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Environmental Monitoring and Greenhouse Control by Distributed Sensor Network

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ABSTRACT

A sensor is a miniature component which measure physical parameters from the environment. Sensors measure the physical parameters and transmit them either by wired or wireless medium. In wireless medium the sensor and its associated components are called as node. A node is self-possessed by a processor, local memory, sensors, radio, battery and a base station responsible for receiving and processing data collected by the nodes. They carry out joint activities due to limited resources such as battery, processor and memory. Nowadays, the applications of these networks are numerous, varied and the applications in agriculture are still budding. One interesting application is in environmental monitoring and greenhouse control, where the crop conditions such as climate and soil do not depend on natural agents. To control and monitor the environmental factors, sensors and actuators are necessary. Under these circumstances, these devices must be used to make a distributed measure, spreading sensors all over the greenhouse using distributed clustering. This paper reveals an idea of environmental monitoring and greenhouse control using a sensor network. The hardware implementation shows periodic monitoring and control of greenhouse gases in an enhanced manner. Future work is concentrated in application of the same mechanism using wireless sensor network.

***Keywords*—**Sensor, sensor nodes, wireless sensor network (WSN), greenhouse control, environmental monitoring, CO_2 monitoring, distributed clustering.

I. INTRODUCTION

A sensor is able to convert physical or chemical readings gathered from the environment into signals that can be calculated by a system. A multi sensor node is able to sense several magnitudes in the same device. In a multi sensor, the input variables might be temperature (it is also able to capture nippy changes of temperature), fire, infrared radiation, humidity, smoke and CO_2. A wireless sensor network could be an useful architecture for the deployment of the sensors used for fire detection and verification. The most vital factors for

the quality and productivity of plant growth are temperature, humidity, light and the level of the carbon dioxide. Constant monitoring of these environmental variables gives information
to the farmer to better understand, how each factor affects growth and how to manage maximal crop productiveness. The optimal greenhouse [3] climate adjustment can facilitate us to advance productivity and to achieve remarkable energy saving, particularly during the winter in northern countries. In the past generation greenhouses it was enough to have one cabled measurement point in the middle to offer the information to the greenhouse automation system. The system itself was typically simple without opportunities to manage locally heating, lights, ventilation or some other activity, which was affecting the greenhouse interior climate. The typical size of the greenhouse itself is much larger than it was before, and the greenhouse facilities provide several options to make local adjustments to the light, ventilation and other greenhouse support systems. However, additional measurement data is also needed to construct this kind of automation system to work properly. Increased number of measurement points must not dramatically augment the automation system cost. It should also be possible to easily alter the location of the measurement points according to the particular needs, which depend on the specific plant, on the

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possible changes in the external weather or greenhouse structure and on the plant placement in the greenhouse. Wireless sensor network can form a useful part of the automation system architecture in modern greenhouses constructively. Wireless communication can be used to collect the measurements and to communicate between the centralized control and the actuators located to the different parts of the greenhouse. In advanced WSN solutions, some parts of the control system itself can also be implemented in a distributed manner to the network such that local control loops can be formed. Compared to the cabled systems, the installation of WSN is fast, cheap and easy. Moreover, it is easy to relocate the measurement points when needed by just moving sensor nodes from one location to another within a communication range of the coordinator device. If the greenhouse vegetation is high and dense, the small and light weight nodes can even be hanged up to the plants' branches. WSN maintenance is also relatively cheap and easy. The only additional costs occur when the sensor nodes run out of batteries (figure 1) and the batteries need to be charged or replaced, but the lifespan of the battery can be several years if an efficient power saving algorithm is applied. In this work, the very first steps towards the wireless greenhouse automation system by building a wireless measuring system for that purpose is taken and by testing its feasibility and reliability with a simple experimental setup.

Clustering [11, 12] may be centralized or distributed, based on the arrangement of CH. In centralized clustering, the CH is preset but in distributed clustering CH has no fixed architecture. Distributed clustering mechanism is used for some private reasons like sensor nodes prone to failure, better collection of data and minimizing redundant information. Hence these distributed clustering mechanisms encompass highly self-organizing capability.

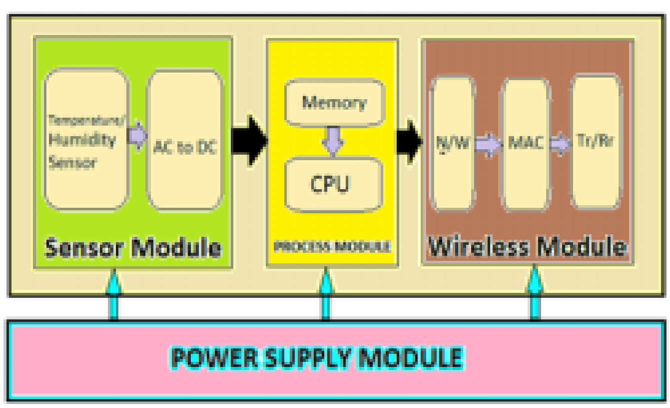

Figure 1: Various components of a sensor node

II. RELATED WORKS IN SENSOR NETWORK

Military applications are very closely linked to the awareness of wireless sensor networks. In fact, it is very harsh to say for sure whether motes were developed because of military and air defense needs or whether they were invented separately and were subsequently applied to army services. Regarding military applications, the region of concentration extents from information collection, generally, to enemy tracking or battlefield surveillance. For example, mines could be regarded as unsafe and obsolete in the future and may be replaced by thousands of isolated sensors that will detect an intrusion of unreceptive units.

Outdoor monitoring is an additional celestial area for applications of sensors networks. One of the most delegate examples is the operation of sensor nodes on Great Duck Island [8]. This sensor network has been used for environment monitoring. The sensor nodes used were talented to sense temperature, barometric pressure and humidity [1, 2]. In addition, passive infrared sensors and photo resistors were betrothed. The array was to monitor the natural environment of a bird and its activities according to climatic changes. For that cause, several motes were installed within birds' burrows, to spot out the bird's presence, while the rest were deployed in the nearby areas. Data are aggregated by the employment of sensor nodes and are passed through to a gateway.

Management of costly possessions like equipment, machinery, different types of stock or products can be a quandary. The dilemma is highly distributed, as these companies enlarge all over the world. A gifted method to achieve asset tracking and cope with this trouble is believed to be with the use of sensor networks. The application of wireless sensors in petroleum bunks and chemical warehouses refers to warehouses and cargo space administration of barrels. The thought is that motes attached to barrels will be gifted to locate nearby objects (other barrels), detecting their content and alerting in case of inappropriateness with their own, aging effects of the field etc.

Health science and the health care system can also yield from the employment of wireless sensors. Applications in this class include telemonitoring human physiological data remotely, tracking and monitoring of doctors and patients within a hospital, drug superintendent in hospitals, etc. In Smart Sensors, retina prosthesis chip consisting of 100 micro sensors are built within the human eye. This allows patients with inadequate vision to see at an adequate level. Cognitive disorders, which almost certainly direct to Alzheimer's, can be monitored and controlled at their premature stages with these wireless sensors.

Robotic applications [9, 10] previously implemented are the unearthing of level sets of scalar fields using mobile sensor networks and imitation of the function of bacteria for looking for and discovering dissipative gradient sources. The tracking of a light source is completed with a few of the easy algorithms. In addition, a reply to the coverage crisis by

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robots and motes is accomplished for thick measurements over a broad area. The connection of both static and mobile networks is accomplished with the help of mobile robots, which travel around the environment and set up motes that act as beacons. The beacons support the robots to portray the directions. The mobile robots can perform as gateways into wireless sensor networks. Examples of such tasks are: sustaining energy resources of the wireless sensor network indefinitely, maintaining and configuring hardware, detecting sensor failure and appropriate deployment for connectivity amid the sensor nodes.

Landslide detection employs sprinkled sensor system for predicting the happening of the landslides. The consideration of predicting landslides by means of sensor networks arose out of a must to mitigate the blemish caused by landslides to human lives and to the railway networks. A mixture of techniques from earth sciences, signal processing, distributed systems and fault-tolerance is used. One solitary trait of these systems is that it combines several distributed systems techniques to deal with the complexities of a distributed sensor network environment where connectivity is underprivileged and power budgets are very constrained, while fulfilling real-world requirements of safety. Generally these methods use a set of inexpensive single-axis strain gauges attached to cheap nodes, each with a CPU, battery and elite wireless transmitter block.

Forest fires, also recognized as wild fires are wild fires occurring in wild areas and root major damage to natural and human resources. Forest fires wipes out forests, blaze the infrastructure and might result in high human death toll closer to urban areas. Common causes of forest fires embrace lightning, human carelessness and revelation of fuel to extreme heat and aridity. It is well known that in few cases fires are constituent of the forest ecosystem and they are important to the life cycle of native habitats

Sensor-Clouds can be used for health monitoring by using a quantity of simply obtainable and most often wearable sensors like accelerometer sensors, proximity and temperature sensors and so forth to collect patient's health-related statistics for tracking sleep activity pattern body temperature and other respiratory conditions. These wearable sensor devices must have sustain of Bluetooth's wireless interface, Ultra wideband and so forth interface for streaming of data, linked wirelessly to any smart phone through the interface. These smart phone devices foresee performing like a gateway between the remote server and sensor through the internet.

III. EXPERIMENTAL SETUP IN A GREENHOUSE

A. The Greenhouse Environment

A modern greenhouse [4-6] can consist of plentiful parts which contain their own local climate variable settings. As a result, a number of measurement points are also needed. This class of environment is challenging both for the sensor node electronics and for the short-range IEEE 802.15.4 wireless network, in which communication range is greatly longer in open environments.

B. Sensors

Hasty response time, low power consumption and tolerance against moisture climate, relative humidity and temperature sensor forms a perfect preference and solution for the greenhouse environment. Communication amid sensor and node can be carried out by IIC interface. Luminosity can be measured by light sensor, which converts light intensity to voltage. Unstable output signal is handled by low-pass filter to get correct luminosity values. CO_2 measuring [7] takes longer time than other measurements and CO_2 sensor voltage supply have to be within few volts. The carbon dioxide value can be read from the ensuing output voltage. Operational amplifier raises the voltage level of otherwise frail signal from the sensor.

C. Greenhouses

A greenhouse is a configuration covering ground frequently used for growth and progress of plants that will return the owner's risk time and capital. This display is mounted with the purpose of protecting crop and of allowing a better environment to its progress. This shield is enough to promise a superior quality in production in some cases. However, when the major purpose is to achieve a better control on the horticulture development, it is necessary to test and control the variables that influence the development of a culture. The chief function of a greenhouse is to provide a more sympathetic environment than outside. Unlike what happens in traditional agriculture, where crop conditions and yield depend on nature resources such as climate, soil and others, a greenhouse ought to guarantee production independently of climatic factors. It is noteworthy to observe that even though a greenhouse protects crop from exterior factors such as winds, water excess and warmth it may cause plentiful problems such as fungus and excessive humidity. Therefore, mechanisms to scrutinize and control a greenhouse environment are incredibly vital to achieve better productivity. To get superior productivity and quality, better control system is necessary and as a result the production costs also get reduced. The chief elements involved in a greenhouse control system are: temperature, humidity, CO_2 concentration, radiation, water and nutrients.

D. Temperature

Temperature is one of the most key factors to be monitored because it is unswervingly related to the growth and progress

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of the plants. For all plants, there is a temperature range considered best and to most plants this range is relatively varying between 10ºC and 30ºC. Among these parameters of temperature: extreme temperatures, maximum temperature, minimum temperature, day temperature and night temperature, difference between day and night temperatures are to be vigilantly considered.

E. Water and Humidity

Another momentous factor in greenhouses is water. The absorption of water by plants is linked to the radiation. The lack or low level of water affects growth and photosynthesis. Besides air, the ground humidity also adjust the development of plants. The air humidity is interrelated to the transpiration while the ground humidity is connected to water absorption and photosynthesis. An atmosphere with extreme humidity decreases plants transpiration, reducing growth and may promote the proliferation of fungus. On the other hand, squat humidity level environments might cause dehydration.

F. Radiation

Radiation is a fundamental element in greenhouse production and sunlight is the key source of radiation. It is an important component for photosynthesis and carbon fixing. The significant radiation features are intensity and duration. The radiation intensity is linked to plant growth and the duration is openly associated with its metabolism.

G. CO_2 Concentration

CO_2 is an essential nutrient for plant development, allowing the assimilation of carbon. The carbon retaining procedure occurs through the photosynthesis when plants take away CO_2 from the atmosphere. During the photosynthesis, the plant uses carbon and radiation to produce carbohydrate, whose function is to permit the plant development. Therefore, an enriched air environment should contribute to plant growth, but it is also vital to note that an extreme carbon level may turn the environment poisonous.

IV. THE PROPOSED MODEL

A solution to the existing drawbacks can be found out from this proposed model. The proposed model is implemented in hardware, tested and the results show an excellent improvement in the sensing parameters when compared to the existing set of environmental monitoring and greenhouse control models. Sensor arrays like temperature sensor, light sensor, humidity sensor and vibration sensors are incorporated in the board. The sensed data is processed by the micro controller and displayed in the LCD display. Wireless transmission of the parameters is accomplished by a zigbee module that sends information to the remote monitoring station periodically. To control and monitor the environmental variables planned in an earlier section, sensors and actuators capable of measuring and controlling the values inside the greenhouse are necessary. Generally, a greenhouse control is implemented just by approximating a measured cost to a reference or ideal cost. Figure 2, shows the basic block diagram of the proposed model. Due to cost considerations, the proposed model uses sensor network instead of wireless sensor network. The sensed data is forwarded to the gateway. The gateway then forwards the data to the remote monitoring base station. The base station is a remotely located software configured computer, where the monitored details are periodically visualized to carry out further control actions.

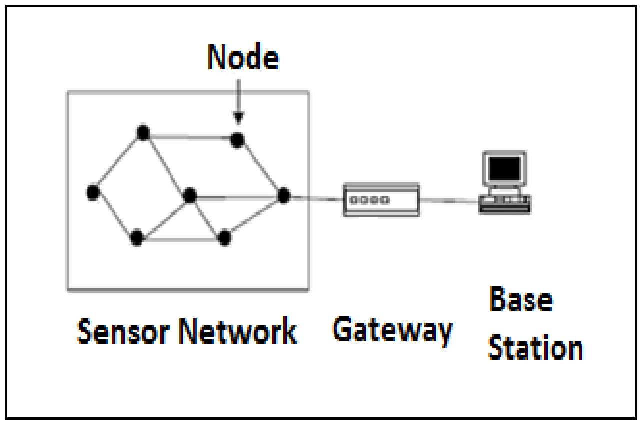

Figure 2: Block diagram of the proposed model

In the proposed model, the ideal assessment depends on the culture and type of plant. Control systems can be separated into centralized and distributed systems. In a centralized system a single constituent is responsible for gathering and processing the data. So, all the components of the system are connected to this solitary element. In a distributed control system the connections between nodes and information processing is distributed amongst the system components. The focal advantages of a distributed system may include: Reliability: a component failure affects barely part of the structure, Expansion: the likelihood of adding up of a new component without enormous changes in the system, Flexibility: changes in the procedure such as adding, removing and substituting of components impacts merely in the components involved in these basic operations. The major trouble of these technologies is that they are not developed for WSN and they do not present mechanisms to improve energy consumption.

In this way, it is probable to check all places inside the greenhouse, identifying not only local values as in many applications, but checking real world and distributed values. Therefore, the greenhouse control ought to be improved,

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allowing a settlement in a way that the complete environment can be adjusted as close as feasible to a set point. It is essential to observe that, in most applications the sensors are placed in a point of a greenhouse and the measures gained are used to direct the entire greenhouse. However, even though in a controlled and relatively tiny place like a greenhouse, it is possible to have different values of climatic agents. Figure 3 shows the experimental setup for environmental monitoring.

Figure 3: Experimental setup for environmental monitoring

Thus, the use of sensor in a greenhouse environment should permit a real time monitoring and an improved measurement through convenient distribution. The collected data in the system proposed must be sent to a base station located outside the greenhouse. The base station is connected by a gateway. With the implementation of this architecture, each node will be answerable for data collecting through its sensors and for sending it to its neighbors until all collected data emerge at the base station. The gateway generally uses wireless and Ethernet communication. The base station will be accountable for managing collected data, so some greenhouse control softwares and some wireless actuators are necessary. In this application node defense will also be necessary to avoid damage by water and inputs. It is imperative to emphasize that the use of wireless sensors and actuators is advantageous to make the system installation trouble-free and to obtain flexibility and mobility in the nodes prototype. The difficulties in applying WSN in agricultural applications might include costs and lack of standardization on WSN communication protocols. Due to cost constraints, the proposed model is designed with sensors. In future, the same sensor network will be simulated in NS-2 for a distributed clustering mechanism. Wireless sensor network with temperature, moisture and light sensing and advanced capabilities will be implemented in real-time environment for green house monitoring in future.

V. DISCUSSIONS

The major contributions of this manuscript are as follows. The design and implementation of large-scale and long-term CO_2 monitoring sensor network is discussed. A low-cost sensor deployment strategy with guaranteed performance which addresses the sensor deployment problems in the existing models has been proposed. Hardware implementation of this model has been done and the parameters are periodically monitored with few sensors.

VI. CONCLUSION AND FUTURE WORK

A model of agricultural application using sensor networks for greenhouses monitoring and control was presented. The wireless sensor network technology, although under development, seems to be promising mainly because it allows real time data acquisition. However, for such agricultural application to be developed, some technological challenges should be resolved. A greenhouse is a controlled environment and does not require a lot of climatic parameters to be controlled. The use of this technology in large scale seems to be something for the near future. In this application, the great number of climatic parameters can be monitored using the sensors available. As a greenhouse is a relatively small and controlled environment, and energy is a limited resource, the possibility of replacing batteries or even resorting to a steady energy source adaptation is a constructive aspect. This paper reveals an idea of environmental monitoring and greenhouse control using a sensor network. The hardware implementation shows periodic monitoring and control of greenhouse gases in an enhanced manner. Future work is concentrated in application of the same mechanism using wireless sensor network. This technology can also be applied in breeding of confined animals in precision zoo, where the sensor nodes should send information about animal temperature, pressure and other vital signals to guarantee a healthy environment to animals. In order to attain better energy efficiency, this mechanism will be implemented in real-world wireless sensor network, with a well-known energy efficient distributed clustering mechanism (HEED).

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