Real Time Monitoring of Agri-Parameters using WSN for Precision Agriculture

Abstract— Wireless Sensor networks (WSN) are used for collecting, storing and sharing the sensed data. Availability of cheap sensors which are capable of measuring a number of environmental parameters allows continuous monitoring of the environment and real-time applications. Today, environmental monitoring has changed its paradigm from on-line sensors to real-time sensor networks. WSN is a system having a set of sensor nodes and a communication system that allows automatic data collection and sharing. They allow monitoring remote, hazardous, dangerous or unwired areas, for example in the monitoring and warning systems for major environmental disasters and for precision agriculture. Precision agriculture is the art and science of using advanced technology to enhance crop production. Wireless sensor network can drive the development of precision agriculture. This paper attempts to ascertain usefulness of WSN in the precision agriculture and seek the solutions to the commonly arising questions during the implementation.

Keywords—Wireless Sensor Networks, Precision Agriculture, Environmental monitoring, Real time sensors, Agri-parameters

I. INTRODUCTION

Environmental monitoring has changed its paradigm from off-line sensors to real-time sensor networks. WSN is a system having a large set of sensor nodes and a communication system that allows automatic data collection and sharing which can used for decision making. They allow monitoring remote, hazardous, dangerous and unwired areas, in the monitoring and warning systems for major environmental disasters and for precision agriculture. Precision agriculture is the science of using advanced technology to enhance crop production. Wireless sensor network can drive the development of precision agriculture. The engineering questions associated with precision agriculture using WSN concentrate on increasing the efficiency of the overall system for improvement. Increase in any efficiency agricultural field will be resulting out of spreading networking sensors on a wide area to sense and then monitor number of agri-parameters and not just integrating this information by display or recording information, but to help the farmer to take sound decision.

By making good use of WSN in precision agriculture, farmers can concentrate their efforts toward deciding upon the crop patterns and areas which are in need of water, nutrients or other attention (like pesticides). This information which is collected in real-time can increase agriculture efficiency by providing the farmer with the values of agri-parameters in a timely manner and therefore to enable him act on it. Design and development of a wide range of such sensor devices would greatly benefit the agricultural sector which happen to be a driving factor of our economy. Wireless sensor networks are used for the integration of various spatial and temporal patterns of the farm-land and also the trends in climate, hydrology, pressure, motion, soil moisture, pests, and reporting best management options to the agricultural farmer. Bio-sensors are becoming an emerging field where sensors are used for detection of the onset of various crop diseases, and the unwanted transport of genetically modified organism (GMO) materials. The sensors capable of detecting GMO material would help in early detection and mitigation of these attacks by highly selective pesticide applications. Sensors which allow the farmers to identify quality, harvest-readiness and to sort in real-time will allow them to compete in terms of price and quality.

II. CURRENT TECHNOLOGY

In Precision—Agriculture field variations are monitored, stored for managing and maintaining the precious resources using technologies to manage and improve production or yield. This can be the tool at the hands of agriculturists for management with goal of optimizing return on investments while preserving natural resources. Precision Agriculture deals and takes care of viz. three branches of science

1. Crop Science: Understanding needs of crops according to weather and managing resources like fertilizers.
2. Environmental Protection: Precision agriculture helps to reduce Carbon, Nitrogen and Methane emissions.
3. Using WSN in agriculture can help reduce wastage, preserve resources, and utilize them effectively resulting in improved efficiency, reduced efforts and boost economy.
WSN Technology can effectively help this to achieve. It has the ability to reach out to the sensors which gives real time data on field helps to achieve real time monitoring (data collection) and control at fields from remote location. Farming efficiency and production can be improved by precision agriculture if the WSN technology can be made to reach the farms. Wireless Sensor Networks has the potential to accomplish this.

Wireless Sensor networks can be used for monitoring spatio-temporal changes in climate, hydrology, pressure, motion, soil moisture, plant eco-physiology, pests and reporting best options to the agriculturist. Having such information at regularly would be a big boon for him. In order to ward of the adverse conditions which challenge the agriculturists, automatic actuated devices can be used to control irrigation, fertigation and pest control. Irrigation management is also one of the important activities in precision agriculture. Microplitis Croceipes, a tiny parasitoid wasp, locates caterpillars attacking cotton plants by keying on a complex volatile organic cocktail emitted from the plant when attacked. Thus sensors capable of detecting this cocktail would result in early detection and mitigation of these attacks by highly selective pesticide applications or wasp introductions.

Conventional precision agriculture has following parts:
   a) Sensing agricultural parameters
   b) Identification of sensing location
   c) Transferring data from crop field to control station for decision making
   d) Actuation and Control Decision based on sensed data

With core parts of WSN like hardware design, routing algorithms, network protocols there is application focused research required for precision agriculture. WSN for precision agriculture broadly has scope in following areas:
   a) Sensor network for agriculture and water monitoring
   b) Provide data on local weather, soil moisture and water quality at high temporal resolution
   c) Develop automatic sensors and data services
   d) Develop agricultural applications and environmental monitoring
   e) Support new business initiatives
   f) Monitoring Local Temperature/ Humidity

It is observed that, the green house technology is a well-accepted concept today in agriculture engineering. The integration of wireless sensor network in green house is the recent phenomenon, which leads to precision agriculture. Blackmore et al. in 1994 [2], explained that, the system can be designed to increase the quality agricultural yield by properly monitoring soil and environment. They also observed that, in early stage of using WSN, farmers were reluctant to deploy it, because of high cost. Technological development has reduced the cost. In addition to advents in MEMS technology for hardware, satellite sensing and remote sensing is also contributing in overall progress [3].

Beckwith et al. had worked on WSN in large vineyard on very large scale design and deployment [4]. They worked on 65 motes, which have only eight hops, to collect the data of pH values of the soil at various places in the vineyard. Predesigned crop management in precision agriculture has been studied in the Lofar Agro project. In this project proper application of pesticides and fertilizer as per real time environmental changes is explored and deployed. For effective control of crop diseases like phytophthora, the information collected from a weather station and the wireless network is very much useful [5].

III. SELECTION OF HARDWARE

When a more number of sensors (to identify the agri-parameters) are needed to be networked wireless then various levels of networking may be required for a typical greenhouse control. A ZigBee sensor network can use to maintain network performance at a high level, alternately Remote Application Server (RAS) can also be employed in the area near to the localized sensor to gather localized data, to host and to manage the network. WSN sensors (motes) are equipped with some smart transducers and micro-controllers for providing processing and network management capability to the WSN. Standard like IEEE 1451.5-2007 (Wireless Communication Protocols & Transducer Electronic Data Sheet (TEDS) Formats) is suitable for integration of the wireless sensors with the special transducer to build intelligent wireless sensors with sensing, computing and communication capabilities. Intelligent sensors and actuators can be used to carry out various automatic functions. Wireless communication protocols, such as 802.11, 802.15.4 and 802.15.5 [6] can also combine. A requirement for design of wireless sensor communications, including issues related to wireless sensor model, user requirements, data integrity, security and bandwidth all are well defined in this Standards.

The Cypress Inc. has developed CY3271 PSoC First Touch Starter Kit with Low-Power RF, which is a low-cost USB thumb drive kit including related IDE software for sense and control of the data collection. It consists of a PC dongle with RF and multifunction board with power amplifiers and two battery boards. It can be also used for touch-sensing, temperature-sensing, lighting-sensing and proximity sensing requirements of greenhouse.

IV. NUMBERS OF SENSOR NODES AND INPUT PARAMETERS

The total number of sensor motes is dependent on the size of greenhouse. About 100 nodes are sufficient if the size of green house is 30m x 100 m. This is the physical size of the targeted area. It is under the range of sensing capacity of the hardware. The sensor nodes can be classified as ‘A’, ‘B’ and ‘C’.

While type ‘A’ is climate sensor for outside, and type ‘B’ is climate sensor for the inside of the greenhouse. Maximum two nodes are more than enough for outside. Type ‘B’ sensors can be placed at a distance of 10 to 15 meters of diameter, to capture precise environmental condition. The type ‘C’ sensors are soil sensors, which are recommended to
use, as per the layout plan of the crop plantation. They can also control water flow of irrigation system used in Greenhouse. They are typically used after every two meters. The different controlling parameter ranges in various modes for some typical crop is as shown in Table 1. This information collected from the data sheet about the crop [5].

<table>
<thead>
<tr>
<th>Crop</th>
<th>Temp °C</th>
<th>CO₂ PPM</th>
<th>Light K Lux</th>
<th>Moisture Air</th>
<th>Soil</th>
<th>pH Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnation</td>
<td>16-22</td>
<td>1000</td>
<td>45-50</td>
<td>65</td>
<td>16</td>
<td>5.5-7.0</td>
</tr>
<tr>
<td>Gerberas</td>
<td>27-30</td>
<td>1000</td>
<td>35-40</td>
<td>65</td>
<td>17</td>
<td>5.5-6.5</td>
</tr>
<tr>
<td>Anthurium</td>
<td>24-36</td>
<td>1000</td>
<td>18-35</td>
<td>75</td>
<td>20</td>
<td>5.5-6.5</td>
</tr>
<tr>
<td>Tomato</td>
<td>16-35</td>
<td>1000</td>
<td>45-50</td>
<td>65</td>
<td>16</td>
<td>5.5-7.0</td>
</tr>
<tr>
<td>Rose</td>
<td>15-30</td>
<td>1000</td>
<td>30-40</td>
<td>70</td>
<td>17</td>
<td>4.0-5.5</td>
</tr>
</tbody>
</table>

The main objective of WSN system for PA is to control the climatic condition as per the crop data sheet. The outside sensor is designed for collecting information about the outside climate of the green house like Temp, Pressure, Light, Humidity, CO₂, Wind speed and wind direction. All these parameters gives the outside world information about the climate. With the help of this, system will decide the action about the controls like, in out air flow control, screen control (protect the direct sunlight and sun heat) and sprinkler (to maintain the humidity and temp).

In typical green-house control, it is necessary to monitor outside wind direction and wind flow. These two parameter helps the system to decide the control of fans which are place at different places to throw the inside air to outside or vice-versa. Soil sensors are placed in heavy density as compare to others. Sensors based on time-domain reflecto-meter (TDR) principal will be used to measure the soil parameter. It is expected to get the soil moisture, soil temperature, soil pH value, and soil electric conductivity. In a real-time environment, we require only two of them, soil temperature and soil moisture. This will help to decide either sprinkler or drift irrigation is to be control. Other parameters will help to improve the soil condition through fertilizer or other treatment of the soil. Some of this process is worked in the background of the system. It may just display the parameters and log it for further process or application to decide the soil treatment.

V. SENSOR TYPES AND PARAMETER CONTROL

In this study and analysis, considered three types of sensors have been considered. Sensor Node ‘A’ which is, outside climate sensor will help to get time to time information about wind flow, wind direction, ambient light, temperature, ambient pressure, humidity and percentage of CO₂. Sensor node ‘B’ is inside climate sensor and will monitor ambient light, temperature, ambient pressure, and humidity and CO₂ percentage from the inside of the green house. Soil sensor node type ‘C’ would be specially design for to monitor the soil conditions like humidity of soil, temperature, pH value, and electric conductivity of a soil.

a) Air Temperature Control

Growth of Plants depends on the photosynthesis process which is a measure of photo synthetically active radiation. Proper temperature level influences the speed of sugar production by photosynthesis radiation. Temperature has to be control properly since higher radiation level may give a higher temperature. Hence, in the diurnal time, it is necessary to adjust the temperature at an optimal level for the photosynthesis process. In nocturnal conditions, plants are not active therefore; it is not necessary to maintain such a high temperature. For this reason, two temperature set-points are usually considered are day-time and night-time [7].

During favourable weather conditions of temperature during the daytime the energy required to reach the optimal temperature is provided by the solar energy. The usual day-time temperature control problem is the cooling of the greenhouse using natural ventilation to achieve the optimal day-time temperature. On the other hand, heating of the greenhouse up to required temperature is the case of night-time temperature control.
b) Humidity Control

Water-vapour inside the greenhouse is one of the most significant variables affecting the crop growth. High humidity may increase the probability of diseases and decrease transpiration. Low humidity may cause hydria stress, closing the stomata and thus it may lower down the process of photosynthesis which depends on the assimilation of CO2 gases. The humidity control is complex because if temperature changes then relative humidity changes inversely. Temperature and humidity are controlled by the same actuators. The main priority is for temperature control because it is the primary factor in the crop growth. Based on the inside relative humidity value the temperature set-point can be adjusted to control the humidity within a determined range. Hence to control the required humidity is a very complex task. For proper control of humidity internal air can be exchange with outside air by properly controlling ventilations of the green house [8].

c) Soil Condition Control

Soil water also affects the crop growth. Therefore, the monitor & control of soil condition has significant importance and specific interest, because good condition of a soil may produce the proper yield. The proper irrigations and fertilizations of the crops are varies as per the type, age, phase and climate. The pH value, moisture contains, electric conductivity and the temp of a soil are some key parameters. The pH valves and other parameters will help to monitor the soil condition. The temperature and the moisture can be controlled by the irrigation techniques like drift and sprinkles system. The temperature of the soil and the inside temperature are interrelated parameters, which can be, control by proper setting of ventilation. Since the temperature control is depends on direct sun radiation and the screen material used, the proper set point can adjust to control soil temperature.

VI. CONCLUSIONS

In present day Precision Agriculture more number of the parameters is required to be monitored and controlled because of the large varieties of the crop at the same time. Use of WSN will be increasing day by day because of the development in WSN technology and its adaption by agriculture technology. In this situation, the wireless sensor network with additional hardware and software is an efficient solution for Precision Agriculture. In future, when more number of agri-parameters is to be controlled, then for WSN technology with present available bandwidth, may not suffice. Then probably WSN with cognitive radio technology may be the futuristic solution. This advancement in precision agriculture through Wireless Sensor Network is extremely useful. This has scope in developing countries like India, where agriculture is the bone of economy.

REFERENCES