Web Based Poultry Farm Monitoring System Using Wireless Sensor Network

Mohsin Murad
N-W.F.P. University of Engineering & Technology
NWFP UET, P.O. Box 814
Peshawar, Pakistan
mohsin_murad@yahoo.com

Khawaja Mohammad Yahya
N-W.F.P. University of Engineering & Technology
NWFP UET, P.O. Box 814
Peshawar, Pakistan
yahyakm@yahoo.com

Ghulam Mubashar Hassan
N-W.F.P. University of Engineering & Technology
NWFP UET, P.O. Box 814
Peshawar, Pakistan
gmjally@yahoo.com

ABSTRACT

In this paper, we have proposed and developed a Poultry Farm Monitoring System based on Wireless Sensor Network (WSN) using Crossbow's TelosB motes integrated with commercial sensors capable of measuring temperature and humidity values. The data collected from the sensors is uploaded to an online database using an agent program and afterward accessed via the internet using web analysis applications. The feasibility of the developed system was tested by deploying the proposed system at N-W.F.P. Agricultural University's research poultry farm in Peshawar in the North-Western Frontier Province of Pakistan. To emulate the proposed idea, the data collected during a daylong experiment was put to test, evaluating the WSN's reliability and its ability to detect and report anomalies in the environment. This paper is the first step towards WSN based poultry farm monitoring systems. We have provided an online monitoring solution for poultry farms and tested its feasibility and reliability by presenting a thorough data analysis of our pilot deployment.

Categories and Subject Descriptors

C.2.1 [Network Architecture and Design]: Wireless communication; D.1.0 [Programming Techniques]: Concurrent Programming—Distributed programming

General Terms

Measurement, Design, Experimentation

Keywords

Poultry Farm Monitoring System, WSN.

1. INTRODUCTION

In advanced poultry farms, various measurement spots are required to record the parameters defining the local climate in different parts of the large poultry farm to make the automation and control system work efficiently. The use of cables makes the system bulkier, complicating the scalability issue and thus rendering the system costly. The hard wired sensing spots, after installation, are exposed to rough environment of the poultry form and difficult to be moved. Thus, a Wireless Sensor Network (WSN) consisting of small nodes (motes) equipped with a radio transceiver and one or many sensors can be an attractive, modular and inexpensive option in building the poultry farm monitoring system.

The most vital climatic factors for the productivity of a poultry farm are temperature and humidity and their maintenance. For instance, a day-old chicken requires 33°C (91°F) at a relative air humidity of 50%. If the outside temperature is 24°C (75°F) and the air is headed straight into the zone occupied by the nascent birds without being heated first, then weather would be too hard to resist. Therefore, proper heating/cooling solution should be provided along with appropriate ventilation. With advancement in technology, it is possible to automate the monitoring of these climatic parameters instead of using the conventional monitoring methods. The favorable poultry farm climate adjustments especially during the summer and winter seasons can help to improve the productivity of the farm and economize the energy usage.

Conventional poultry farms rely solely on a single centralized measuring point to provide feedback to the poultry farm automation system. These systems are usually not equipped with the options of controlling zonal heat, ventilation and/or any other climatic aspect. With the passage of time, the size of the poultry farm has greatly increased and the provision of various options such as, local adjustments to the heating, ventilation and other poultry farm support systems, has improvised. Provision of these facilities is made possible by the automation system whose accuracy directly depends upon number of measured values. As increasing the accuracy and thus number of measurement spots raises the cost so a compromise is to be made between the cost and accuracy. There must be a possibility of relocating the measurement spots according to the particular needs, which depends on the control plant, possible changes in the external weather or the poultry farm structure and the position of the plant in the poultry farm.

Wireless Sensor Network (WSN) can be a useful part of the automation system architecture in modern poultry farms. Some parts of the control system itself can be implemented in a distributed manner such that local control loops are formed. Similarly, wireless communication can be used to gather sensor values and to communicate between the centralized control and actuators located at different parts of the poultry farm. Compared to a wired system, the installation and deployment of a WSN is fast, cost effective and easy. It is easier to relocate the

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measurement spots by simply moving the sensor nodes (motes) from one location to another within the communication range.

WSN maintenance is comparatively economical and user friendly as compared to the conventional cabled measurement system. This is implied by a fact that a faulty mote can be replaced without affecting the entire network. Even the relocation of motes can be handled by untrained personnel saving the extra costs incurred. Additional cost occurs owing to the fact that battery life is limited and needs replacement or recharging, once out of power, but the power efficient algorithms such as [14] can handle this shortcoming.

In the proceeding work, we have taken the first step towards WSN based poultry farm automation system by building a web based monitoring system and testing its feasibility with a simple experimental setup. For test deployment, a commercial sensor was integrated to CrossBow's TelosB [1] platform which enabled us to measure two climatic variables: relative humidity and temperature. The network uses CTP [11] protocol, which allows us to send data packets to a sink mote over IEEE 802.15.4 networks.

2. RELATED WORK

Ayahiko et al. [2] are doing research in a broiler-house environment system using sensor network and mail delivery system. In their work, they have combined WSN with the mail delivery system to observe environmental change in the broiler-house. The environmental system needs to be deployed in some broiler-house to measure climatic changes. A user shall be able to inspect the summary data from the cellular phone and the data can be transmitted through a warning mail incase of a rapid temperature change. The sensor modules are deployed in each broiler-house and the network is constructed using wireless LAN communication, as the system needs to monitor two or more broiler-houses. The always-connected high-speed Internet is preferable to accumulate, to process data, and to offer it to the user in a comprehensible form. But, it is difficult to provide always-connected high speed Internet at the chicken farm which is used by experiment. The server is set up in the remote place, and they propose the system that delivers data from the chicken farm with mail [2].

LU Wu-Yi et al. [12] have proposed a paper to protect historical documents in a library environment by deploying a wireless sensors network. Using this setup they are able to continuously measure various climatic parameters, such as temperature, relative humidity, light and pollutants, either in repository or bookrack rooms. They have presented a practical testbed which is deployed in the Hunan library, located in Changsha, China. The WSN consists of three wireless sensor nodes and one sink node (or base station) to gather the network's data. Currently, it measures the most important parameters, which are temperature, humidity and light; however, internal voltage is also monitored so that the user is aware of the state of the nodes' batteries. The paper suggests that the use of WSN for environmental monitoring of a library is, indeed, a simpler and more reliable solution. It is also less expensive than manual data collection or than a wired central monitoring system [12].

The Rinnovando group [3] is doing research work in a tomato greenhouse in the South of Italy. They are using Sensicast devices for measuring the air temperature, relativity humidity and soil temperature measurements with wireless sensor network. They have also developed a Web-based plant monitoring application. Greenhouse grower can read the measurements over the Internet, and an alarm will be sent to his mobile phone by SMS or GPRS if some measurement variable changes rapidly. Bridge node gathers data from other sensor nodes, which transmit the measurements of temperature and relative humidity in one minute intervals [3].

3. POULTRY FARM CONTROL SYSTEM

A main concern in humidity and temperature control of a poultry farm is to provide the best suited environment for poultry nourishment. Humidity control is also an important tool to prevent the spread of broiler diseases in poultry farms. Normally, the range of healthy relative humidity for the broilers is from 30% to 60%.

Temperature and humidity are closely linked together in a poultry farm. Cold air has a lower moisture-holding capacity than warmer air, and therefore the decrease of the relative humidity is a sign of increased air temperature [5].

Poultry farm monitoring and control can be divided into three main tasks: Measuring, calculating and adjusting. The measured values of the climate variables are first converted from analog to digital and then transmitted to the computer. Because of the coarse internal environment and high moisture, the computer is usually located outside the poultry farm. In conventional systems, the signal generated from the sensor is sent over transmission medium as intact so owing to the medium constraints the signal deteriorates and it must be reconditioned. WSN does not have problems like these, as measured value is first converted into digital data, which needs regeneration if degraded, and transmitted over a radio link to the base station (sink) node which is connected to the computer (see Figure 4), or it can be transmitted in a multi-hop manner via router nodes, if the distance between the measuring nodes and the computer exceeds the length of a single radio link. Besides data collection and control algorithms, the computer also shows the poultry farm's humidity and temperature statistics for monitoring. The climate control system, while executing the poultry farm control algorithm, generates the new values for the control signals typically in 25-60 seconds.

Each control signal generated is fed to a relay, which is used to switch the equipment on or off through the second relay which provides the required voltage to the devices.

A modern poultry farm can consist of several parts like breeding compartment, feeding hall and laying zone each having its own local climate settings. Therefore, a distributed sensing mechanism, comprising of several measurement spots, will be required.

4. EXPERIMENTAL SETUP IN A POULTRY FARM

4.1 The Poultry Farm

We have done our experiments in N-W.F.P. Agricultural University's research poultry farm [6] in Peshawar in the North-Western Frontier Province of Pakistan. The size of the poultry farm is 30 x 90 meters (see Figure 1) and its only measurement unit, being located in the middle, is wired.

The poultry farm is mainly divided into four zones: hatchery, feeding, egg production and multiplier breeder flocks zone which provides broiler hatching eggs (broiler breeder). Depending upon zonal chicken population and distribution, each zone has its own local climate.

Figure 1. N-W.F.P. Agricultural University's research poultry farm in Peshawar.

The communicating motes could work at maximum possible distances in their communication range as the hindrance offered by the obstacles and the chickens is negligible. In deployment, the distance between communicating motes was limited to 40 meters.

4.2 Motes

The wireless sensor nodes used are CrossBow's TelosB Mote TRP2420 (see Figure 2) [1]. Key features of the mote include 250kbps 2.4GHz IEEE 802.15.4 Chipcon Wireless Transceiver, Integrated ADC, DAC, Supply Voltage Supervisor, and DMA Controller. It also has integrated onboard antenna with 50m range indoors / 125m range outdoor. It also has USB based programming and data collection, a low-power MSP430 Microcontroller with extended memory and an optional sensor suite. The motes had a built in battery pack and used two AA-batteries as power source.

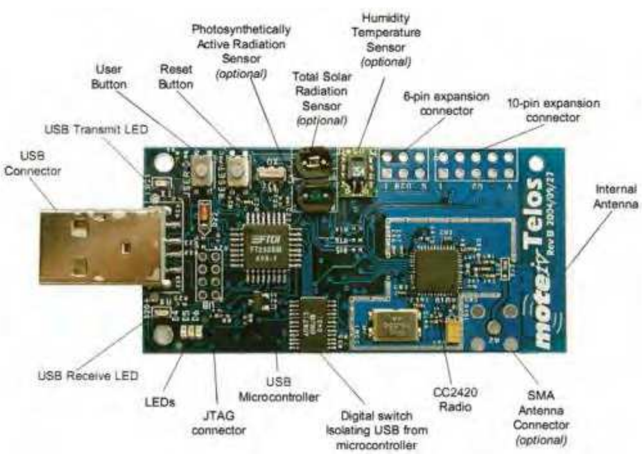

Figure 2. CrossBow's TelosB Mote with integrated temperature, humidity and light sensors.

4.3 Sensors

For measuring the temperature and relative humidity we used Sensirion SHT11 [4] all-round temperature and humidity sensor. SHT11 is Sensirion's family of surface mountable relative humidity and temperature sensors. The sensors integrate sensor elements plus signal processing on a tiny foot print (see Figure 3) and provide a fully calibrated digital output. A unique capacitive sensor element is used for measuring relative humidity while temperature is measured by a band gap sensor.

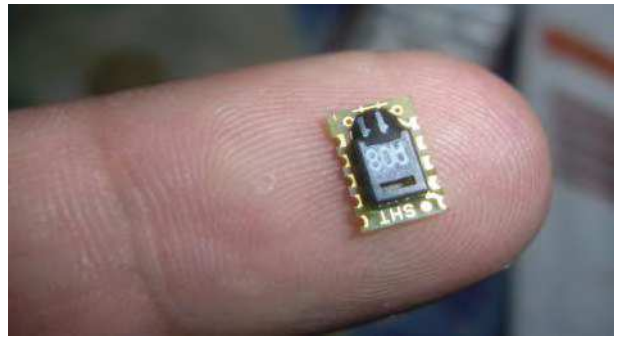

Figure 3. Sensirion SHT11, temperature and relative humidity sensor.

Both sensors are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit. The 2 wire serial interface and internal voltage regulation allows for easy and fast system integration. Temperature accuracy of the sensor is ±0.3 °C and the accuracy of the relative humidity under ±2 %. The tiny size and low power consumption makes SHT11 the ultimate choice for even the most demanding applications including sensor networks.

4.4 Motes deployment and network architecture

We placed our motes in a star fashion [10] where sensors, mounted on 4 motes, measured climate variants and communicated directly with the base station node for data relaying. The base station mote acted as a coordinator and received the measured data from the sensor motes. A laptop computer was connected to the base station mote via USB-cable and was placed outside the feeding compartment.

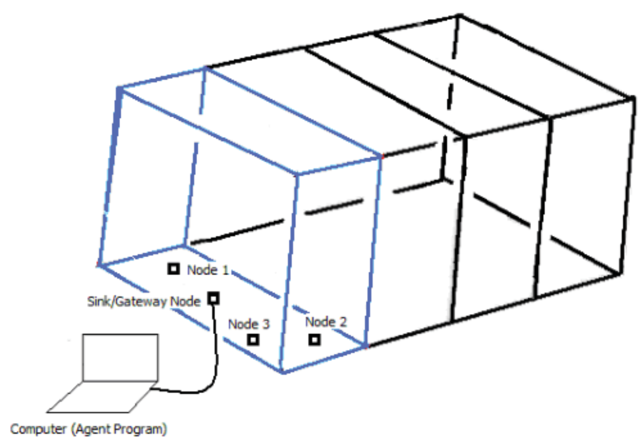

Figure 4. Motes deployment in the feeder compartment of poultry farm.

As mentioned earlier, the poultry farm is divided into four distinct zones and each zone was monitored by three motes. Figure 4 shows the deployment of motes in feeder zone. Node 1 (see Figure 5) was placed 100 cm away from the feeding room's door. Node 2, closer to the side wall, was placed 162 cm away from the ventilation window to monitor the climate variables. Node 3 was placed at the geometric centre of the zone near the drinking water counter.

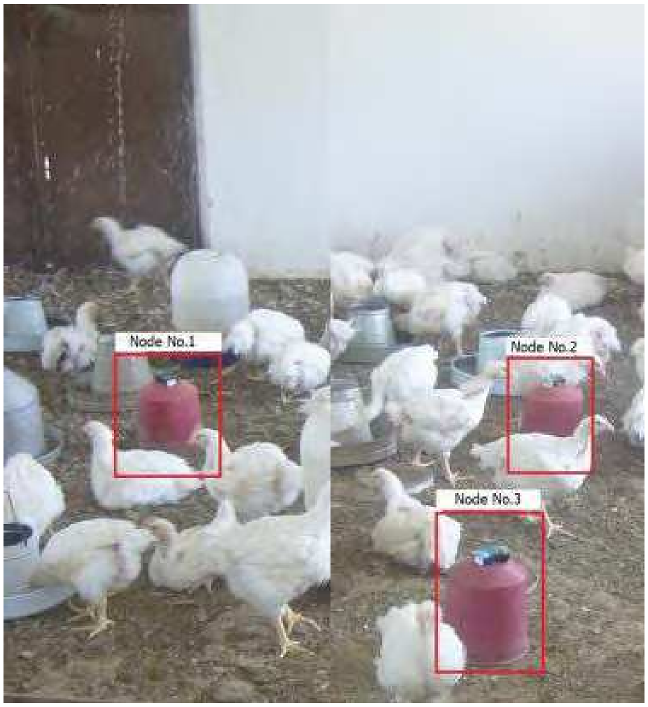

Figure 5. Motes deployed in various locations at N-W.F.P. Agricultural University's research poultry farm.

Sleep and wake modes were applied in a periodic manner. For a particular mote, the wake time was 10 seconds and sleep time was 600 seconds (10 min). At an instance, only one of the four motes equipped with temperature and humidity sensors was reading data from the sensors and transmitting it to the base station mote. This technique was employed to avoid collisions between packets sent by the motes. The computer receives WSN data using a java serial forwarder and this data is injected into an online mySQL [13] database using java database connectivity (jdbc) driver. The database fields are then plotted using a PHP based web application (see Figure 6).

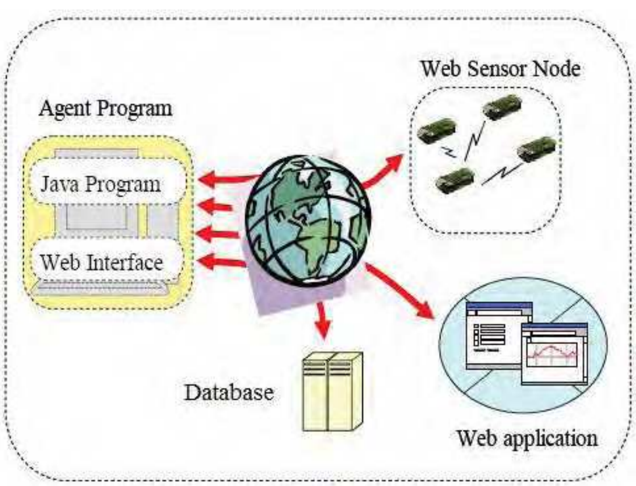

Figure 6. Architecture of the web based monitoring system.

5. RESULTS

In our monitoring setup, 3 motes were deployed in the feeding zone to acquire information about the differences in varying climate variables. In the three hour period, every mote measured temperature and relative humidity values once every 10 minutes. We observed that the reliable range in terms of tolerable packet loss was approximately 40 meters. It was figured out in a test where the distance between the individual measuring mote and the base station mote was increased until the connection was lost. Compared to the maximum indoor communicating distance of the motes which is approximately 50 meters, the reliable range fell by 10 meters which is 20% less than the maximum communicating distance.

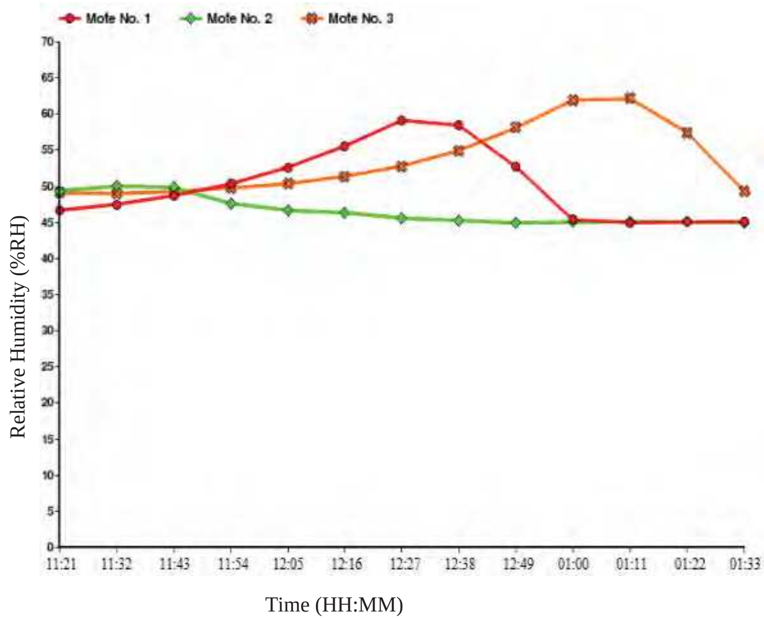

Figure 7. Relative Humidity values from the motes.

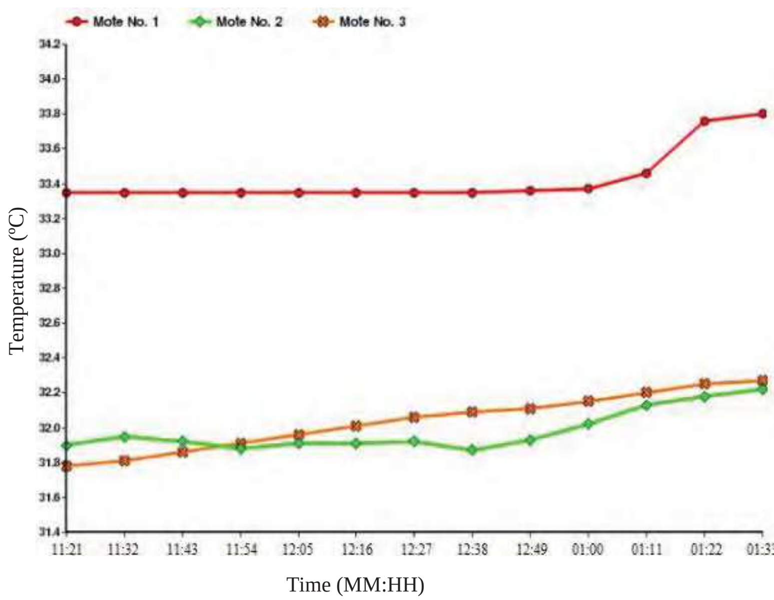

Figure 8. Temperature values from the motes.

The humidity and temperature relation has already been mentioned in Chapter 3. The readings collected by the motes verified the fact that lowering of the relative humidity increases the air temperature and vice versa. Figure 7 shows the changes in relative humidity between three nodes. Comparison between temperature and humidity values (Figures 7 and 8) shows how variables are linked together. Temperature values increased at the same time when moisture dropped, as shown in Figure 7.

6. CONCLUSION AND FUTURE WORK

In this work, we have integrated commercial sensors to CrossBow's TelosB mote to measure temperature and humidity values for a poultry farm monitoring system. The system feasibility was verified in a simple star topology setup in a research poultry farm. We achieved up to 40 meter communication range with tolerable 5% packet loss. The measurements also indicated that the system is able to detect the local anomalies in the poultry farm environment, such as different climate layers which exist from poultry farm ventilation windows to the center.

Applying 10 seconds wake period between 10 minutes sleep periods fulfilled the requirements of the energy efficient wireless sensor network architecture. Each sensor node was sending packets in its own turn. SHT11 humidity/temperature sensor with low current sleep mode is well suited for motes powered by batteries.

In addition to networking in data collecting purposes, we will develop the control part and introduce a feedback system. The control commands will be counted in a centralized or locally centralized manner, and then transmitted wirelessly to the actuators located in the different zone of the poultry farm. Required local control implementations hint at using DSP-units with some of the wireless sensor nodes.

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