Review of WSN based Precision Agriculture Monitoring System

Jyotshna Kumari
Student
Amity University, Lucknow

Satish Kumar
Professor
Amity University, Lucknow

ABSTRACT
-Relaying on the study of the development of agricultural process and mechanisms, system of farming process reforms, protection of farming and agricultural methodology and also by the development in the area of information technology, it became possible to perceive the process of precision agriculture. Comprehensive review of the monitoring systems of the agricultural environment system has been offered in this paper which is based on one of the emerging technologies called Wireless sensor network (WSN). WSN provide processed real time field data from sensors physically distributed in the field .In this paper introduction to the theory of the monitoring system is described along with discussion of the features of hardware components design & software design of the parts composed, topologies of the network, along with communication protocols in addition with present challenges in the area are overviewed. Researches have been conducted the by researchers and scientists are involved in the work to show that node can attain information from environment aggregation and transmission related to agriculture which may improve the efficiency in farm production and automated level notably.

Keywords
Agricultural monitoring system, WSN protocol, monitoring environment, data acquisition

1. INTRODUCTION
In agriculture related information evolution sector, the gathering of related facts via some technologies are very important for research administration in scientific agriculture. A WSN finds extensive applications in agricultural area. The real time weather and soil conditions can be received, processed and monitored easily by embedded system. The cheaper and highly-smart instruments and appliances are being used in the agriculture fields for improving the conventional agriculture. The term precision agriculture (PA) is an approach to the farm which pinpoints the important parameters in which crop production yield is bounded by variable parameters, and figure out integral spatial variability [1]. It can be termed as more precise farm managing technology made achievable by modern technologies. The variations going on in the properties of the crops and soils within a field are observed and plotted & after that necessary managing steps are acquired in result of continued assessment of the spatial variability in the observed sector. The typical traditional farming has been practiced for uniformity in application of insecticide, fungicide and irrigation, fertilizer, herbicide, excluding the accounting for spatial variables. For reducing the bad-effects of the overmuch and lower than upper limit use of the inputs, the new stereotype of P.A has introduced [2]. Managing of spatial variability site of agriculture field is evolved for maximizing crops yields while at the same time reducing environmental pollution and degradation and sustaining the development of the agriculture. Spatially the production of variable crops in bulk scale are driven by the emerging modern technologies. The new instruments and appliances used in the precision agriculture are the upgraded technologies of computers and electronics such as Geographic Information Systems (GIS), Remote Sensing Technologies and Global Positioning System (GPS). These technologies includes in it, data collection, analyzing captured information and implementing required steps in regard of the information.

Because of rapid evolution of Micro-Electro-mechanical systems, Wireless Sensor Networks (WSN) may be used generally in applicative areas like in consumer electronics sector, healthcare, industrial monitoring & controlling, agricultural field, etc due to the reason that it minimizes the investment and time. Taking into consideration the sensor nodes sites with huge accuracy, scientists adopt networks which well arranged instead of using an ad-hoc network. Diversity in the routing and multiple transmissions are provided by wireless sensor network [3].Authors depict a P.A architecture relaying on wireless sensor network. The installed great-scale wireless sensor network based sensors collaborates with each other to gather, process and communicate over wireless channel about some physical phenomenon. WSN has important and relevant importance and use in area of the smart agriculture, though they too have few of the drawbacks. They are able of collecting the environmental facts, yet are poor at controlling the field environment. The architectural systems in agriculture system are illustrated beginning at the hardware of the sensor node in the bottom to managing the sub-system at top and are analyzed in the real-installment. The system to regulate the atmosphere making use of the feedbacks from the collected facts and data is mentioned in the paper.

2. AGRICULTURAL SYSTEMS DESIGN RELAYED ON WSN
An effective precision agriculture system has the function that the terminal node can acquire soil moisture content, humidity, temperature, conductivity and light intensity through self-organized network. The collected information are transmitted to the gateway wirelessly using modes like LAN or WAN. The systems embrace the cluster topologies & hierarchical routing protocols for this purpose. Every sensing node are split into several clusters and each cluster is analogous to a kind of immovable self-systemizing network. The nodes are then further split in common & the cluster-head nodes. Work of the common nodes is to accumulate the facts which is sent to the cluster head nodes. The received facts are banked into the memory unit. Then expert decision support system analyzes & processes facts.

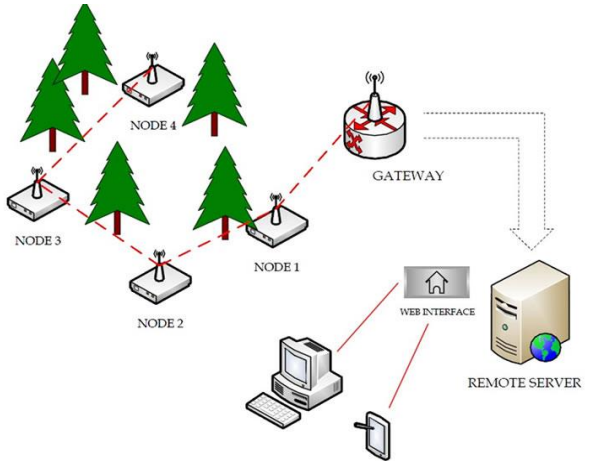

Fig: 1 WSN Network

2.1 Hardware Design of Sensor Nodes

The P.A system architecture dependent on WSN technology comprises six basic sub units:- (1) sensor unit, (2) amplifier unit,(3) analog to digital converter(ADC), (4) transceiver, (5) processor unit and power unit in addition with base stations, Internet access , hardware and software systems. From Fig2, it shows the node network structures which boosts system scalability [4]. Sensor is basically a transducer which functions to convert the physical quantity to be measured into an equivalent analog electrical signal. The transducer output may not be appropriate to fanout ADC, so it is amplified to proper level and digitally converted by ADC. The processing unit control the operation of the sensing nodes, and processes the collected facts raw information. The processor unit is generally a microcontroller which manages local processing operation on the sensed data. Also microcontroller is programmed to carryout different communication protocols for transmission of locally sensed data to the nodes in neighborhood. For multihop controller is also responsible to relay the sensed data by a different node to next node in direction to coordinator node. Transceiver unit is for communication among WSN nodes. Wireless communication module as the name suggests, communicates to another nodes, swap controlling information and transmit and collect data .Sensor nodes, routers and gateway are used to develop the WSN platform for the precision agriculture. Using multiple routers allows wide coverage of network for the precision agriculture.[17]

Sensor module functions for gathering temperature, humidity, light intensity and other parameters and information converting module. The power unit supply power required for the sensor unit, the processor unit and the wireless communication unit. Structure of hardware of node is shown in Fig.2

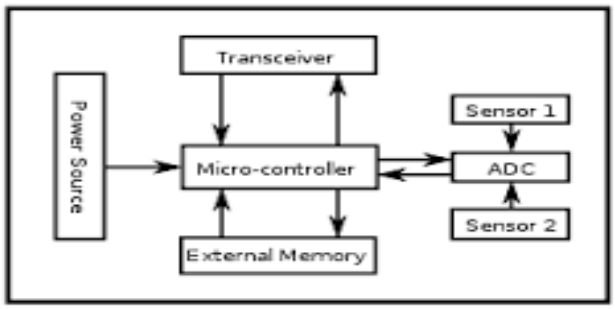

Fig.2 Hardware Structure of Node

2.2 Cluster-Head Node's Hardware Design

Environment facts are acquired by the cluster-head nodes itself. Signals from the deployed sensor nodes are received by it which further integrate them and stores the data automatically [5]. Node or cluster-head node hardware is branched further in units like the , the analog to digital converter (ADC) module, moisture sensor, the Wireless communication unit, Liquid crystal display module, memory unit and the power supplies. The sensed sensor signals are sent to the signal processing circuit via cluster-head nodes. Post analog to digital conversion, data is then sent to the Microprocessor [6]. In case when Cluster-head node enquires to self-systemized nodes , then cluster-head node get in return the information from the concerned node regarding the enquiry. Received data by the cluster-head node is then stored automatically in the regular universal serial bus device.

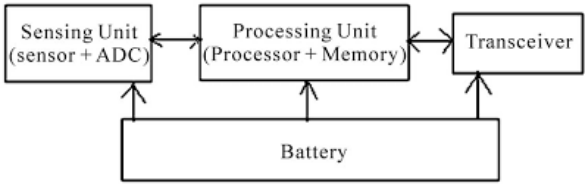

Fig.3Cluster-head node unit[15]

2.3 Remote Control System

This system realizes processing of Real-time data by a network accessing system with internet, interface display control managing system and remote monitoring system. The real time data processing functions, like Data reporting, Graph generating, Data banking, the statistics if fault analysis and its statements, prints and reports[7]. In remote control system network connectivity is attained through TCP/IP and communicates inbetween the central station and terminal node. Analyzing & evaluating the facts and information in system provides standard assessment to agriculture environment.

3. SOFTWARE SYSTEM DESIGN

3.1 The Architecture Software

Software architecture in sensor nodes is split into embedded OS kernel layer where kernel is the computer program constituting the central core of the computer's operating system and application programming interface layer (API). Tasks are provided by the embedded module, communication protocol and power management [7]. Sensor acquiring and Radio frequency communication module are provided by the API layer. The architecture the software of sensor node is shown in Fig4[15]. The flow of control throughout the OS is seen via module called task debugging , which is generally to initialize wireless sensors & for maintenance of the operating mode. The processor, sensors, Radio frequency transceiver in addition with other parts consuming energy of the state control is supported by the power management module [8]. The nodes waking at correct time, running in the less-power mode and maximizing the usage of energy is ensured by power management.

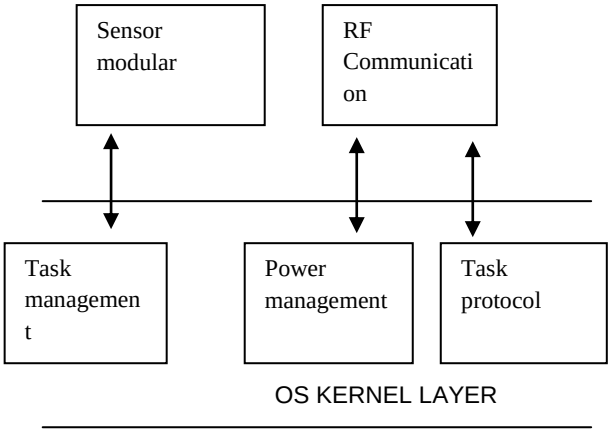

Fig 4. Sensor node software architecture

3.2 Wireless Sensor Network Protocol Function [15]

Standards of communication in wireless protocol between the cluster-head nodes and nodes are provided by the wireless network communication protocol,[9]. It attains registration, data acquisition, sleep the node, device controlling, settings of parameters and debugg.

a) Registration: In this, nodes when work on, the Medium access control is registered by the node to the cluster-head node, and network subnet number is accessed. It is assigned to a child node ID.

b) Node Sleeping: Data packets are sent by the cluster-head node to figure out the node sleep interval in future.

c) Collecting Data: In corresponding to the testing conditions, the task of collecting data is assigned by the cluster-head nodes. Example- light intensity, temperature, humidity, and gas concentration related data.

d) Device Control: The data and information are analyzed by the cluster-head node. Decision is also made by it. Then the control instruction packet is transmitted to the nodes.

e) Settings of Parameter: The reshaped instruments parameters are sent to child node by the cluster-head node.

f) Debugging: This is for the equipment development and debugging purpose.

3.3 Stack protocol of wireless sensor network

Gateway & the Sensor nodes are software components. Managing and processing data is done by gateway software [10]. It primarily comprise serial port communicating software, Radio frequency (RF) communication software, task management and command software. TinyOS is the used operating system. The directions by cluster-head node is received by software of the sensor nodes and then sends information to the sensor gateway[11]. Fig.5, shows the protocol stack of wireless sensor composed of the medium access control (MAC) layer physical layer, network layer & the other components. The application interface provides with a software interfacing which includes the application sub-layer plus device object, so that the management of the equipments are achieved by the application layer. It consists of various GUIs to provide suitable information and support user request. The user can access agricultural environment information and status through the various platforms like smart phone web etc. Physical layer consist of soil sensors, actuators, and CCTV cameras. This sensors will collect environmental and soil information periodically and transmit it to sensor managers.

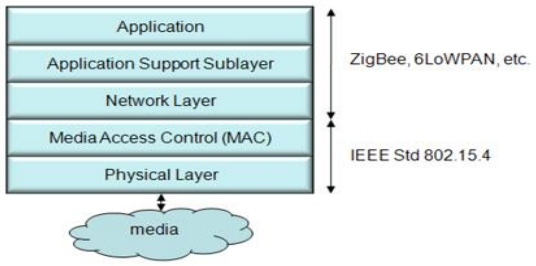

Fig.5 The protocol stack architecture[16]

4. CHALLENGES AND PROSPECTS

In monitoring system of agriculture environment, the nodes works under the unfavorable environment conditions, hence they are different in design on comparing with the conventional one. Due to the wide sector of agriculture productions to be monitored, there is large number of sensor network dispersed in various regions for achieving the comprehensive monitoring in agricultural fields. Due to the limited energy of sensor nodes, the chances of failure of nodes are very large. Hence the reliability problem must be solved by the monitoring system. The lifetime of WSN is dependent on the sensor node failure. Precisely saying the agricultural monitoring system must have to solve the following problem:

4.1 The Large-Scale High Density Network Structure

Monitoring necessity the movements of materials in the geographic space is the main inspiration of the sensor networks. On comparing to conventional mode based on the radar or satellites, Wireless sensor network acquires few technical supremacy on a distributed multi-dimensional and multi-angle information processing [13]. It considerably improves the SNR, and reduces shadows and blind spot. The network node must be on bulk-scale, and high density deploying method for monitoring of the coverage sector and connectivity [14]. A big number of nodes in the network might raise the cost price affecting the network in the practical application. The premise of agriculture application is to design an available and economic deployment mechanism for WSN.

4.2 Node Energy and Processing of Data

Communication system is energy consuming. Every node are capable of processing data which alleviates network transmission expense by extracting & processing originally obtained data. A clear sketched networking, plus data transferring and irrigation algos are of much importance throughout the lifetime of network.

4.3 Tolerance and Redundancy of Network

The fidelity and validation of information in agricultural environment monitoring technology system is of much importance. Optimizing node distribution is surveyed for reducing the consuming of energy and ensure the effectiveness in information and data acquisition in WSN. Network fault tolerance covers detection of failure of nodes and recovery of the same. It is important to locate the node failure. If portable GPS devices are consisted by each node, it will automatically raise the expense of the whole network. Hence balancing in-between the cost of network configuration and node failing detection is the problem to get solved. The node failing recovery replaces

general failure of the redundant nodes, so there is need to design the number and location of the redundant nodes.

5. CONCLUSION

In this paper, reviewed the designs and installation of a wireless sensor network for the purpose of monitoring agricultural atmosphere and estimated the reactivity, robustness, longevity of the network in the required area. Comparing to conventional agricultural system, this system greatly enhances agriculture production and yield efficiencies. In future, agriculture may need to face the challenges for providing enough nutrition for people. Therefore need of an hour is to take decisions, how to raise agriculture productivity as the production for most of the food crops in developing countries are lower. It is obvious that for sustainable and equitable distribution of natural resources, latest tools of science and technology are applied. For managing the farm precisely the new technology may be able for several possibilities. Future work will concentrate on the bounds of the current prototype in robustness of packet delivery and network longevity, and also in guaranteeing network response to event of interest.

6. REFERENCES

[1] Richard Beckwith,Daniel teibel and Pat Bowen.Report from the field results: From an Agricultural Wireless Sensor Network. In First IEEE Workshop on Embedded Networked Sensors, 2004.

[2] A.K Fung, F.T Ulaby. Scattering from a Vegetation Layer .IEEE Transactions on Geoscience Electronics, vol. 17, pp.I-6.

[3] Samuel Madden, Michael Franklin, Michael, Joseph Hellerstein, and Wei Hong TAG. A Tiny Aggregation Service for AD-Hoc Sensor Networks. In 5th Symposium on Operating System Design and Implementation, pages 131-146, December 2002.

[4] V.I Adamchuk et al. On-the-go Soil Sensors for Precision Agriculture. Computers and Electronics in Agriculture, vol.44,page.71-91,2004.

[5] Alan Mainwaring, Joseph Polastre, Robert Szewczyk, David Culler and Jhon Anderson. Wireless sensor Networks for Habitat Monitoring. In Proc. First ACM International Workshop on Wireless Sensor Networks and Applications, September 2002, Atlanta, Georgia, USA, 2002.

[6] Bogena H R, Husiman J A, Obed rster C, et al. Evalution of a low-cost soil water content sensor for Wireless Sensor Network applications[J]. Journal of Hydrology, 2007, 344 (I): 3242-3250.

[7] C.T. Leon et al. Utility of Remote Sensing in Predicting Crop and Soil Characteristics. Precision Agriculture, Kluwer Academic Publishers, vol.4,pp.359—384, 2003.

[8] Pottieg Kaiser Wireless integrated network sensors[J]. communications of the ACM, 2000, 43(5)551-558.

[9] D.Pimentel,D, J Houser, E Preiss, O.White, H.Fang, L.Mesnick, T.Barsky, S.Tariche, J.Schreck, and S.Alpert.Water Resources agriculture; the Environment and Society, Bioscience, vol. 47, no.2, pp.97-106, Feb. 1997.

[10] Jhon Heidemann, Fabio Silva and Deborah Estrin. Matching Data dissemination algorithms to application requirements. In proceedings of the First International Conference on Embedded Networked Sensor System, pages 218-229,2003.

[11] Lin K, Zhao H. Energy Prediction and Routing Algorithm in Wireless Sensor Networks [J].Journal on Communications, 2006,27(5):21-23.

[12] RodoapluV.MengTH Minimum Energy Mobile Wireless Networks [J]. IEEE J.Select. Areas Communications ,I 999.17(8):1333-1334.

[13] CardeIl20Iiver R, Smettem K, Kranz M, et at. A reactive soil moisture sensor network design and field evaluation [J]. International journal of Distributed Sensor Networks, 2005, I(2):149-162.

[14] Sinem C E. Power efficient and delay aware medium access protocol for sensor networks[J]. IEEE Transactions on Mobile Computing 2006, 5(7):920-930.

[15] Lei Xiao."The realization of precision agriculture monitoring system based on wireless sensor network",2010 International Conference on Computer and Communication Technologies in agriculture Engineering, 06/2010

[16] Joe Tillsion. An introduction to wireless sensor network concept. August08, 2011.

[17] Ibrahim Mat, Mohamed Rawidean Mohd Kassim, Ahmad Nizar Harun. Precision Agriculture Application using Wireless Moisture Sensor Network. 2015 IEEE 12th Malaysia International Conference on Communications (MMIC)