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Embedded Sensor System with Wireless Communication for Greenhouse

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Abstract- Greenhouse environment is unpredictable, irregular, nonlinear, multi-parameter and volatile structure. To gain high and quality yield it is necessary to control the greenhouse environment according to crop requirement and for that design and analyze the embedded sensor system with wireless communication for greenhouse is prerequisite. The blueprint of system is such that it is compatible to technically less proficient farmer of developing countries. The system is designed with DAQ card for data acquisition and analysis that is compatible with Graphical User Interface LabVIEW which helps the user to easily monitor and analyze the state of greenhouse environment. Based on the data analysis any farmer can take decisions like, when to irrigate the crops and when to enable the cooling system. Actions based on the data analysis from the system may lead to better crop yield and less wastage of the resources. To make the system energy efficient a data averaging energy efficient algorithm is used in software. By analyzing the recorded data received from sensor node, an efficient strategy for node placement is designed to cover maximum area of greenhouse.

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EMBEDDEDSENSORSYSTEMWITHWIRELESSCOMMUNICATIONFORGREENHOUSE

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Abstract- Greenhouse environment is unpredictable, irregular, nonlinear, multi-parameter and volatile structure. To gain high and quality yield it is necessary to control the greenhouse environment according to crop requirement and for that design and analyze the embedded sensor system with wireless communication for greenhouse is prerequisite. The blueprint of system is such that it is compatible to technically less proficient farmer of developing countries. The system is designed with DAQ card for data acquisition and analysis that is compatible with Graphical User Interface LabVIEW which helps the user to easily monitor and analyze the state of greenhouse environment. Based on the data analysis any farmer can take decisions like, when to irrigate the crops and when to enable the cooling system. Actions based on the data analysis from the system may lead to better crop yield and less wastage of the resources. To make the system energy efficient a data averaging energy efficient algorithm is used in software. By analyzing the recorded data received from sensor node, an efficient strategy for node placement is designed to cover maximum area of greenhouse.

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I. Introduction

Recently for scientific and research community Wireless Sensor Networks have come to the front position. The exploit of wireless sensors and the opportunity of assemble them into network have exposed many research concern and have highlighted new customs to handle with certain dilemma(Awasthi, 2013). The accessibility of elegant, efficient and economical sensors measuring a broader range of environmental factors has allowed continuous time monitoring of the environment for genuine purposes (Arun & Sudha, 2012). This task was not feasible in past because former monitoring was based on wired sensors which require manual data downloading and laboratory analyses.

Temperature, humidity, light intensity and soil moisture are the common essential factor for the yield and quality of crop growth(Mampentzidou, Karapistoli, & Economides, 2012).

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By constantly supervise these environmental factors the farmer can enhance understanding of how each factor influence growth of yield and how to handle utmost fruitfulness of crop and to achieve remarkable energy savings.The greenhouse yield depends on various different aspects. For selected environmental variables, the farmer can set the reference values, and then the greenhouse automation system intention to maintain the variables in these limits (Deore & Umale, 2012).

A WSN is a structure consists of sensors, radio frequency (RF) transceivers, microcontrollers and power resource(Galluzzi & Herman, 2012). In this paper, an embedded sensor system is designed using DAQ card for data logging, XBee Pro transceiver module and sensors for monitoring temperature and humidity of greenhouse environment. The software part of the system is designed and programmed using LabVIEW.

II. Literature Review

A key part to the design and implementation of any system is an in depth knowledge and solicitous understanding of the attribute that influence that specific system. For that motive, systematic literature studies require to examine the available wireless sensor networks for environment monitoring.

The idea of (Lee, Hwang, & Yoe, 2010) is to choose a sensor network MAC protocol, which would be optimal to farming site with good power efficiency and admirable transmission delay concert. For that total 2,500 sensor nodes involve with star network topology in which sink node in the center and the physical shape of sensor nodes is grid. The simulation result shows that the energy performance of LPMAC is to some extent improved than X-MAC and S-MAC.

To accurate determination of crop growth in greenhouse, the (Song, Gong, Feng, Ma, & Zhang, 2011) proposed the system based on AVR Single Chip microcontroller and wireless sensor networks. In this paper Modular design thought is adopted, First it solves Energy supply problem of sensor node. Secondly it design funnel effect (Due to imbalance of load distribution) of greenhouse WSN system. Monitoring & Controlling system is developed in which author use as sensor node (HSM 20G) PIC 18F452 as microcontroller, signal is transmitted through ZigBee module, transceiver used is Tarang F4 ZigBee module is connected to the host computer through RS-232, LABVIEW software is used to analyze the data.

In the research paper (Marimbi, Munyaradzi, Nyambo, & Mashonjowa, 2012) author design a model, this integrates optimum node position and data aggregation to observe the combined effect on the efficiency of the WSN, in terms of latency, power consumption and utilization, network lifetime. Also the different topologies model designed and estimate through simulations to come up with the best model that achieves optimum placement to minimize the number of nodes without compromise on the data as well as incorporating data forwarding and aggregation.

The author (Sengunthar Gayatri & Mehul, 2012) presents a survey report on present Greenhouse Monitoring and control systems. Base on the review of multiple papers the author proposes a pioneering Greenhouse automation system for multiple greenhouses which can be controlled from the middle location wirelessly. For that it suggests a standard architecture which can be functional for many other computerization applications.

The authors of this paper (Mampentzidou et al., 2012) survey and review number of research papers related to WSN on various applications like operating system used, power supply and node platforms. Based on that information they provide a generic guideline for less proficient farmers for deploying WSN in their field or greenhouse. Potatoes taken as object crop for one season (about 4 months) in 100 m2 area with Mica2, TmoteSky or Micaz type node platform, microcontroller, radio transceiver, memory size or type all are depends on node platform. User can use various sensing parameters on single sensor node but normally one sensor node is placed in 1 m2 area. For continuous power supply needs can use rechargeable batteries and solar panel. IP67 case is use for waterproofing of hardware device.

This research paper (Kumari & Devi, 2013) proposed a hybrid communication (means wired and wireless both) system for modernized agriculture. The whole green house farm can be controlled by LAN Network. Every sensor node will be coupled with the various sensors, solenoid valves to control the water flow of the plants, ARM Microcontroller LPC2138 based on Cortex M3., used communication standard like CAN bus for wired system and ZigBee for wireless system, Ethernet for online controlling and supervising the environmental parameters. The software of whole system was encoded in Embedded C and realize in Proteus with JAVA background.

This paper (Jao, Sun, & Wu, 2013) use MicaZ motes, MDA300CA data acquisition board, and EC-5 soil moisture sensors as hardware and TinyOS 2.1.1 open source embedded operating systems as a software to make WSN. In this paper solar panels and LiFePO4 18650 rechargeable batteries are used as power source to construct realistic applications. Author use sand soils with different water contented.

III. Factors Influencing WSN Design

WSN designs commonly influenced by factors such as operating atmosphere, transmission media, energy consumption, manufacture costs and physical size (Kumar, 2000). When designing a WSN system essentially considers these factors. The next sections describe these factors and their impact on the functioning of the system.

a) *Manufacture Costs*

WSN may have more than a hundred nodes, and for commercialization the cost of a single node should not go beyond a few dollars (Akyildiz, Su, Sankarasubramaniam, & Cayirci, 2002).Two key factors, initial deployment cost and total cost of ownership are important for consideration.

b) *Physical Size*

Smaller nodes can placed in locations that are more feasible and used in number of scenarios, like in node-tracking scenario, tiny nodes will result in the ability to track more objects(Joo, Park, Pyo, & Chae, 2008).

c) *Operating Atmosphere*

WSN can deploy ingenerous as well as extremely hostile atmosphere like a residence, industrial unit, on machines, battlefield, ocean beds, combat zone, disaster areas, noxious areas(Marimbi et al., 2012) etc.

d) *Data Aggregation*

Reducing the number of surplus data in effective way in the system called data aggregation (János & Matijevics, 2010). It can define as the process of merging data from different sensor nodes according to a definite function such as maxima, minima or average.

e) *Area Coverage*

Area coverage is the all time primary assessment metric for a wireless sensor network. To increase a system's value to the end user, it is always beneficial to have the skill to deploy a network over a bigger physical area(Younis & Akkaya, 2008).

f) *Energy Consumption*

Energy consumption in a sensor node can divided into three parts, sensing, processing and communication (Hoblos, Staroswiecki, & Aitouche, 2000). The largest part of its energy consumed during communication because both start-up and active states of transceiver unit consumes huge energy(Alippi, Anastasi, Di Francesco, & Roveri, 2009).

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IV. Hardware Setup

The hardware part of the system consists of two modules, one is server and other is client. Server side consists of XBee receiver and computer system having installed LabVIEW receiver program on it. The client side includes RTD PT100 temperature sensor, SY-HS220 humidity sensor, Advantech USB 4711A DAQ card having inbuilt screw terminal board, XBee Pro transmitter module and a computer system having installed LabVIEW transmitter program. Now the following subsections describe the hardware devices used in the system.

a) *USB 4711A DAQ card*

The USB-4711A consist true plug & play data acquisition module. There is no longer need to open the chassis to install DAQ modules. Just plug in the module, and then get the data. It's easy and efficient. Reliable and rugged enough for industrial applications, yet inexpensive enough for home projects, the USB-4711A module is the perfect way to add measurement and control capability to this system(manual, 2013). The features of this device includes Supports USB 2.0, Portable, Bus-powered, 16 analog input channels, One -bit resolution AI, Sampling rate up to 150 kS/s, 8-ch DI/8-ch DO, 2-ch AO and one 32-bit counter, Detachable screw terminal on modules and lockable USB cable for secure connection included(advantech.com, 2014).

b) *XBee Pro Wireless transceiver*

XBee is the brand name from Digi International for a family of form factor compatible radio modules based on the 802.15.4-2003 standard designed for point-to-point and star communications at over-the-air baud rates of 250 Kbit/s(Zhang, 2011). The XBee radios can all be used with the minimum four numbers of connections power (3.3 V), ground, data in and data out (UART), with other recommended lines being Reset and Sleep.In API mode the data is wrapped in a packet structure that allows for addressing, parameter setting and packet delivery feedback, including remote sensing and control of digital I/O and analog input pins(Digi, 2009). Features of the XBee Pro also includes no configuration needed for out-of-the-box RF communications, common XBee footprint for a variety of RF modules, fast 250 kbps RF data rate to the end node, 2.4 GHz for worldwide deployment and sleep modes supported for extended battery life(http://www.digi.com, 2009).

c) *SY HS 220 Humidity Sensor*

This sensor module converts relative humidity (30-90%RH) to voltage and can be used in weather monitoring application. The specifications (SYHITECH, 2013)for this device are given below

Rated Voltage:	DC 5.0
Current Consumption:	≤3.0 mA
Operating Temperature Range:	0-500C
Operating Humidity Range:	30-90 % RH
Storage Humidity:	Within 95% RH
Storage Temperature:	30-85oC
Standard Output Voltage: (at 250C 60% RH)	DC 1,980mV
Accuracy: (at 250C 60% RH)	±5% RH

d) *RTD PT 100 Temperature Sensor*

The resistance that electrical conductors exhibit to the flow of an electrical current is related to their temperature. A PT 100 is a precision platinum resistor that exhibits 100Ω at 00C. It has a positive temperature co-efficient so as the temperature rises, so does the resistance(Rhomberg, 2013).

V. Software Design Of System

This section will cover an introduction to LabVIEW, transmitter and receiver part of the designed system.The software part of embedded sensor system is designed in LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench). It is a programming environment in which user can create programs using a graphical notation (connecting functional nodes via wires through which data flows); in this regard, it differs from traditional programming languages like C, C++, or Java, in which program is written with text(Fang & Wang, 2011). LabVIEW is written on graphical structure.

a) *Transmitter Mode*

In transmission mode the software is developed to acquire data from sensor nodes and to transmit it to server computer. The front panel and block diagram of program designed in LabVIEW is as shown Fig.1 and Fig.2 respectively.

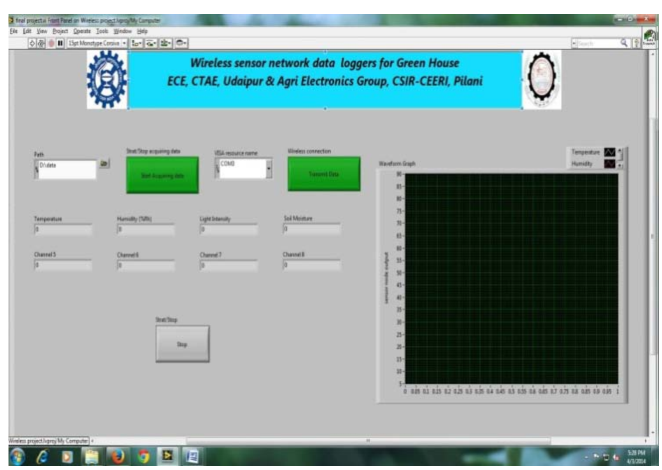

Figure 1 : Front Panel of transmission mode

The software program of transmission mode is developed for 8 channels. Digital and graphical value of

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sense data is displayed by front panel. At there user first select the COM port and then define the path of file that store the history of data. The received data is continuously stored in history curve for further data analysis.

The block diagram of the system designed for data logging by DAQ card, averaging the sensed data by algorithm and storing data in history curve. The history curve can display by block diagram by single click. The sensed data is stored in .doc file

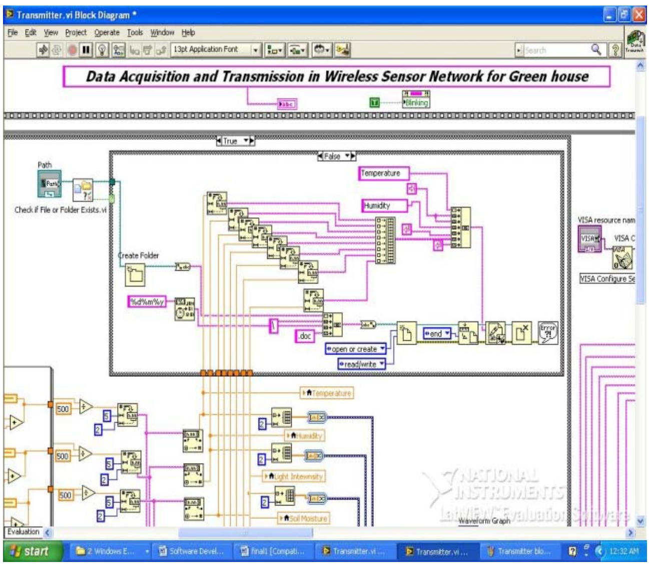

Figure 2 : Block Diagram of transmission mode

b) Receiver Mode

In receiving side program is developed to receive data at server computer from remote client computer. With the help of XBee Pro the transmitted data is received at remote location and LabVIEW program is stored that data in .doc file by history curve for further analysis. The block diagram of program designed in LabVIEW is as shown Fig.3.

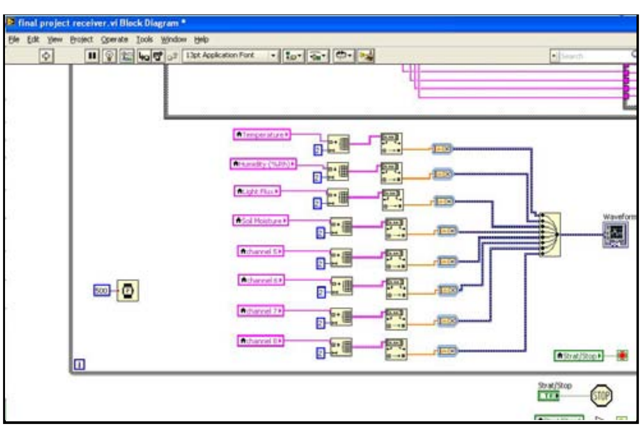

Figure 3 : Block Diagram of receiver mode

VI. Working Of The Proposed System

As discussed in above sections, the proposed system is having two modes, Server mode or receiver mode and Client mode or the transmitter mode.

Transmission mode is used to take the environmental data through the sensors from the remote location and send that data through the wireless XBee. Data transfer, energy efficiency and sensors data analysis are the main part in which the whole software based. For the energy efficiency and data analysis the software part used the algorithm and store and sends the data. For the energy efficiency concern the sensors are programmed by the software as like they transferred data after 2 min every time and then go to the sleep mode. It saves the energy and increases the efficiency of the system. At the same time the software shows the data trend curve of the sensors data, records the sensor data and send that data on the server location where the receiver program is running.

Same time receiver mode (at server location) is used to pick the sensor data through the wireless XBee, which is sent by the transmission mode software (from remote location). The receiver program logs that sensor data into the computer for analysis purpose and according to requirement it shows the history curve also.

VII. Results And Discussion

The finally developed system (hardware and software part) is placed in the Green house of size, 30 feet X 45 feet for the field trials. Some of the field trials are shown in Fig.4: shows that RTD-PT 100 temperature sensor and SY-HS 220 humidity sensor are connected through the Advantech DAQ card 4711A. As shown in figure there is no need to external power to run system because all system is working on 5V that is fulfilled by USB connected to computer system. XBee and Advantech DAQ card 4711A is connected to PC by USB that is used to transmit the sensed data with the help of software.

Figure 4 : Connections of Hardware Design

The system is used to store data into the *.doc format (current date) into the MS Word file. All the analysis work completed, which are shown by figure 5 and figure 6, that shows the temperature sensor (RTD) data and Humidity sensor (SY HS220) data day by day which are transmitted and stored into the word file. The software data are compared with the standard data and the obtained results are same. All the data analyzed day by day which is shown in the graphical form listed in Fig.5 and Fig.6.

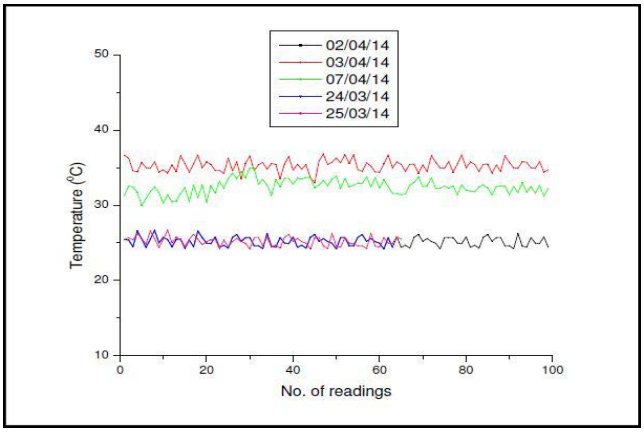

Figure 5 : Combined Temperature Curve

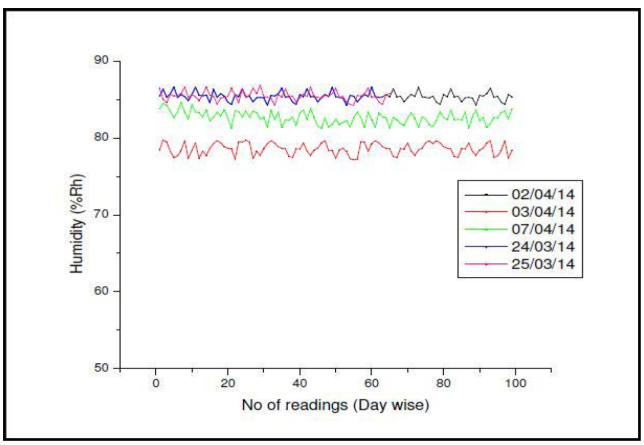

Figure 6 : Combined Humidity Curve

VIII. Conclusion

In this research work wireless sensor network is used to transfer and receive the data through the XBee proand the sensors like RTD PT100 temperature sensor and SY-HS 220 humidity sensor. All the results are shown through the graph, which are shown in Fig.5 and figure 6The graphs show the daily temperature variations and humidity variations in the green house. This project is very useful for maintaining the green house temperature and humidity. The add-on features can also be used in future to detect, analyze and control the environmental parameters in green houses at large scale. The software is tested for basically two environmental parameters in green house but it can further increases up to 8 parameters to detect the environmental sensor data like light flux, pH, CO2, soil temperature and soil humidity etc.

This research work also used the energy saving basics by the data averaging algorithm designed in LabVIEW. The software store and control the sensor node data analyze the data and provide sufficient information on front panel to the user. The software program controls the transmission and receiving mode for travelling the data from remote location to server location. The software acquires the sensor node data after every 2 min. and transmits through the wireless sensor network to the receiving end at server location, where the receiver program receiving the data and storing that data for further analysis.

On the basis of analysis of stored sensor node data an efficient node placement strategy is designed that cover maximum possible area of used greenhouse. In this strategy data monitoring system use only one sensor node and a small pulley system for movement of sensor node that make system more reliable and cost effective.

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