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A Review of Wireless Sensor Technologies (Communication) and Applications in Agriculture: Trends with Focus on Zigbee Technology

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Abstract-Wireless Sensor Network (WSN) is to monitor the environment via devices called sensor nodes or motes for parameters such as temperature, light, humidity, moisture and improve agricultural techniques like water management. It helps to improve crop productivity, reduce production cost and make use of real time values for decision not prediction. The paper is to review precision agriculture and standards for wireless communications (IEEE for LAN, Wi-Fi, Bluetooth, GSM/GPRS) and using ZigBee in the Agri-Food sector.

Keywords: Agriculture; Monitor; Zigbee; Environment; Wireless Sensor Network (WSN).

I. INTRODUCTION

A system to monitor various parameters like Temperature, Humidity, Soil moisture, water level sensor with remote (wireless) control of Motor. We are using a wireless sensor network based on Zigbee/IEEE 802.15.4 standard as a station network to send weather information. This research focuses on developing devices and tools to manage, display and alert the weather/disaster warnings using the advantages of a wireless sensor network system. Zigbee is new wireless technology guided by IEEE 802.15.4 Personal Area Network standard [1]. It is primarily designed for the wide range controlling applications and to replace the existing non-standard technologies.

The agricultural practices such as irrigation, crop rotation, fertilizers, pesticides are traditional. The concern of better quality agricultural products from the consumers made the farmers adapt to latest agricultural techniques by implementing modern technologies for producing better agricultural products. Traditional farming involves human labor. With good monitoring and data on the crops and market, the farmer will deliver the quality products to the consumer.

In this paper we have discussed about online monitoring of agriculture parameter using multiple sensors like temperature, humidity and water level sensor. Real-time update of data from the sensor node data is transferred to the Zigbee to another end server PC [2]. Values from field are send to farmer to know condition of field. Ability to record changing environmental parameters over time is important and research on remote weather stations.

The objectives of this paper are:

- Monitoring agricultural field parameters.
- The Data are received by the central monitoring server via Zigbee.
- The server transfers the result.

II. ENERGY CHANLLENGE

Quorum method and MAC protocol with continuous active and sleep mode studied to save energy at idle stage of sensors and enhance energy efficiency of network for communication. Wireless

sensors are battery based and need to conserve/save energy. Communication protocols like MAC layer, routing and transport are means of saving energy. Also protocols like LEACH, TEEN, APTEEN etc are means of conserving energy.

Integrated circuits also allow suitable power design, neural networks algorithms allow energy conservation and Adaptive Access Parameters Tuning (ADAPT) algorithm IEEE 802.15.4 standard as a RF-Biological system used. In smart green house, sensors like soil moisture, tank water level, light, temperature and humidity sensors all connected to a microcontroller. WSN uses clustering with protocols for performance. MAC protocol saves energy by eliminating collision and interference of data packets. Biologically inspired techniques also studied the algorithm, system architecture and network biologically based.

Quorum sensing is used for energy conservation/saving as biological process (bacteria cells behavior similar to clustering) to control communication. The idea of MAC protocol, Grid based quorum and traffic load calculation eliminate extra energy consumption (control of sleep mode and wake up mode by MAC protocol with the traffic load that sets the Grid size) [3]

III. IRRIGATION

Irrigation improvement with technology (WSN) and not to depend on rain prediction is required. Wireless sensor network (WSN) in the field are in clusters (group), with each group having all the sensor types like moisture sensor and communicate to a network on the real time conditions of crops (connected to nodes/routing and nodes to station network via Zigbee). Normal irrigation methods are not efficient; drip irrigation can be used with WSN to give required estimate of water to plant. Wireless modules such as RF, Zigbee, Bluetooth and GSM are used [4].

For different soil, water will reach sensor at different time. Real-time data can be sent to remote place by internet satellite. Crop simulation models like Decision Support System for Agro Technology Transfer (DSSAT), Agricultural Production System Simulator (APSIM) can be used to monitor crop growth. Normal irrigation system is called surface irrigation (Level, Furrow and border strip basin) are inefficient due to water, energy and fertilizer waste. Micro irrigation (drip and sprinkler) methods used to solve water wastage. Drip irrigation gives drops of water to root zone of crops. Sprinkler irrigation is an artificial rain, all conserve water and fertilizer. Zigbee module is networked for communication in drip irrigation used to monitor soil moisture. Through SMS via GSM or Bluetooth module, farmer gets data from field and does control through GSM at long distance and through Bluetooth at close distance. Data sent from SMS are from EEPROM storage.

Soil fertility is tested for potassium, phosphorous and nitrogen as essential soil nutrients, before using drip irrigation system.

IV. INSECTS MONITORING

Monitoring of insects by their behavior can prevent damage to crops. Insects are divided into benefiting and damaging ones. Beneficial insects includes earth worm and bumble bees in terms of fertility and pollination. WSN can be used to measure level of earthworm to fertile the soil. Damaging insects directly sucks the plant tissue or chew part of the plant. The types of damages caused by insects depends on the insects mouth parts. Monitoring insects is done manually by adhesive traps, which consumes energy and time. Sensor can be used to

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do the task automatically. Chemiresistor sensors with a poly3-hexylthiophene (P3HT) active layer for the detection of insect infestation are used at early stages. Volatile compound is emitted by plants when attacked by insects and is detected by the thin film P3HT. The reaction of the thin film with vapor of the volatile compound causes increase in the resistance of the sensor. A threshold decides to indicate insect detection. Acoustic traps can be used to attract insects to traps such as mosquitoes, moths, crickets. Image processing using MATLAB or python programming, image from camera can be send to station for monitoring by comparing images from field with normal images to observe changes and take action. Microprocessor (MCP) shown in Fig. 1 below can be use for different sensors [5]. Computer voice recognition is used to identify flying insects.

V. ZIGBEE (WIRELESS COMMUNICATION TECHNOLOGY)

To maintain wireless end-to-end connectivity to the devices Digi XBee modules are embedded solution. For fast point-to-multipoint or peer-to-peer networking these modules uses the IEEE 802.15.4 networking protocol. It is typically used in long battery life and low data rate applications that require and secure networking. Defined rate of ZigBee is 250kbit/s and it is best suited for intermittent data transmissions from input devices or sensors. Applications are like traffic management systems, electrical meters, and other industrial equipment and consumer which require short-range low-rate wireless data transfer [6]. ZigBee specification is intended to be cheaper and simple than other WPAN suchas Wi-Fi or Bluetooth. Block diagram is shown in Fig. 2 below.

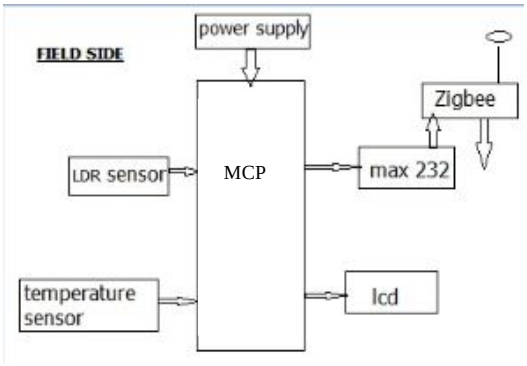

Fig. 1. Microprocessor Block Diagram.

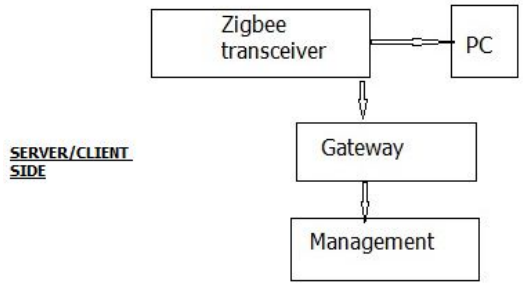

Fig. 2. Block Diagram of Zigbee Communication.

The hardware circuit in the field side measure the soil parameters using the sensors such as Humidity sensor, Gas sensor, and Light sensor and Temperature sensor. This information is collected by the hardware controller and transmitted using Zigbee transceiver. On the other side all this information are received by the Zigbee transceiver which is stored in the server computer .Then the information which is collected is send to the mobile of the user using the drop box technology.

A. Field Side

A prototype hardware board has been implemented. In this prototype the hardware gets the Humidity and temperature from corresponding sensor in hardware circuit 1 and light and gas form corresponding sensor in hardware circuit 2 then it send all the information to the server using the Zigbee transceivers .

B. *Server Side*

In the server prototype the gathered values from the Zigbee transceivers are saved in the form of Microsoft Excel format and then it is transferred to user as mobile data using Drop Box technique so that it can be retrieved immediately and also for future references.

C. *Client Side*

The received data is stored in the server pc for later reference and also the stored real time information is securely send to user or client by using drop box synchronizing technique between mobile and server. So that user can able to get real-time information about the land at anywhere at any time. Slave nodes reads parameter values from soil moisture sensor, temperature sensor, humidity sensor, light sensor. Then this sensor data is given to signal conditioner. Analog signals require some form of preparation before they can be digitized. Signal conditioning is the manipulation of a signal in a way that prepares it for the next stage of processing. Analog to Digital converter takes this processed data and then convert it into digital form. Microcontroller takes input from ADC. The signal sent from the remote control is captured by the microcontroller. The microcontroller controls the channel selection. The MAX232 IC is used to convert the TTL/CMOS logic levels to RS232 logic levels during serial communication of microcontrollers with PC. The controller operates at TTL logic level (0-5V) whereas the serial communication in PC works on RS232 standards (-25 V to + 25V). This makes it difficult to establish a direct link between them to communicate with each other. ZigBee is trans receiver which can work on serial port and used for serial communication between PC and Microcontroller. MAX-232 works on serial communication. Zig-Bee are flexible, they send and receive data over serial port which means they are compatible with both computer and micro-controller. The MAX232 IC is used to convert the TTL/CMOS logic levels to RS232 logic levels during serial communication of microcontrollers with PC.

VI. ADVANTAGES

- It is wireless, the network is only deployed once and labor is minimal.
- Many nodes are deployed (densely), so data acquisition has high accuracy.
- Communication between sensor nodes with storage capacity.
- It has scalability (new nodes).
- Real time sensing and communication.
- monitoring and control is economical together with production [7].

Fig. 3 below shows the advantage of Zigbee technology for the wireless communication.

VII. APPLICATIONS

- For Low cost solutions.
- For remote location applications.
- Applications to alert farmers.
- To analyze the various environmental/climate parameters like CO2, temperature and humidity.
- Remotely used for the operations of Green House Devices as a small scale.

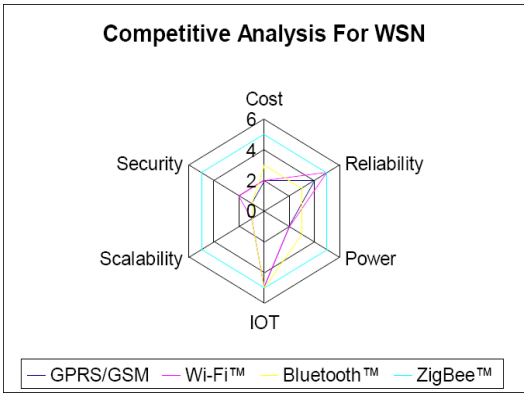

Fig. 3. Zigbee technology comparism with other wireless communication technology.

VIII. CONCLUSION

Zigbee-based agriculture monitoring system serves as a reliable and efficient system to monitor the environmental parameters. Wirelessly reduces labor and accurate values. Its economical, consumes less power and can control 254 devices, which in turn leads to the development of Home Automation, Health Care Automation, Traffic etc.

This research focuses on developing devices and tools to manage, display and alert the weather/disaster warnings using the advantages of a wireless sensor network system. WSN is emerging technology and it have wide range of applications. WSN plays an important role in development of precision agriculture. Using WSN we can utilize water to increases crop yield for maximum profit.

In farming Temperature, Humidity and CO2 are the most essential parameters. The growth of crops is mainly depending on these three parameters. Currently farmers don't have any system which will show real time levels of these parameters [8]. The proposed system is going to monitor these changes periodically and take an action automatically. Visualization of the graphical representation of all the data from the green house and later on farmer can operate the devices from remote location by using its smart phone.

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