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Compensating and monitoring of environment conditions through wireless sensor networks for friendly green environment

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Abstract:
Greenhouse facilitates precise monitoring and controlling of various parameters, so as to cultivate quality conscience crops without slaying resources. The cabling laid for the sensors, deployed inside the Greenhouse is not feasible. Hence the need for an automated system employing wireless communication and remote sensing is imperative. This paper proposes a Wireless Sensor Network (WSN) based embedded system and deals with the implementation of Zigbee network (over IEEE 802.15.4) for remote controlling of the Greenhouse parameters. The detailed information regarding establishment of Zigbee network in Star topology as well as in Mesh Topology, inside the Greenhouse is illustrated. It also demonstrates the real time monitoring of parameters such as temperature, humidity, as well as the total power consumption of the system, with the help of a PC based GUI application developed on Java platform. An integrated Liquid crystal display (LCD) is also used for real time display of data acquired from the various sensors and the status of the various devices. Also, the use of easily available components reduces the manufacturing and maintenance costs. The design is quite flexible as the software can be changed any time. It can thus be tailor-made to the specific requirements of the user. This makes the proposed system to be an economical, portable and a low maintenance solution for greenhouse applications.

Index Terms: Green House, Real time monitoring, WSN, Embedded system, Zigbee (IEEE 802.15.4), Topology, GUI.

I. Introduction :

Proposed system is an embedded system which will closely monitor and control the microclimatic parameters of a greenhouse on a regular basis round the clock for cultivation of crops or specific plant species which could maximize their production over the whole crop growth season and to eliminate the difficulties involved in the system by reducing human intervention to the best possible extent. The system comprises of sensors, Analog to Digital Converter, microcontroller and actuators .When any of the above mentioned climatic parameters cross a safety threshold which has to be maintained to protect the crops, the sensors sense the change and the microcontroller reads this from the data at its input ports after being converted to a digital form by the ADC. The microcontroller then performs the needed actions by employing relays until the strayed-out parameter has been brought back to its optimum level. Since a microcontroller is used as the heart of the system, it makes the set-up low-cost and effective nevertheless. As the system also employs an LCD display for continuously alerting the user about the condition inside the greenhouse, the entire set-up becomes user friendly.

Since environmental diversity exists and there are changes in the ecological conditions from region to region, there is a variety in the cultivation of crops. The main objective of the green house is to breed plants in any particular region independent of its existing environmental conditions. For this purpose an automatic embedded system is required to facilitate the smooth maneuver of cultivation. Ral Aquino-Santos et al.have discussed the applications of WSN in greenhouse control environment and stated it can be a cost effective option for development of the greenhouse control system. The detailed comparative study of the different short range wireless protocols viz. Bluetooth (over IEEE 802.15.1), UWB (over IEEE 802.15.3), Zigbee (over IEEE 802.15.4) and Wi-Fi (over IEEE 802.11a/b/g), it is found that Zigbee is an efficient protocol in field of automation. Being a controlling and a monitoring system our proposed model is implemented with Zigbee protocol. It consists of two modules i.e. one is user side module in which the transceiver is connected to the user PC to control the various green house appliances remotely and the other is green house side module to which sensors are interfaced. It

monitors all the parameters, fetches the real time sensed value and depicts the same on LCD display. This paper is organized as follows; Section II provides the details regarding the Zigbee protocol and its super frame structure whereas our proposed system design is discussed in Section III. Section IV elaborates the network establishment using Zigbee protocol in detail . Section V presents the result analysis and outcome of the system and the final Sectionpresents the conclusion of the paper.

The Hardware System

Micro controller: This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

ARM7TDMI: ARM is the abbreviation of Advanced RISC Machines, it is the name of a class of processors, and is the name of a kind technology too. The RISC instruction set, and related decode mechanism are much simpler than those of Complex Instruction Set Computer (CISC) designs.

Liquid-crystal display (**LCD**) is a flat panel display, electronic visual display that uses the light modulation properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

II. Design of Proposed Hardware System

TRANSMITER SECTION:

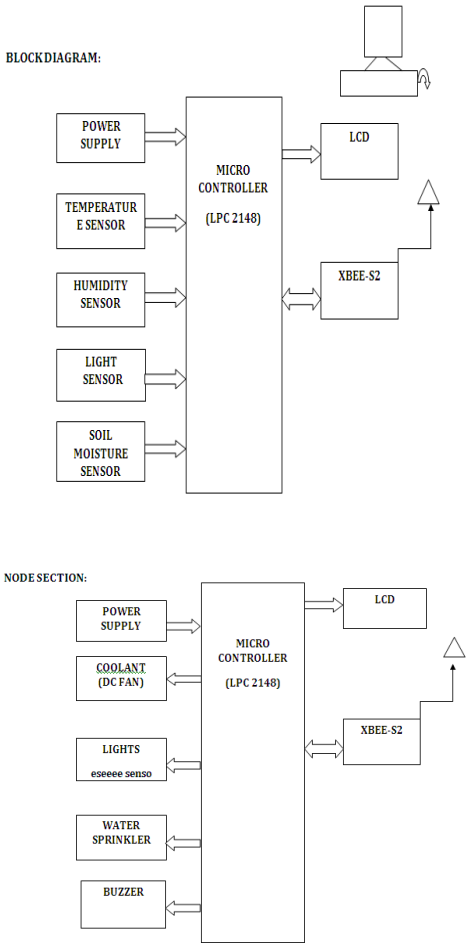

Fig.1.Block diagram

Due to the research and advancement in the field of automation, it has facilitated development in wireless communication. Automation along with the use of Wireless Sensor Networks (WSNs) have superseded the traditional manual control systems hence gaining popularity in industrial, domestic as well as in agricultural sector. This has led to an integrated way leading to new solutions, better performance and an absolute system . In the field of automation WSNs have revolutionized the design of emerging embedded systems in terms of various factors viz. scalability, mobility, power consumption etc. A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to cooperatively monitor the physical or environmental conditions, such as temperature, vibration, pressure, motion etc. As described in and stated by Palanisamyet al.in the unique characteristics of WSNs are:

- Can store and harvest limited power
- Ability to withstand callous environmental conditions

- Ability to cope with node failures
- Mobility of nodes is possible
- Dynamic network topology
- Heterogeneity of nodes
- Large scale deployment
- Unattended operation and self governing ability
- Node capacity is scalable, only limited by bandwidth of gateway node.

Since environmental diversity exists and there are changes in the ecological conditions from region to region, there is a variety in the cultivation of crops. The main objective of the green house is to breed plants in any particular region independent of its existing environmental conditions. For this purpose an automatic embedded system is required to facilitate the smooth maneuver of cultivation. Ral Aquino-Santos et al.have discussed the applications of WSN in greenhouse control environment and stated it can be a cost effective option for development of the greenhouse control system. The detailed comparative study of the different short range wireless protocols viz. Bluetooth (over IEEE 802.15.1), UWB (over IEEE 802.15.3), Zigbee (over IEEE 802.15.4) and Wi-Fi (over IEEE 802.11a/b/g), it is found that Zigbee is an efficient protocol in field of automation. Being a controlling and a monitoring system our proposed model is implemented with Zigbee protocol. It consists of two modules i.e. one is user side module in which the transceiver is connected to the user PC to control the various green house appliances remotely and the other is green house side module to which sensors are interfaced. It monitors all the parameters, fetches the real time sensed value and depicts the same on LCD display. This paper is organized as follows; Section II provides the details regarding the ZigBee protocol and its super frame structure whereas our proposed system design is discussed in Section III. Section IV elaborates the network establishment using ZigBee protocol in detail . Section V presents the result analysis and outcome of the system and the final Section presents the conclusion of the paper.

III. Board Hardware Resources Features

THERMISTOR: Thermistors are a temperature sensing devise. It is used to sense the temperature. In this project by depends on the value of temperature the exhaust fan will run.

HUMIDITY:

Humidity is the amount of water vapor in the air. In daily language the term "humidity" is normally taken to mean relative humidity. Relative humidity is defined as the ratio of the partial pressure of water vapor in a parcel of air to the saturated vapor pressure of water vapor at a prescribed temperature. Humidity may also be expressed as absolute humidity and specific humidity. Relative humidity is an important metric used in forecasting weather. Humidity indicates the likelihood of precipitation, dew, or fog. High humidity makes people feel hotter outside in the summer because it reduces the effectiveness of sweating to cool the body by preventing the evaporation of perspiration from the skin. Absolute humidity is the quantity of water in a particular volume of air. The most common units are grams per cubic meter, although any mass unit and any volume unit could be used. Relative humidity is defined as the ratio of the partial pressure of water vapor in a gaseous mixture of air and water vapor to the saturated vapor pressure of water at a given temperature. Relative humidity is expressed as a percentage. Specific humidity is the ratio of water vapor to air (including water vapor and dry air) in a particular volume. Measuring and regulating humidity.

LDR: LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically. However, when light shines onto the LDR its resistance falls and current flows into the base of the first transistor and then the second transistor. The LED lights on. The preset resistor can be turned up or down to increase or decrease resistance, in this way it can make the circuit more or less sensitive.

Soil moisture sensors:

Measures the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors. Measuring soil moisture is important in agriculture to help farmers manage their irrigation systems more efficiently. Not only are farmers able to generally use less water to grow a crop, they are able to increase yields and the quality of the crop by better management of soil moisture during critical plant growth stages. Besides agriculture, there are many other disciplines using soil moisture sensors. Golf courses are now using sensors to increase the efficiencies of their irrigation systems to prevent over watering and leaching of fertilizers and other chemicals offsite.

ZigBee

Zigbee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio needing low rates of data transfer. The technology defined by the Zigbee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. Zigbee is targeted at

radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

Zigbee is a low-cost, low-power, wireless mesh networking standard. First, the low cost allows the technology to be widely deployed in wireless control and monitoring applications. Second, the low power-usage allows longer life with smaller batteries. Third, the mesh networking provides high reliability and more extensive range.

COOLANT:

We are in an era of a revolution in electronics demanding high performance and circuit miniaturization. This dual increase in performance and reduction in size causes an increase in power consumption and heat dissipation. Thus, thermal management is an issue in applications ranging from personal computers to high-end servers,

Thermal management is done by forced convection where heat dissipation is increased by moving the air inside and around the heat source. This is commonly achieved using brushless DC (BLDC) fans. The speed of these fans depends on the incoming RMS voltage. Fans come in standard sizes; 40 mm, 80 mm, and 120 mm are common. The most important specification when selecting a fan for a cooling application is how much air the fan can move. This is specified either as cubic feet per minute (CFM) or cubic meters per minute (m3/min). The size, shape, and pitch of the fan blades all contribute to the fan's capacity to move air. Smaller fans need to run at a higher speed than larger fans to move the same volume of air in a given time.

Applications that are space constrained and need smaller fans due to physical dimension limitations generate significantly more acoustic noise. To manage acoustic noise generation, the fan controller can be configured to drive fans at the minimum possible speed, simultaneously maintaining safe operating temperature limits. This also extends the operating life of the fan compared to systems that run all fans at full speed all of the time.

Fan manufacturers specify the duty cycle to RPM relationship in their datasheets, with tolerances as high as ± 20%. To guarantee a fan will run at the desired speed, system designers need to run the fans at speeds 20% higher than nominal to ensure that any fan from that manufacturer provides sufficient cooling. This can result in excessive acoustic noise and higher power consumption..

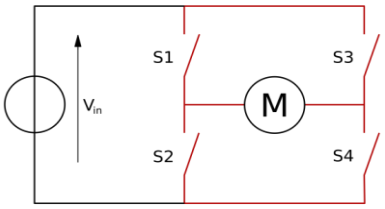

Fig.7. H-Bridge

BUZZER

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke.

Relay:

The RLY102 provides two SPDT relays with convenient screw terminal connections for the inputs and contacts. It includes active driver circuitry allowing lower current input signals (such as 5V TTL) to be used. LEDs provide visual indication on the status of each relay.

WATER SPRINKLERS:

Sprinklers providing irrigation to vegetation, or for recreation, as a cooling system, or for the control of airborne dust. The sprinkler system irrigates the field drop by drop and thus it is widely used in sandy areas as it checks the wastage of water through seepage and evaporation. Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water. In South India it is used in Karnataka and tamilnadu for the production of many crops.

BULB:

An incandescent light bulb, incandescent lamp or incandescent light globe is an electric light which produces light with a wire filament heated to a high temperature by an electric current passing through it, until it glows (see Incandescence). The hot filament is protected from oxidation with a glass or quartz bulb that is filled with inert gas or evacuated. In a halogen lamp, filament evaporation is prevented by a chemical process that re deposits metal vapor onto the filament, extending its life. The light bulb is supplied with electrical current by feed-through terminals or wires embedded in the glass. Most bulbs are used in a socket which provides mechanical support and electrical connections.

Incandescent bulbs are manufactured in a wide range of sizes, light output, and voltage ratings, from 1.5 volts to about 300 volts. They require no external regulating equipment, have low manufacturing costs, and work equally well on either alternating current or direct current. As a result, the incandescent lamp is widely used in household and commercial lighting, for portable lighting such as table lamps, car headlamps, and flashlights, and for decorative and advertising lighting.

The designed WSN based system is the real time monitoring of various green house parameters such as temperature, humidity, soil moisture level, light intensity. These parameters had been displayed on the LCD at SAN system. Along with that using reliable wireless communication over 802.15.4, these were successfully transmitted to the PCN system to fulfill the aim of real time monitoring of these parameters at remote place. The system also provides the remote control of various appliances using GUI based application and actuator nodes.

Transmitting the sensed parameters of SAN system towards PCN and plotting real time graph was the primary aim. Hence we instead of using very accurate and sophisticated sensors, we have implemented readily available sensors. The result obtained are discussed further.

Temperature monitoring:

The real time temperature monitoring using Java based application at PCN system is as depicted in One sensor is implemented outside and other one is inside the green house. Black line indicates the uncontrolled outside ambient temperature whereas the red line indicates the controlled inside temperature. It can be easily recognized that controlled temperature provides more stabilize parameter reading.

Humidity monitoring:

The real time humidity monitoring at PCN system is as depicted in The uncontrolled humidity was monitored for the span of 5 hours and graph was plotted by application accordingly. Also the additional feature of observing the parameters simultaneously is provided by system as depicted.

Power monitoring:

The unique feature of real time power monitoring in green house is incorporated in the system. It enables the user to estimate the total power consumed by various appliances as well as helps him to recognize any malfunctioning of appliance. The system provides GUI for controlling the appliances as shown in Fig. 11. For testing purpose two loads (Incandescent bulbs) of power rating 60 Watt/load, were used. Fig.12 depicts the total power consumption in green house.

Conclusion:

The 802.15.4 viz.ZigBee is an efficient wireless protocol in terms of power consumption, scalability and it also provides a suitable data rate for controlling and monitoring purpose. Hence, we can say that the advent of 802.15.4 revolutionized the automation industry. This paper describes a Wireless Sensor Network (WSN) based embedded system built using the ZigBee technology and emphasis on hardware implementation of sensor and actuator nodes. It also describes the network establishment using ZigBee protocol. A GUI application developed on the Java platform facilitates controlling of various appliances remotely in order to stabilize the green house parameters. Hence our proposed system provides real time monitoring of various green house parameters along with the remote control of appliances using GUI based application as well as providing amount of power consumed.

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