nodes has risen due to their small physical size and lack of wires. Constant power supply is not their because they are not connected with wires. Sensor nodes are battery driven and it is difficult to replace or recharge batteries because sensor network contains hundreds or thousands of nodes and deployed in remote environment in fields for crop monitoring. This problem has to be solved by using harvesting sensors.

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